PROBLEM BASED LEARNING PROJECTS

STUDENT DEVELOPMENT PROGRAM

2021-22

PAPER SUBMISSION

IUCEE Foundation

POPBL Program for Students

July 2021 – Feb 2022

Program Coordinator

Sampada Pachaury

Title of the book:

PROBLEM BASED LEARNING PROJECT STUDENT PAPERS

Publication Year: 2022

***The IUCEE Editorial Board**

❖ Sampada Pachaury (Editor)

Director, IUCEE Foundation, India

❖ Amit Lathigara (Member)

Name and address of publisher:

Prof. Krishna Vedula, Registered Address of IUCEE

Place of publication:

Virtual/Online and IUCEE Foundation, India

ISSN: To be advised

Price: Indian Rs. 500 (To be finalised)

MESSAGE

Indo Universal Collaboration for Engineering Transformation (IUCEE) Foundation has been working on a Mission to raise the Quality of Engineering Education in Tier 2 & 3 Engineering Colleges of India for the last 10 years. Prof. Dr. Krishna Vedula, retired – Dean Emeritus, University of Massachusetts, Lowell, USA is supported in this humongous endeavour by his network of passionate leaders and academicians from universities in USA, Singapore and Australia. A global community of 100 leaders have brought significant impact to a Consortium of 100 Institutions across States of India. IUCEE has conducted weekly Webinars, Annual Events & Conferences, Research Publications, Faculty Certifications, Joint accreditations programs and engaged with Institutional Leaders, Faculties and Students at all levels to bring a transformation from the root. Several consortium institutions have risen their ranks at NIRF, NAC and ARIA and have also turned autonomous as a result of this deep rooted impact created by IUCEE initiatives over multiple years.

Year 2021, was a year focussed on Projects and Problem Based Learning as part of NEP directed programs. The Student Development Vertical led by Ms. Sampada Pachaury devised a Project Oriented Problem Based Learning Program for Students. The multi phased program ran for 8 months involving close to 100 student teams from IUCEE Consortium member and a few non-member institutions.

This document is a select compilation of Student authored Papers that were submitted as part of the completion of the POPBL 2021 Program.

SAMPADA PACHAURY

Director, IUCEE Foundation

sampada@iucee.org

TABLE OF CONTENT

PROBLEM BASED LEARNING BY DOING PROJECTS

The Story

Engineering is about solving problems of the world we live in.

IUCEE Foundation has been working on the philosophy of "I am teaching, are they Learning" for over a decade with their Consortium member colleges pan India.

Among the various programs and initiatives run by IUCEE, the approach is to enable its' members to adopt "engineering by doing"

In March 2021, Col Raman Thapar, Deputy General Manager at Indian Micro Enterprises Development Foundation (IMEDF_ presented a Webinar on Sustainable Livelihoods focussed on the empowerment and enablement of the small and medium scale enterprises by providing them means to employment and sustenance.

This Webinar was well received by IUCEE team. This was followed by several meetings between IUCEE and IMEDF and a special session dedicated to Manufacturing of Toys in Channapatna, Karnataka to Students and Faculty of IUCEE Consortium. This session excited the audience to do something for the society and add engineering and technology value to the work being done by IMEDF.

Col Raman Thapar and his team provided 8 different real time challenges faced by a few of the 200+ clusters. These challenges formed the basis of the launch of the first pilot of POPBL program by IUCEE Foundation in 2021

Summary by Numbers

1. IUCEE received 8 problem areas from IMEDF on 4th July 2021
2. IUCEE launched a Project oriented PBL program on 5 primary problem areas on 30th July 2021 to its' Consortium of Institutions
3. IUCEE received 204 Applications from 600+ students and 200 Faculty guides from 50+ consortium colleges to work on these 5 project tracks
    1. **Low Cost Field Testing Kit for Honey Purity standards**
    2. **Efficiency improvement of Distillation of Essential Oils**
    3. **Toys for Autistic Kids**
    4. **Waste Management of Perishable Fruits & Vegetables**
    5. **Block Chain Mapping of Products**
4. An Orientation Session on POPBL led by IUCEE was conducted on 12th Aug 2021 for all participating teams. A total of 900 attendees joined the Orientation
5. 200 Teams submitted & presented their Preliminary Findings on their respective project tracks from 4th Sept to 10th Sept 2021 in presence of IUCEE Jury

6. The Teams were guided and coached for the next 10 weeks to implement PBL approach to ideate and submit their POC by 15th Nov 2021
7. 76 Teams submitted their conclusive Prototypes on 15th Nov to IUCEE
8. 74 Teams (from 30 Colleges) presented their work in presence of Domain Experts from Industry from 22nd Nov to 2nd Dec. Each team was provided detailed feedback by the respective Jury members
9. IUCEE identified 25 Class A projects, 30 Class B and 20 Class C projects from this Pilot cohort
10. Class A teams submitted Papers on their project work by Feb 2022
11. Class B teams were piloted on NEN-ACTIVATE 14 week program under IUCEE & Wadhwani Foundation collaborative partnership.
12. Class C teams were issued participation certificates

Program Coordinator: Ms. Sampada Pachaury, Director, IUCEE Foundation, M.Tech. (VLSI Design) IIT Delhi, with 17 years of experience in Semiconductor industry and 6 years of working with engineering student community and Faculty of multiple Institutions as part of Electronics Sector Skill Council of India and currently serving as Director with IUCEE Foundation for 3 years.

LAUNCH NOTICE/CIRCULAR TO ALL MEMBERS

Project Definitions

IUCEE Foundation Student Development Programs brings a unique opportunity to its' students to get involved in doing engineering projects inspired by real time challenges faced by local and regional industries in crafts and agro space.

IUCEE invites Students to take up these projects as their PBL activity.

Interested students need to pre-register in teams of three, by 11th August, Wednesday with one faculty guide using form link: (Insert surveymonkey link here)

These teams will be invited to attend an **Orientation Webinar on Thursday, 12th August at 6 pm**, to explain the process of POPBL and to clarify the project expectations

The Project is divided into 5 phases

- **Problem Statement**: Preliminary findings and Abstract submission (26th August 2021)
- **Explore**: Critical Thinking of various possibilities this problem can be solved within the constraints of design and functionality. There could be diverse models, depending on the need and local resources
- **Ideate**: Creative lab model prototype on paper and/or by CAD
- **Evaluate**: Lab Trials and Results and Analytical Conclusion

- **Launch**: Paper submission (15th November 2021)

Deadline for submission of preliminary findings and Abstract: Thursday, 26th August, 2021

Call 9818357105 or email sampada@iucee.org for clarifications

Cash Prizes will be awarded to best Paper submissions during IUCEE Annual Student Forum 2022

Papers could be published as UG research

Possibility of IP rights and patents

All reasonable submissions will be given certificates.

PS: This competition is an excellent example of how engineering students can obtain a holistic and multidisciplinary education as required by NEP 2020 Guidelines using the Problem Based Learning pedagogy

I – LOW COST, FIELD TESTING KITS FOR HONEY QUALITY & STANDARDS

Background

The lab testing of quality and standards of honey is very expensive. Each lab establishment can cost in a range of 5-10 crore. This results in adulterated and poor-quality honey penetrating and dominating the market and loss of market share for genuine honey supplier brands.

Project Honey

Develop an On-Field Low-Cost Testing Kit that can provide an equivalent substitute to lab testing or a preliminary rapid checking of quality standards before the samples are sent to Lab testing.

- **Preliminary findings**: Study the existing conditions and methods of Honey Testing in India and other countries. Collect data based on their geographical regions, sources, types & methods of honey extraction, processing, testing, and packaging methods and cost involved at every stage. Provide a reference data of parameters being tested of honey sourced in different regions of India and their acceptable range for purity guarantee (Basic, Intermediate, Advanced Tests, Sample Size)
- **Abstract Submission**: Prepare a chart (tabular, graphical) to present your data and **your analysis of the data**

- **1st proto-type** field testing kit: A Sample working kit that can test multiple samples of 1 type of honey at a cost of INR 25,000 – 50,000 at a rate of 100 samples in 10 hours
- **Paper Submission** by 15th November 2021: A well written UG Research paper detailing the findings, purity standards and their levels of quality checks, data collection, data analysis, Kit development, Sample testing and comparison with existing kits for purity and cost trade-off. Conclude with results of the samples tested and the proposition for the low cost field testing kit based on the condition prescribed above.

II – DISTILLATION UNITS FOR ESSENTIAL OILS

Background

In the process of Essential oil distillation, there is a loss of heat & constant temperature levels are not maintained, resulting in drop in oil extraction. The Distillation material used does not provide stable thermal efficiency. The quality of the fuel used in heating and the fluctuating temperatures are the identified cause of problem.

Project Essential Oil

Propose (more than one) ways to improve the efficiency of the essential Oil Distillation process by <0.6 %. General productivity standard for oil recovery is 0.6%, although it can up to 1.2%. Sun drying, Fuel quality and time of harvesting are some of the factors impacting the efficiency of the oil extraction.

- **Preliminary findings**: Study the existing steam distillation, methods of oil extraction and monitoring methods. Understand the effect of heat treatment on the characteristics and the efficiency of the oil being extracted. Study alternative (i) materials and (ii) possible bio-fuels that can improve the efficiency (firewood, efficiency)
- **Abstract Submission**: Prepare a chart (tabular, graphical) to present your data and **your analysis of the data**
- **1st proposal**: A Paper presenting the Experiment Data supported with evidence and results and its analysis from your College Lab. The lab results should highlight the impact of alternative (i) materials and (ii) possible bio-fuels on improved (by 0.5%) extraction efficiency of the oil

- **Paper Submission** by 15th November 2021: A well written UG Research paper detailing the findings, Sample testing and comparison with existing methods and their cost trade-off. Submit a clear proof of achieving <0.6% efficiency. If the efficiency improvement experiments fail or you face challenges in achieving the required efficiency, please document those as part of your paper submission. Failed experiments will be accepted as well as successful experiments provided the teams are able to submit coherent data.

III – TOYS FOR AUTISTIC KIDS

Background

The market caters to high volume of consumers and hence most toys are made for a "normal" average individual. The toys are mostly designed to cater only to a certain age group of children and may or may not prescribe to the stimulation needs of an autistic child.

Project Toy for Autism

Design a Toy or a Game that can help improve the concentration ability and provide stimulation to an autistic child less than 16 years old. The design can be designed to suit a smaller age range anywhere between 2 years to 16 years. It could be a single or a multi-player toy that can help an autistic kid to deal with their weakness and/or improve their cognition within the spectrum of a normal child.

- **Preliminary findings**: Study the Autism behaviour patterns of a kid. Understand what triggers and which responses differentiate and isolate an autistic kid from a non-autistic kid. Collect data of several studies conducted among Indian population to identify the above said responses and their impact on their life and personality development. Prepare a list of Institutions and Agencies working on this.
- **Abstract Submission**: **Prepare a chart** (tabular, graphical) to present your data. **Prepare a survey Form/Questionnaire** that you will send out to Experts and Users and affected population. The purpose of this survey is **for you to receive enough responses that can help you to design a Toy** based on above recommendations.
- **1st proposal**: A Paper/CAD design of the Toy supported with experimental evidence. Back your Toy Design with the scientific understanding of the impact on the Autistic kid

- **Paper Submission** by 15th November 2021: A well written UG Research paper detailing the findings, design and development. Sample testing (if possible) and comparison with existing methods and their cost trade-off for affordability and high volume of use. Submit a clear proof backed by opinions from at least two or more experts to validate your proposal.

IV – (WASTE) MANAGEMENT OF PERISHABLE FRUITS & VEGETABLES

Background

The perishable fruits and vegetables incur heavy losses to the farmers and suppliers due to their low shelf-life

Project Fresh produce

Identify ethical and environmentally sustainable solutions to prolong shelf-life of fresh produce, organic methods to utilise the excessive produce and also ways to manage the waste produced due to transfer and storage

- **Preliminary findings**: Study (in India) the demand and supply of perishable fruits and vegetables based on time, season and region of harvest, transport and distribution, packaging and shelf-life. Find what causes maximum loss to the farmers and distributors and why. Collect data for current conditions that exist to preserve, utilise items and waste generated and treated. Understand natural farm-based preservation methods based on traditional knowledge systems. Cold storage, processing facility at the source, farming techniques –shelf life has increased, new processes like solar drying
- **Abstract Submission**: **Prepare a chart** (tabular, graphical) to present your data. **Prepare a survey Form/Questionnaire** and collect data from Experts and Users and affected Suppliers. **Provide analysis of the data** collected, root causes and the variability in the nature of the problem
- **1st proposal**: A Paper presentation on the primary and secondary challenges and possible solutions which are ethically sound and environmentally sustainable, affordable. The solutions should be more aligned to traditional and local sensibility of the farmers
- **Paper Submission** by 15th November 2021: A well written UG Research paper detailing the findings, design and development. Sample testing (if possible) and

comparison with existing methods and their cost trade-off for affordability and high volume of use. Submit a clear proof backed by lab results on few samples of fruits and vegetables and their prolonged shelf life and/or preservation and handling of the waste generated.

V – BLOCK CHAIN MAPPING OF PRODUCTS

Background

Currently the product database and supply chain links, quality checks, personnel movement tracking, resource engagement are not centrally controlled and monitored. Hygiene factors, tracking of raw material, purity, adulteration issues and unethical practices like child labour concerns exist. Need of the hour is to track product to market value chain, to ensure fair value to the farmers, eliminating dependency on human agents in the chain and linking product maker to the customer on a fair transparent digital platform.

Project Blockchain mapping

To establish tracking and database management from origin to end-user. Bring source of origin, material, procurements, supplies, personnel on App with geo-tagging, block chain or, other tools

- **Preliminary findings**: Study one particular (local) agro or handicraft industry in detail. Identify the entire development cycle from material procurement and source to the end-user marketing and supply. Mark out all dependencies and points of handover across multiple entities involved in the chain. List out sources of personnel and their work conditions.
    - Individual harvesters- get the honey, enter the name details, qty (register), purchasing honey tribal cooperatives, after processing outlets, information tally software.
    - Handicrafts – Cloth Label is put , Tailor Label is put , Weaver Tags are put but not transferred to customer.
- **Abstract Submission**: Prepare a chart (tabular, graphical) to present your data. Present a mapping across multiple sectors and their inter-dependencies. Present existing Apps, Block chain or Geo-tagging features that can be roped in. Elaborate all challenges, risks, failures and threats to a transparent and fully mapped chain.
- **1st proposal**: A Paper presentation on the above mapping identifying the various stages and simplifying the QR coding and Barcoding method. Provide sustained and

permanent solutions to the challenges/limitations of the local infrastructure and facilities, network connectivity along the entire supply chain. The suggested approach should exhibit zero tolerance to challenges posed.

- **Paper Submission** by 15th November 2021: A well written UG Research paper detailing the findings, failure modes, design and development of blockchain mapping. Provide a working solution with zero tolerance to failures and risks backed by a sample case study

TEAM

Experts & Jury

ADITYA BHATNAGAR
Senior Partner @ The MindCrafters STEM Education and Learning

Dr. VEENA KUMAR
Professor University of Maryland
Chief Architect for IUCEE International Engineering Educators Certification Program for Faculty

DR. RAJU DANDU
Professor of Mechanical Engineering Technology and Director of Kansas State University Bulk Solids Innovation Center

DR. SUBHASH C RASTOGI
Educator, Author, Entrepreneur, Mentor-Trainer, Speaker
Founder Innovative LEAN Mentoring Academy

GAURAV KEDIA
Chairman, Indian Biogas Association

DEEPAK GADHIA
Chairman, Sunrise CSP Pvt. Ltd.
Trustee NGO Muni Seva Ashram
Mentoring start-up and supporting Entrepreneurs in Clean-Tech Sector

JOJI VARGHESE
Print2block, CEO, Co-founder
10+ years, Blockchain Expert, Web product Technology, Hyper Ledger, Node Js

RAMAKANT HARLALKA
Managing Director at Nishant Aromas

DR. PRATHIBA NAGABHUSHAN
Educational Psychologist
Teacher of Psychology at St Mary MacKillop College, Canberra and
English Curriculum and Teaching Methods to M. Teach students at the Australian Catholic University in Canberra

COL RAMAN THAPAR
Ex- Army Veteran, Dy. General Manager Indian Micro Enterprises Development Foundation

RAMESH SHASTRI
38 years journey from Software professional to working with NGO called MAYA on livelihood initiatives for the Channapatna toymakers over the last 5 years

SIDDAPPA SETTY R
Fellow (Associate professor)
Centre Convener at Centre for Environment and Development in ATREE, Bangalore.

VINOD KAUSHIK
President End Poverty India

Technical Support & Guidance

SRIDHAR NORI
Staff IUCEE Foundation

KEITH FERNANDES
Assistant Professor at Department of ECE, St Joseph Engineering College, KN

AMIT LATHIGARA
Director, RK University, GUJ

DR. SIDDHARTH JADEJA
Director, B H Gardi Vidyapith, GU

IMPLEMENTATION OF MICROCONTROLLER-BASED TOY FOR AUTISTIC KIDS.

Authors: **Stephi Jacob**
Pommayan Thileja
Nithiya Lakshmi.A
Email Id: 9920004130@klu.ac.in
9920004107@klu.ac.in
9920004094@klu.ac.in

ABSTRACT:
Autism is known as a spectrum disorder because it has a wide range of conditions and diagnoses. Children with autism have triad impairments such as restricted social behavior, lack of communication, and repetitive behavior. Some autistic kids cannot understand emotions and shapes. To overcome these difficulties and to improve their skills, a microcontroller-based toy is designed. The microcontroller used here is ATmega328P (Arduino UNO). Arduino is an open-source platform to develop the usage of electronics in multidisciplinary projects. Arduino can be easily programmed with the help of Arduino IDE and the programming language can be C or C++. But the programming language opted for this project is C. On the whole, the toy can perform various tasks, where the autistic kid has to think and guess the answers for a few questions regarding arithmetic operations and geometrical shapes. The toy intends to bring several changes in autistic kids including the improvement in emotional behavior and to identify shapes.

ACKNOWLEDGEMENTS:
First of all, we would like to thank the almighty God for his enormous blessings. Our sincere thanks to INDO UNIVERSAL COLLABRATION FOR ENGINEERING EDUCATION(IUCEE) for providing this wonderful opportunity along with guidance and appreciation in every stage of this project. A special thanks to Ms. Sampada Pachaury and Dr. Krishna Vedula for all the efforts they took to make us understand the need and demands of this project. We extend our sincere thanks to Mr. Aditya Bhatnagar, who made us come up with drastic improvements in the project by giving his valuable suggestions and comments. We are grateful to Dr. Prathiba Nagabhushan for her mentor sessions in which she discussed various aspects of paper writing. Thanks to Kalasalingam Academy of Research and Education and IUCEE KARE Student Chapter for the constant support. We would also like to express our sincere gratitude to our project guide Dr. C. Bala Subramanian Assistant Professor, Kalasalingam University for encouraging us to develop a project with an open-source platform. His knowledge of microcontrollers was our first inspiration to do this project. Finally, our hearty thanks to our family and friends for their love, care, prayers, sacrifice, and support which made us overcome all the tough times. We are extremely happy and satisfied with the outcomes of this project.

TABLE OF CONTENTS:

TABLE OF FIGURES

INTRODUCTION:

Autism is a neurodevelopmental spectrum disorder [1]. Autistic kids often find them difficult to socialize [2]. Most autistic kids do not engage in the group plays because they need communication and cooperation, so they prefer to play alone. Sometimes they are attracted by spinning objects like wheels and toys. The aim of the project is to design a toy to develop the skills of autistic kids and to find solutions for some of their problems. Toys can teach many good lessons along with stress relief. Toys are the first thing that makes the child explore art, shape, and math. At a young age, it is very important to engage autistic kids in toy play and physical play. This will stimulate their brain and help them to pay attention. The project mainly focuses on three factors: emotions, shapes, and math. This project helps the kids to learn how to identify emotions and shapes and also to develop their mathematical skills (savant skills). This project aims on both problem solving and developing some of their existing skills. Introducing educational toys which have challenges can improve concentration and creative thinking [3].

BACKGROUND:

Some of the signs of autism are preferred to be alone, avoiding eye contact, lack of attention, emotion, and communication. Among these, lack of emotion recognition and communication are the ones which make the surroundings of young autistic kids worse. This will also lead them to be less concerned about their loved ones. For example, we cannot expect an autistic kid to act upon diverse emotions. The autistic kid may laugh if his sibling is crying hard. This improper social behavior must be taken into account to improve the well-mannered behavior of an autistic kid. Up To now, there are not many toys that aim for the development of emotion recognition but, by day-to-day activities, parents and teachers of autistic kids are keen on teaching them different emotions with facial expressions.

1. **Social Stories [4]**

   Teaching social stories which have strong emotions in each character is a traditional way to teach emotions. The issue with this is, 5-7 years autistic kids may have difficulty in understanding stories.

2. **ABA- Applied Behavioral Analysis [5]**

   ABA works by demanding the emotion from the autistic kid and then rewarding them. This is like a positive reinforcement method. Though ABA is the most effective way to treat autism, this may mislead us to hurt autistic kids.

The method that was adopted in the project is,

PECS- Picture Exchange Communication System [6]

This method is the usage of cards in which there are faces of people with different emotions along with facial expressions. Those cards will be shown to the autistic kid, and they will be questioned.

The PECS model has been slightly improved with some more features. This was implemented with the help of a microcontroller ATmega328P (Arduino), LCD display, a keypad, a potentiometer, few push buttons and resistors.

THE SPECIFICATION AND DESIGN:

Children with ASD have sensory issues. Either they are hypersensitive or hyposensitive [7]. Because of sensory issues, they lack emotional recognition and control. This resulted in the invention of a variety of toys and products to relax and calm them. The aim of the toy is basically to make the autistic kid understand

different emotions along with the facial expression. 5-7 is the age when most autistic kids can recognize happiness and sadness, But not the subtle expression of fear, surprise, disgust, and anger. Introducing the concept of shapes is very essential for autistic kids. It helps them to organize the visual information and later makes them recognize the shapes in all things they see.

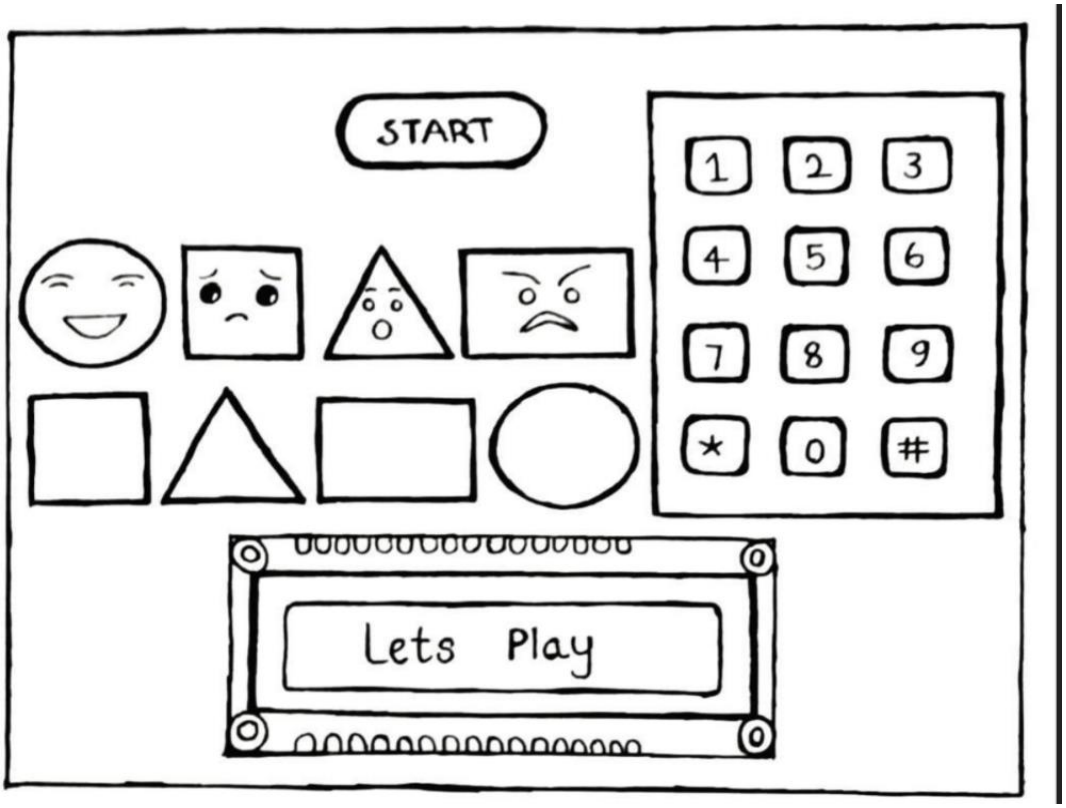


Figure 1. Model Toy Design

The concept of the toy is “Why this face”. This toy will help the autistic kid to understand the various situations in which a person can be sad, happy, angry and surprised, etc. At the start, an emoji pushbutton is pressed and at the end, the kid will get to know why the emoji have such facial expressions. In Between the kid should pass in two levels one is to recognize the shape and the other is a single-digit arithmetic operation. There is a start button on the top of the toy. By pressing the start button the toy starts functioning. The toy consists of four buttons. The first row consists of 2 buttons that exhibit shapes along with the facial expressions of a few emotions. The second row has two buttons that exhibit only the shape. An LCD is used as an output unit to display a few commands and a keypad is used as an input unit to give answers. Push buttons play an important role in this toy. If more emoji and shape buttons are added, then playing with the toy becomes more interesting. The microcontroller ATmega328P (Arduino Uno) consists of 14 digital pins and 6 analog pins. If all the pins are used then only 4 pushbuttons, one keypad and LCD can be attached. But if Arduino nano or Arduino Due are used some more push buttons can be added. Adding many push buttons can also be achieved by Interfacing two Arduino Uno. The cost of implementing on an Arduino Due is equal to interfacing two Arduino Uno. Hence the cost can be varied according to the features that are added and the tools that are used.

THE PROCESS OF PLAY WITH THE MICROCONTROLLER-BASED TOY FOR AN AUTISTIC KID.

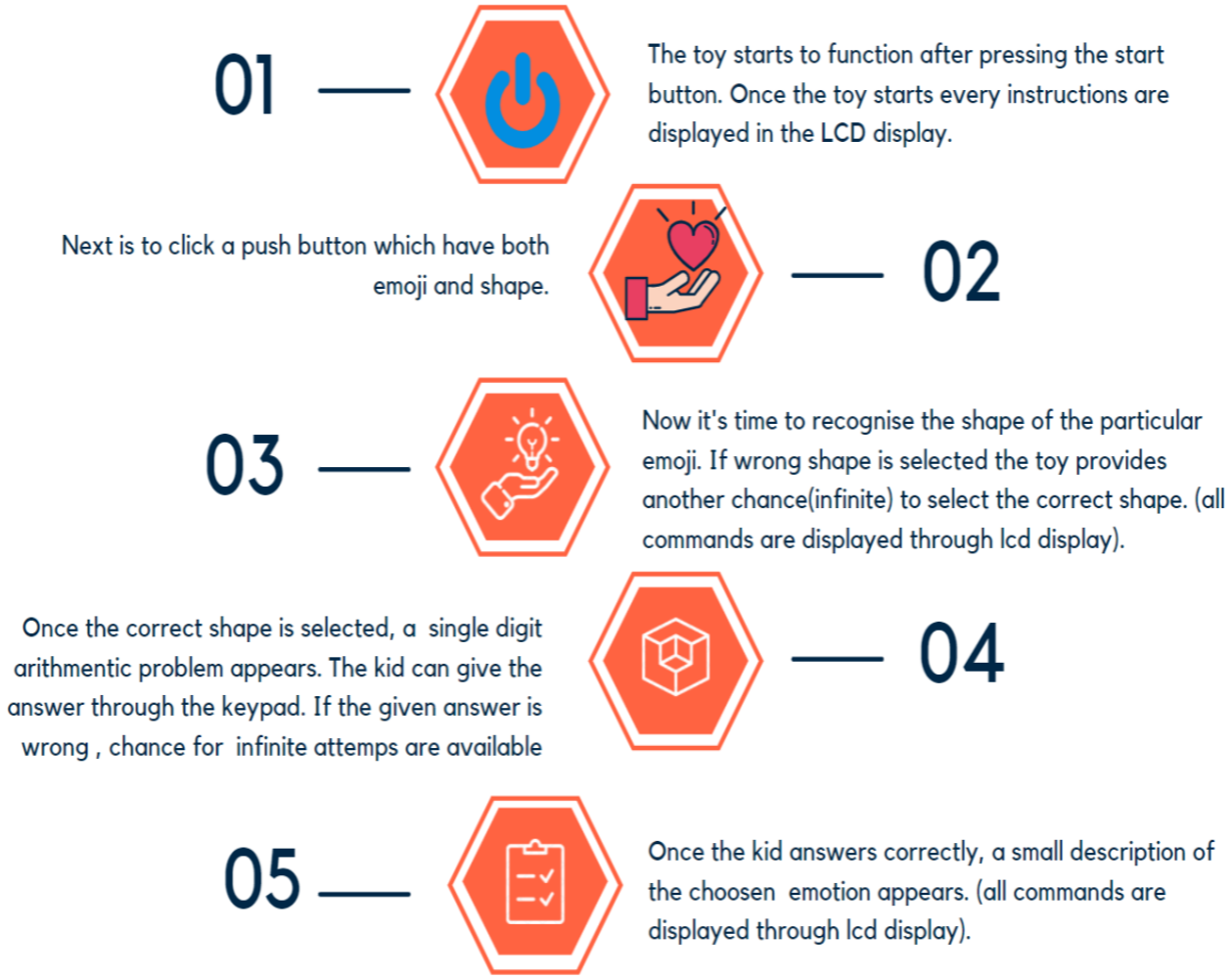


Figure 2. Process flow chart

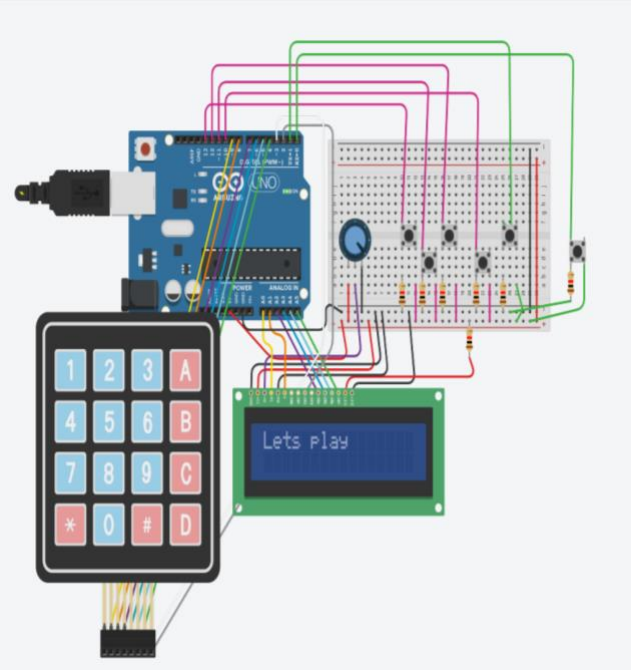


Figure 3. Circuit

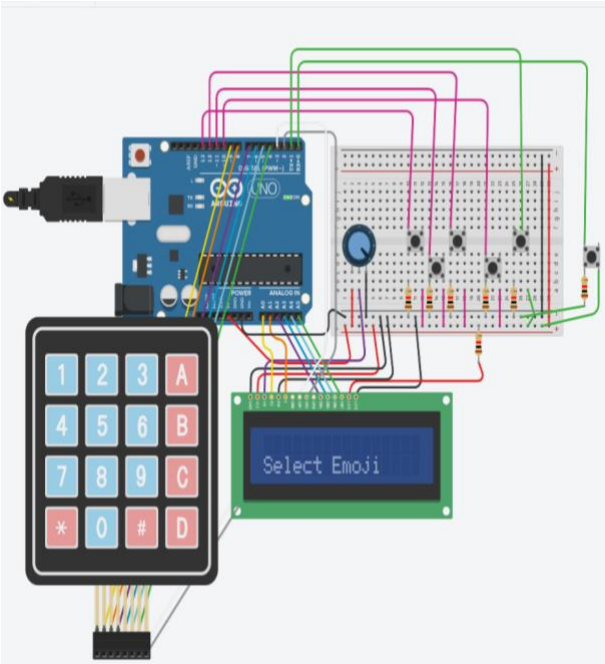


Figure 4. Circuit

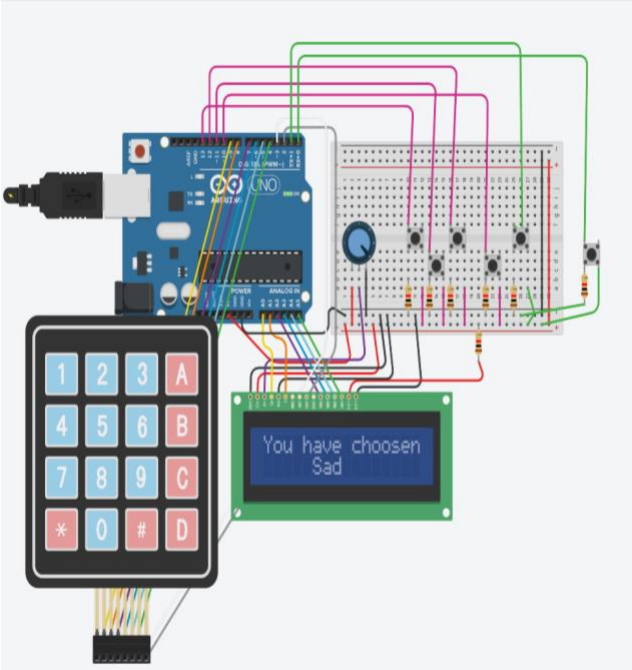


Figure 5. Circuit

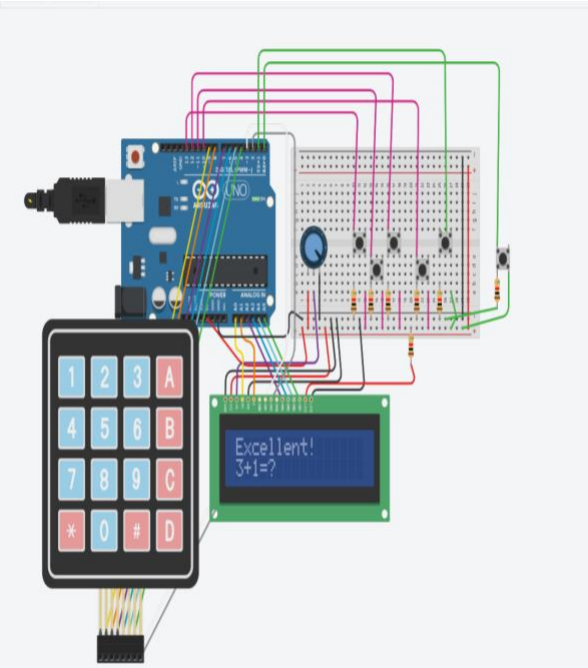


Figure 6. Circuit

There are different kinds of plays like Exploratory play, Cause and effect play, Physical play, Pretend play, Toy play, and constructive play. All these can make autistic kids engage themselves. Among these, toy play and constructive play are implemented in this project.

Table 1: Types of play and benefits.

TYPES OF PLAY	DESCRIPTION	SKILLS GAINED
Toy play	Playing in the way they were designed.	Develop thinking ability.
Constructive play	Playing to achieve a goal.	Builds a steady concentration

IMPLEMENTATION:

Play is important for a child's development. When it comes to ASD kids the response is varied from one to another. When a toy is given to an autistic teen the way they play is entirely different from a normal kid. Mostly they prefer to play alone but some may require help, some like to line up the given toys or move the toy forward and backward repeatedly. Being a spectrum disorder, when a toy is designed it is not sure all the autistic kids will enjoy playing with it. Also, there is no assurance that the kid will play with the toy in the exact way it is designed.

The possibilities that the "WHY THIS FACE" toy will attract the autistic kids at first sight are:

- Attractive colors.
- Different Geometrical shapes.
- Push-button feature (touch sensory).
- Emoji.

While playing with the toy "WHY THIS FACE", all the commands will be displayed on the LCD display. Either the autistic kid must be able to read or the parents or teachers must guide them to complete the game. Not all autistic kids have difficulty in reading, 3-10 is the age where we can guess their reading ability but with that, it is not good to make a judgment. So, the purpose of the toy is not fulfilled if the autistic kid plays alone with the toy without reading ability. In such cases, the help of parents or teachers is highly required.

The design is implemented in Arduino UNO because of the availability of online simulators. The same design can be implemented both in Arduino Nano and Arduino Due. More features can be done in Arduino Nano and Arduino Due when compared to Arduino UNO.

RESUTLS AND EVALUATION:

Play is a foundation to learn, so playtime is a learning time. Especially in the life of an autistic kid, play is required for learning, gaining proper attention, eye contact, and communication. There is a good demand for a new variety of toys that are designed for autistic kids. Some parents of autistic kids feel not to break the routine of the kid by introducing new toys. But some others are in search of new toys that can improve the abilities of the kid. The toy "WHY THIS FACE", makes the children be aware of different emotions and shapes. Learning about emotion could bring good changes in the self-behavior and social behavior of the kid. Other than emotion and shape recognition, the expected results are:

- **COGNITIVE SKILLS**- The skills on Problem-solving, thinking, reading, remembering, giving reason or a response, and paying attention.
  The toy is designed by focusing on all the above-mentioned cognitive skills. The whole game needs strong attention and thinking ability to complete the task. Some autistic kids who have an interest in mathematics will have problem-solving skills. A small arithmetic problem is included to kindle the interest of such kids to play with the "WHY THIS FACE" toy.

- **COMMUNICATION SKILLS**- Parents play a crucial role in encouraging autistic kids to speak. No toy can benefit the kid more than the parents do. Every toy will become more efficient once parents or teachers involve and play with the child. To promote interaction, parents can ask the child to do all the facial expressions that are present in the toy [8]. Teaching all the words and sounds (voice modulation) that are related to the particular emotion will make the child remember the emotions in an accurate way. Hence, interacting in a friendly manner and praising them will nurture the child's self-confidence [9].

FUTURE WORK:

Nowadays voice assistants have become a part of life for every individual. If an autistic kid has difficulty in reading, then the designed toy may not be helpful for the kid. If the toy is integrated with a voice assistant feature it will be beneficial for many autistic kids irrespective of its limitations. As of now, the keypad is used as an input unit. If mike is used as an input unit, the toy will become an interactive toy which will improve the communication skill of the autistic kid.

A microcontroller toy is designed with an LCD display. This toy helps autistic kids to learn emotions, shapes, and math through the LCD display. The future work of the project is to insert a microphone instead of an LCD display. Most of the autistic kids have a monotone that means they can't express what they are feeling through their voice. Some of them don't have control over their voice for example, speaking loud in a place where they are not supposed to. The microphone inserted in the toy reads the hints after completion of the game in the respective ways. For example, if the child chooses the happy emotion and completes the game, it reads the hint in a happy way. This can help the autistic kids to show variation in their voice and helps to overcome monotone.

CONCLUSION:

Today, every child is interested in intelligent technological Frameworks. Consequently, the new generation will be more enthusiastic about using such tools. As an extension of such a trend, a microcontroller-based toy had been designed. The Study has clearly proven that the microcontroller-based toy will surely make the various degrees of ASD Children understand the facial expressions, shapes of different objects, and math skills. The result of understanding facial expressions will make ASD kids to detect human feelings at a particular moment without actually asking them. Basically, some children with autism are good at math. So, concentrating more on this will allow them to solve complex problems. It cannot assure that the developed toy is suitable only for a particular age group. This toy is suitable for almost all the age categories who have the ability to read and understand commands executed by the LCD display. On the technical aspects, two more modifications are compelled in the present toy to make it more user-friendly. Present toy consists of only four push buttons out of which 2 exhibit shape along with emotion and the other two exhibit only shapes. The game will be more interesting if the number of push buttons are increased. Secondly, If the kid recognizes the shape correctly a single digit arithmetic question is asked. In the present toy the same

question is asked repeatedly, because of this the kid may be bored. It would be better if multiple questions are asked. Autistic kids show exceptional talents in spite of having disabilities. Hence, "WHY THIS FACE" toy can improve their talents and abilities for a better future.

REFLECTIONS:

The aim of the project is to design a toy to satisfy the autistic kids.10% of autistic kids have rare and outstanding skills called savant skills. These skills include art, music, mathematical and calendar calculations, remembering maps, dates, places, etc. Mathematics is focused in the project to improve the math skills. Non-savants can also improve their math skills. Emotion is very important to human beings. Some of the autistic kids find it hard to feel the emotions, so they cannot show any emotions on their face (blank expression) and also fail to understand the emotions of other person. The main reason for choosing these three factors (emotion, shape and math) is to improve or stimulate their skills to differentiate objects and to make them understand their own emotion and emotion of other. There are very few toys which are based on savant skills, emotions and shapes. But this microcontroller (Arduino) based toy is embedded with these three factors in a single toy. The expected outcome of the toy is to recognize the emotions, geometrical shapes and also to improve the math skills of an autistic kid.

REFERENCES:

1. U. Qidwai, M. Shakir and O. B. Connor, "Robotic toys for autistic children: Innovative tools for teaching and treatment," 2013 7th IEEE GCC Conference and Exhibition (GCC), 2013, pp. 188-192, doi: 10.1109/IEEEGCC.2013.6705773.
2. Dawson, Geraldine, Andrew N. Meltzoff, Julie Osterling, Julie Rinaldi and Emma L. Brown. "Children with Autism Fail to Orient to Naturally Occurring Social Stimuli." *Journal of Autism and Developmental Disorders* 28 (1998): 479-485.
3. Qi, Yueer and Jia Xuan Han. "Rehabilitation Educational Design for Children with Autism Based on the Radial Basis Function Neural Network." *Journal of Healthcare Engineering* 2021 (2021): n. Pag.
4. Alkldi, Aiman. "A review of the effects of using social stories to promote behavior, communication, and social skills for students with autism spectrum disorders (ASD)." (2021).
5. Yi, Zhihui and Mark R. Dixon. "Developing and Enhancing Adherence to a Telehealth ABA Parent Training Curriculum for Caregivers of Children with Autism." (2020).
6. Santos, Patricia de Almeida, Daniela Bordini, Monica Scattolin, Graccielle Rodrigues da Cunha Asevedo, Sheila Cavalcante Caetano, Cristiane Silvestre Paula, Jacy Perissinoto and Ana Carina Tamanaha. "The Impact of the Implementation of the Picture Exchange Communication System - PECS on Understanding Instructions in Children with Autism Spectrum Disorders." *CoDAS* 33 2 (2021): e20200041 .
7. Seo, Jinsil Hwaryoung, Pavithra Aravindan, and Annie Sungkajun. "Toward Creative Engagement of Soft Haptic Toys with Children with Autism Spectrum Disorder." In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition*, pp. 75-79. 2017.
8. Schadenberg, Bob R., Dennis Reidsma, Dirk K. J. Heylen and Vanessa Evers. "Differences in Spontaneous Interactions of Autistic Children in an Interaction With an Adult and Humanoid Robot." *Frontiers in Robotics and AI* 7 (2020): n. Pag.

9. Davison, Daniel P., Frances M. Wijnen, Vicky Charisi, Jan van der Meij, Dennis Reidsma and Vanessa Evers. “Words of encouragement: how praise delivered by a social robot changes children’s mindset for learning.” *Journal on Multimodal User Interfaces* 15 (2021): 61-76.

CNC-based Bluetooth-operated Learning Aid for Neurodiverse Children

Abstract

The main objective of our team was to make an appealing learning assistant for kids who have neurodevelopmental conditions or impaired motor neuron abilities. Although many individuals with autism spectrum disorder today are able to speak, read, and live outside institutions, and some show a decrease in symptoms of the disorder by adulthood, for most of them it is difficult to work full-time or live independently. The common symptoms of such individuals are restricted social communication skills and repetitive sensory-motor behaviours. Our team surveyed some autistic care centres where the specialists said that even in the present age of digitally transforming world when it comes to the education of autistic children, a long-term effective output has not been observed and hence, it could not be predicted whether the kid is getting benefitted from the e-learning materials or not. Our vision was to make a device that will help such a child to learn writing through systematic repetition and stimulating audio-visual signals.

Acknowledgement

Our team would like to express our gratitude to SRM Institute of Science and Technology for the support and guidance . Our team would further express our gratitude to Mrs Nilanjana Rambothu, Founder and Director of Sunshine Autism Care, Kolkata, and consultant RCI holder in Special education (ASD), for the time, knowledge and constant encouragement she has lent us for making this project. We express our special thanks to Mr Shantanu Sinha, marketing consultant at TCS, for his genuine support and guidance in bringing the product to the market in the future.

Our team extends gratitude to Mrs Sampada Pachaury, Mr Krishna Vedula and Mr Aditya Bhatnagar for their diligent guidance and for their support during our research work with Indo Universal Collaboration for Engineering Education (IUCEE).

We used DigiKey Scheme-it, a free online schematic and diagramming tool, available at https://www.digikey.in/schemeit/home/ for the schematics provided in the paper. We used Inkscape v0.48.5, a free and open-source vector graphics editor primarily used for creating or editing vector graphics, for generating the g-codes. This was made possible by the MI Inkscape extension for GRBL firmware. From https://winder.github.io/ugs_website/ the controlling software for debugging and testing named “Universal Gcode Sender” was downloaded. A similar application for mobile was “G-Code2GRBL” and was downloaded from the Google play store. And most importantly, the GRBL firmware that was programmed into the microcontroller was downloaded from https://github.com/gnea/grbl/.

Content

Introduction

Autism is a term that is used to describe a particular group of people with specific neurodiverse conditions– conditions characterised by lack of ability to interact socially, communication problems and abnormal motor-neuron activity. Autistic Spectrum Disorder is observed in people around the world, irrespective of culture, background, race and ethnicity. "Spectrum" refers to the wide range and severity of symptoms shown by such individuals.

During a study period of 2009-2017, children most of the age from 3-17 were seen diagnosed with disabilities, which includes cerebral palsy, blindness, hyperactivity disorder, autism. Conditions are characterised by contrast in social interaction and communication. Over the study, it has been found that there are numerous causes. It can be due to genetic mutations, having an immediate family member who is autistic, metabolic imbalances, Exposure to heavy metals and environmental toxins, a history of viral infections, fatal exposure to the medications valproic or thalidomide. Subjects show snappy interhemispheric connections in the cerebral cortex.

Autistic kids might not get to the enlightening milestone like their fellow mates. They have difficulty sleeping, irregular food patterns and show signs of heightened anxiety. They often prefer a similar environment with a regular routine. They often show repetitive and restricted motor behaviour. The common motor deficit conditions seen in children with autism are hypotonia, which is characterised by poor muscle strength and disordered spinal reflexes, and motor apraxia, which is a defect in horizontal eye movement. Studies have also found deficits in overall fine motor gross motor development and locomotor skills for such children. These difficulties not only hamper their learning ability but also cause a great deal of anxiety to them.

Statistical data regarding the autistic population

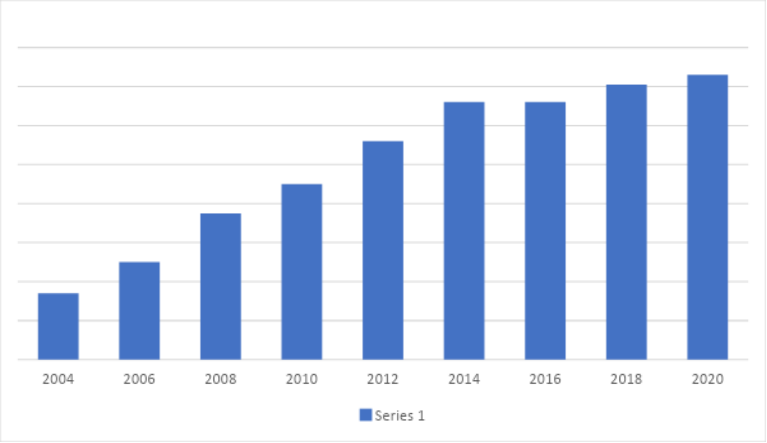


Fig. 1, Prevalence of Autism Increased by 10%, to 1 in 54 Children by Southwest Autism Research & Resource Center

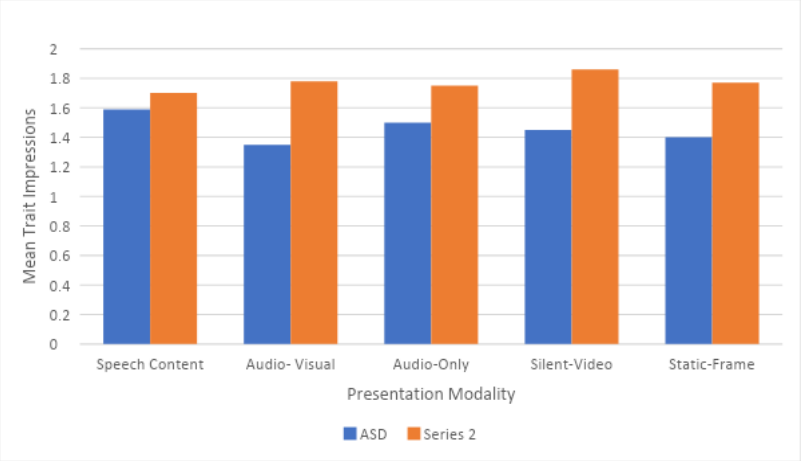


Fig. 2, Neurotypical Peers are Less Willing to Interact with Those with Autism based on Thin Slice Judgments

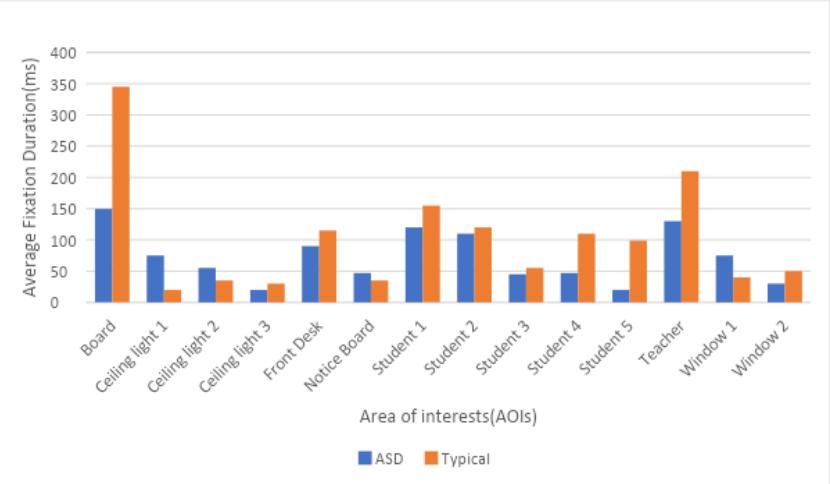


Fig. 3, Effect of a normal and regular classroom set up on the concentration and attentiveness of youngsters with autism spectrum disorder: an eye-tracking study

Background

The purpose of the present project is to create a link between play and physical therapy, resulting in therapy for such subjects who have writing problems from their very childhood–children who have difficulty distinguishing between 6 and 9, b and d, the alphabetical order, a step from our team to make the basics strong and solve the neurological problem in kids. From the research and surveys performed, it is understood that even in the present era of a digitally-transforming world, when it comes to e-learning platforms and persons with neurodevelopmental disabilities, a proper output is very difficult to ascertain. Given the plethora of application-based learning options, the child would still not receive physical help in actually writing what they have learnt. In special exams, such students would pronounce their answers and a helper would write for them.

Design and Specification

The aim of the project was to make the subject learn to write and correlate what they want to write and what their hand traces on paper by holding a robotic arm in the form of a mini CNC (Computer Numeric Control) machine. The device shall track the pattern of the letter and guide the user to move the hand in the right way to complete the pattern by interactive methods, which is basically the input given from the phone or computer in which the supporting application is installed. The application can be used easily by both the subject(person with a neurological disability) and their mentor. The principle of operation of the CNC machine is the movement of a structure about 3 degrees of freedom, namely the X, Y and Z axes, based on input fed through a computer. They are controlled by stepper motors which can be AC or DC operated. The operations and configurations of the motors like feed, speed, etc. are set with the help of coordinate-like codes.

Control and Power System

Microcontroller-ATMEGA328P

In today's world we have many controllers, so why ATMEGA328P?

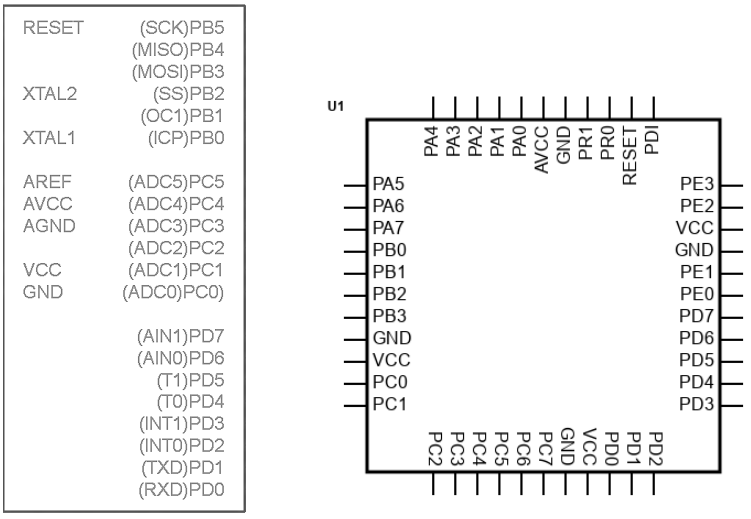
ATMEGA328P is one of the most popular because it is cost-effective with exciting features in it. And so due to these features a controller like ATMEGA328P is used to develop Arduino boards. Features like, with a variation on power saving modes it can be used on mobile embedded systems, it has the RISC architecture, as a result of it the program executes quickly, has a timer, the watchdog timer to reset anytime under error on the system with just a human interface and so on. RISC is nothing but a reduced instruction set computer which is a type of architecture that uses a hugely optimised set of instructions than what is found in other architectures. ATMEGA is quite the same as any other microcontrollers in the market. And yes it is well known that there should be a set of instructions in the form of programs provided by us at the instant, without the program nothing is executing the way it should be. As already discussed, there should be a program present in the ATMEGA328 flash memory. This whole execution is done by the controller after the code is dumped and provides an appropriate response. This process is explained in the following steps,

- First step is listing out all the functions that the controller should execute. Functions in programming language can be run at IDE, now here we can use the Arduino IDE too to be discussed later. After the code we need to compile to look for errors.
- The IDE converts the compiled program to the HEX file. The HEX file constitutes the machine code that is executed or written in the controller flash memory.
- Choose the programming device (usually SPI programmer made for AVR controllers) which establishes communication between PC and ATMEGA328P. One can also program ATMEGA328P using the ARDUINO UNO board.
- After the execution all that is needed to do is, disconnecting the programmer, and connecting with the appropriate peripherals for the controller and running the system.

Features

1. The CPU used is an 8-bit AVR with a speed of 1MBPS for 1MHz .

2. There are a total 28 pins present.
3. Operating voltage ranges from +1.8 V to +5.5V.
4. There are 23 programmable I/O lines. For programming this controller, there are three types of communication interface, Master/Slave SPI Serial Interface(17,18,19 PINS).
5. Programmable Serial USART. This controller can be programmed using pins. Peripheral devices such as sensors, memory devices and servos are connected with the help of Two-wire Serial Interface pins.
6. It has ADC Module Of 6 channels, 10-bit resolution ADC. Timer module of two 8-bit counters with Separate Prescaler and compare mode. One 16-bit counter with Separate Prescaler,compare mode and capture mode.
7. There are a total of 1 analog comparator with 6 PWM channels.
8. External Oscillator with 0-4MHz in 1.8V to 5.5V, 0-10MHz in 2.7V to 5.5V, 0-20MHz in 4.5V to 5.5V and an internal oscillator with 8MHz Calibrated Internal Oscillator.
9. Program Memory Type is of flash memory with 32 kilobytes. RAM is 2kbytes Internal SRAM with an EEPROM of 1k bytes.
10. Programmable Watchdog Timer with Separate On-chip oscillator with program lock.
11. 6 major power save modules, Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby.
12. The operating temperature is -40°C to +105°C.



(a) (b)

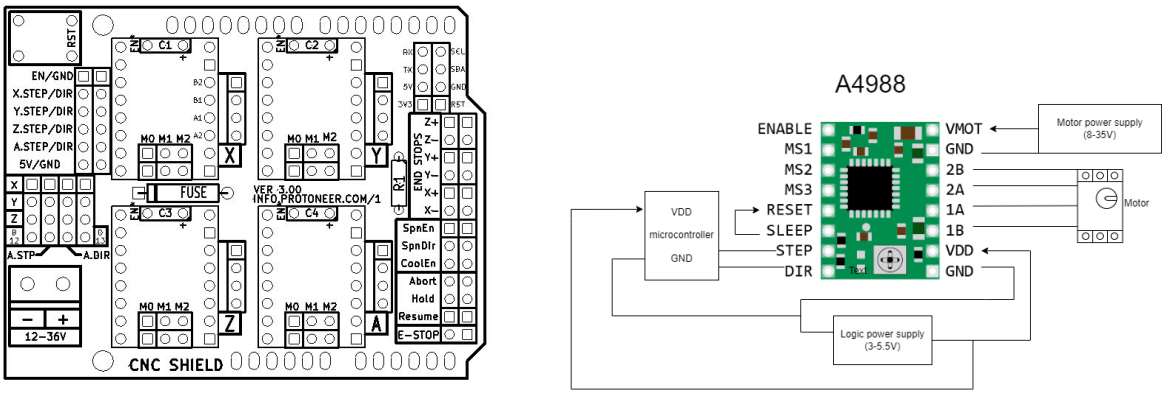
Fig. 4, (a) Logical block of the ATMEGA328P processor; (b) ATMEGA328P pin configuration

CNC V3 shield

The CNC V3 shield is made particularly for Arduino based controllers which allows us to build such machines which are used to engrave, like a mini CNC, A 3D printer and so on. It just needs to be fitted on the top of the Arduino with no external wiring required. There are 4 slots for stepper motor drivers in the shield. It supports an input voltage of 12V to 36V. If an input of more than 36V is applied, it will damage the motor drivers.

A4988 Stepper motor drivers

The stepper motor driver, A4988, is a microstepping motor driver fully compatible with the CNC V3 shield. The bipolar stepper motors can be controlled in full, half, quarter, eighth and sixteenth step modes with the help of the drivers. They receive PWM signals from the Arduino and feed the required power according to the motors. The sixteenth step mode is used by inserting 3 jumper caps to cover M0, M1, M2 to improve the precision of the drawing.



(a) (b)

Fig. 5, Pin-configuration of (a) CNC V3 shield; (b) stepper motor driver A4988

NEMA 17 Stepper motor

A stepper motor rotates by taking one step at a time, with the energy input given to it by DC and thereby, converts electrical energy into mechanical shaft rotation.

These motors are a vital part of the movement of the x and y axes in analog step values. “NEMA” is the measurement standard provided by the National Electrical Manufacturers Association. NEMA 17 stepper motors are used for this project. A heavier model was used because it could provide large enough torque to rotate the long and heavy metal shaft. For refined models with shorter axes lengths, smaller motors would be sufficient.

SG90 Microservo

Servo motor can be defined as a motor with a specific part, suitable for a closed-loop control system. Servo motors are used in robotics, CNC machining applications and so on. There is the control signal which is the input, it can be analog or digital, representing the final position for the shaft. An encoder serves the role of a sensor with speed and position.

The project deals with the principle of CNC machines and in such cases, nothing is better than the stepper motor to convert instructions into actions. Here the action is depicted as the up and down of the pen for writing and moving to the next consecutive letter.

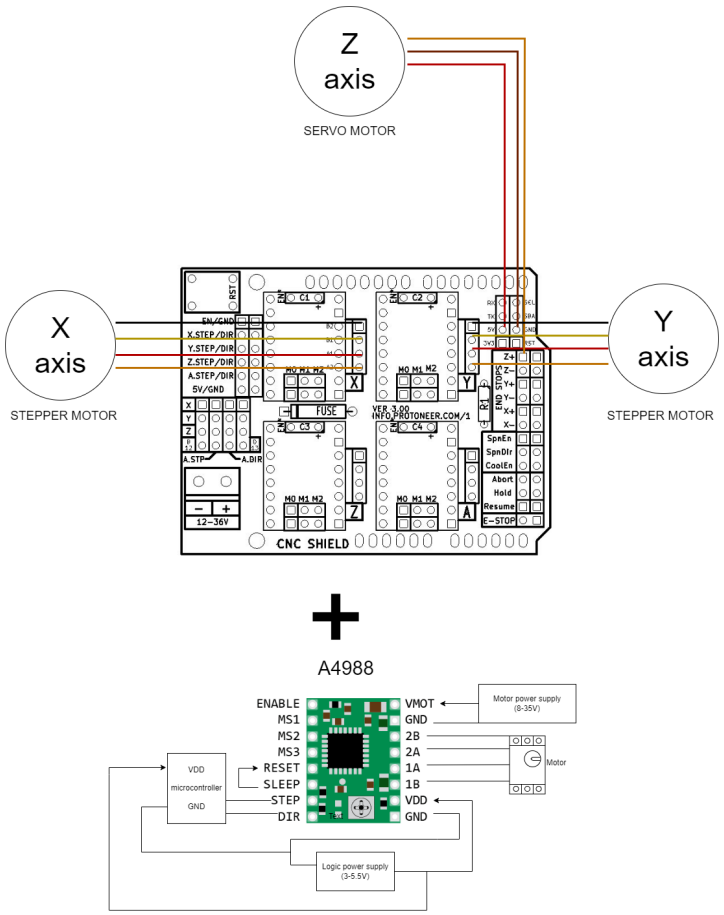


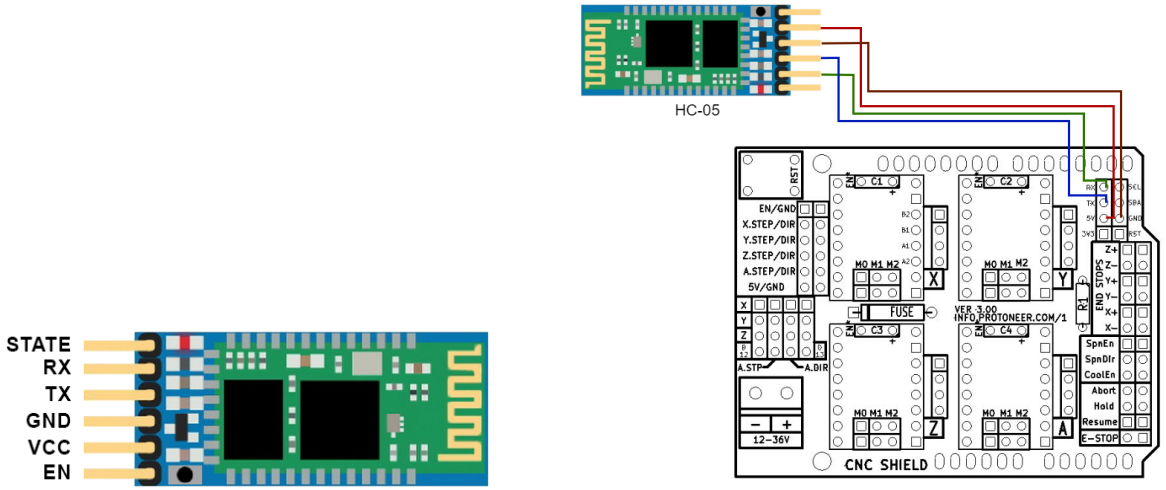
Fig. 6, Configuration of the motors and respective motor drivers

HC-05 Bluetooth module

Bluetooth HC-05 can be defined as serial communication to communicate with the world of electronics. Connecting to devices with short-range to exchange files. Just the way files are going to get exchanged in the project with a frequency band of 2,4 GHz. HC-05 has a transfer rate of 1Mbps within a range of 10 meters. Input power voltage is 4-6V with a baud rate of 9600, 19200, 38400, 57600, as selected by the user.

The pins of our interest are described below:

1. VCC - Pin which is connected to +5V power supply
2. Ground - Pin which is connected to the ground of the system
3. Tx (Transmitter) - Pin which transfers the wirelessly received data by UART method to the microcontroller
4. Rx (Receiver) - Pin which receives data to be broadcast from the microcontroller.



(a) (b)

Fig. 7, (a) HC-05 Bluetooth module; (b) Connecting the Bluetooth module with the controller

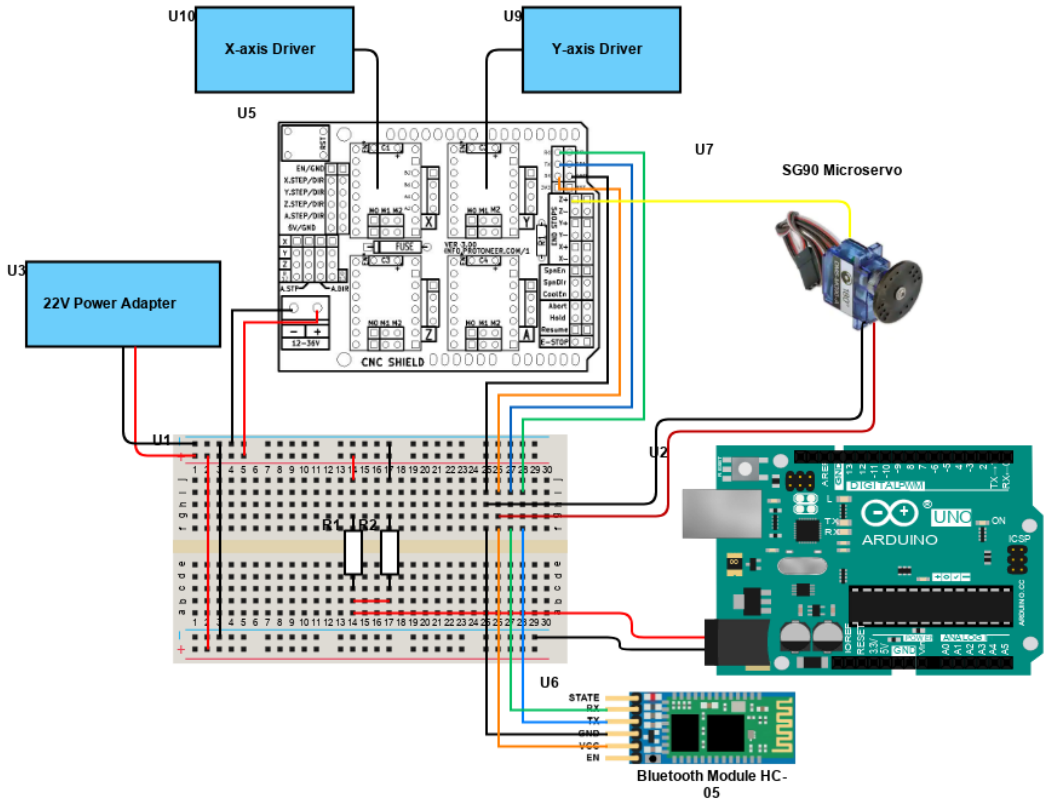


Fig. 8, Physical connections for the entire apparatus. It is to be noted that the CNC V3 shield is inserted onto the Arduino UNO board

GRBL control code

The shield is GRBL compatible. GRBL is an open-source firmware that is programmed into the Arduino and enables the g-code to be understood by the processor. For the intended purpose, the shield, before running with the stepper motors, needed to have the GRBL firmware installed in the Arduino's memory. In simple terms , the GRBL uses the motion as the output through the motors via arduino and uses the G-code as an input to run through it.

G-code

G-code simply means “Geometric Code” that can be defined as the language of programming for a Computer Numerical Control machine, a CNC machine. This language is used to set the instruction to the machine to get operated. The speed and the path of the machine can be followed by the GRBL code. From 3D or 2D printing to manufacturing G-code runs the instruction layers formise a precise geometric shape in all dimensions.

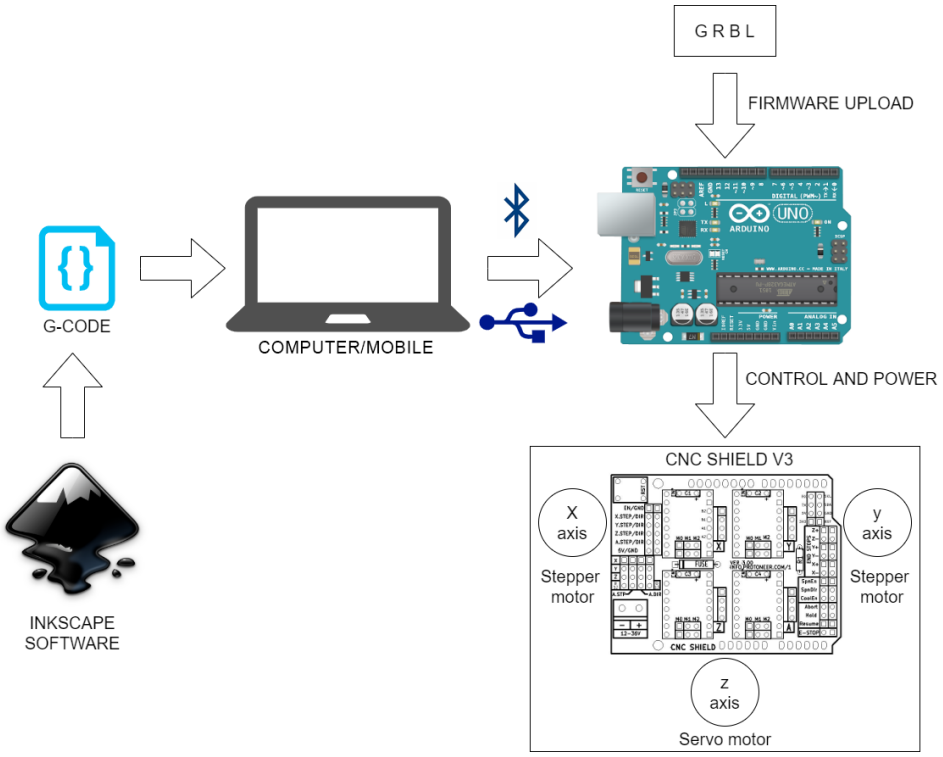


Fig. 9, How the g-code containing information of coordinates is transferred in the system

Application software

The hardware and its functioning will be controlled by an application running in the mobile phones. It has been assumed that during a teacher-student interaction the hardware is held by the individual with autism/cognitive disability while the mobile application is run by the teacher. A connection will be established over Bluetooth between the app and the actual hardware device. The mobile phone should have the capability to establish Bluetooth connections to use the app.

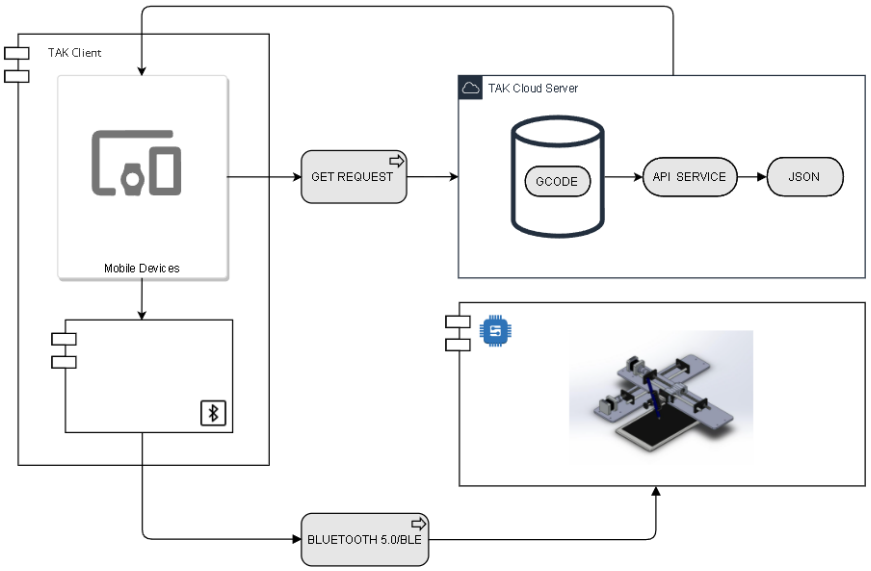


Fig. 10, System architecture supporting the application

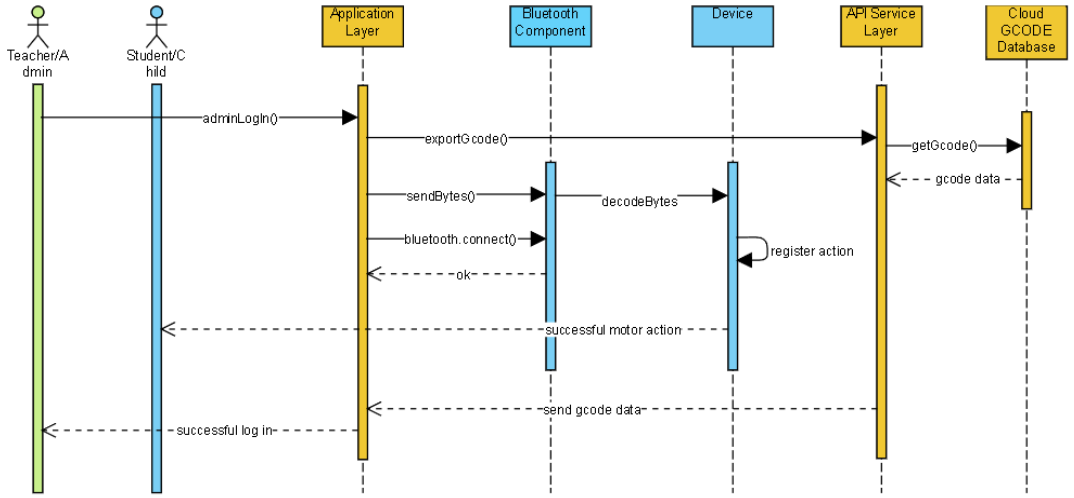


Fig. 11, Sequence Diagram for the API

Working algorithm, simulation

The official Google Developers site writes -

"To create a connection between two devices, you must implement both the server-side and client-side mechanisms because one device must open a server socket, and the other one must initiate the connection using the server device's MAC address. The server device and the client device each obtain the required Bluetooth socket in different ways. The server receives socket information when an incoming connection is accepted. The client provides socket information when it opens an RFCOMM channel to the server.

The server and client are considered connected to each other when they each have a connected BluetoothSocket on the same RFCOMM channel. At this point, each device can obtain input and output streams, and data transfer can begin"

The hardware Bluetooth device was first paired with the device. The mobile application then scanned through all paired devices to display the paired devices. The user needs to choose the hardware Bluetooth device from them. In the instrument, the hardware Bluetooth device is on the client-side and client-side mechanisms were pre-built. So only the server-side mechanisms need to be implemented,i.e, the mobile application.

Once the Bluetooth connection was established, the next task was to exchange data. In this scenario the exchange of data should be one-way, i.e, instruction signals should be sent from the device running the mobile application to the hardware Bluetooth device.

The hardware part of the product understands only G-code(just like a computer understands only machine language, so whatever high-level programs are written are ultimately converted to sequences 0s and 1s). So the job of the mobile application is to send the G-code corresponding to the relevant action.

The application will have sections like Alphabets, Digits, short sentences, almost everything you and I have been taught when we first went to school. Suppose a kid was learning about the alphabets and the teacher wanted the student to learn “A”. The user interface has buttons corresponding to all the alphabets. When the button displaying “A” was clicked, the corresponding g-code was sent to the hardware Bluetooth device. The Bluetooth accepts the data, decrypts it and a signal is sent to the hardware to trace the alphabet “A”.

The frontend interface will be intuitive and self-explanatory, so that it becomes easy to use and navigate. The home page of the application will be divided into well demarcated sections like alphabets, numbers, etc. Each section will have contents relevant to that topic. We will be using audio visual techniques to capture the attention of the audience. It is said one should pronounce what we read, because it helps in better retention. Thus pre-recorded voices reading aloud a text or an alphabet will be used for better engagement.

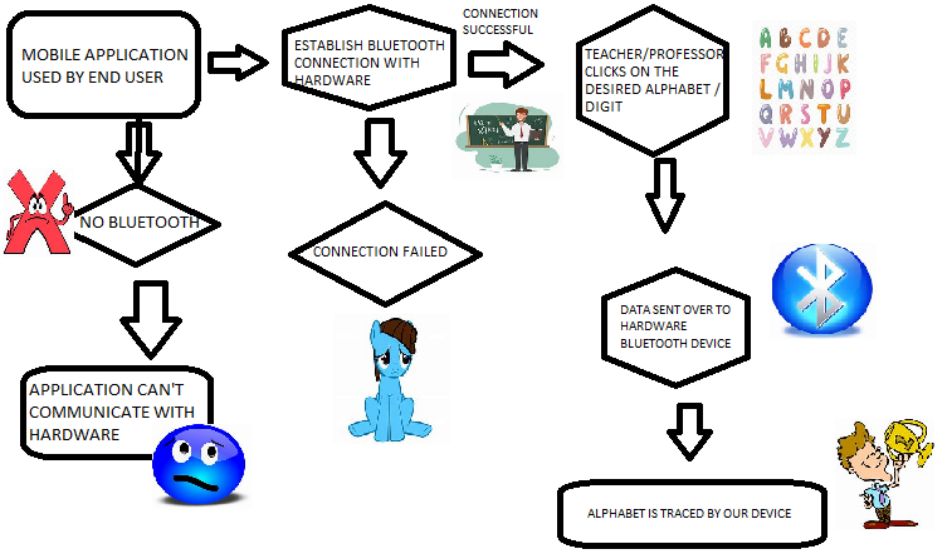


Fig. 12, Flowchart describing the functioning of the application

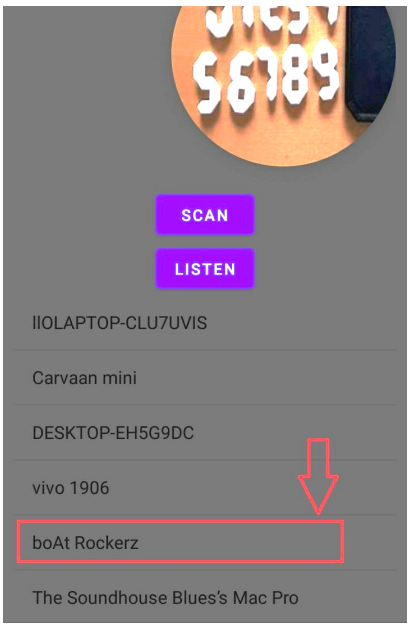


Fig. 13, All paired devices are displayed in the app being developed. Suppose a particular device should be connected, the relevant name must be clicked

Conclusion

While this is just a prototypic model of the software, there are a lot many improvements that can be added in course of time:

- A Local Area Network can be used for connecting the devices and exchanging data. This is more stable than Bluetooth, and also provides more flexibility. It is possible to control more devices from a single running instance of our application, unlike Bluetooth which allows one-to-one and not multiport connection.
- Speech recognition APIs like Google Translate can be used that allow users to write what they speak.
- The app can be made available in regional languages as well.

Implementation

For the apparatus, a wooden plank was used each for supporting the stepper motors for the x and y axes, along with the metallic shafts and gliders. The plank for the y-axis which held that of the x-axis was made slightly bigger in length to accommodate the microcontroller board and battery that would be fitted later on. Otherwise, both the axes looked similar. Each consisted of a NEMA 17 stepper motor fitted with a flexible coupling, THSL Lead Screw, EN31 Steel rod, linear motion ball bearing, linear bearing bush, radial bearings, block to hold the rod as well as bearings and the axial base. These two axes played a major role in the movement of the main module that is the pen stand. As for the z-axis which consists of a pen fitted to a vertically-moveable wooden block, it had two discrete states characterised by the position of the holder block that either stays down as the pen touches the paper or is lifted up such that there is no contact between the pen and the paper. The pen stand worked on the principle of linear motion provided by the motor and moved with the pen module attached to

it. The stand was connected with the x-axis plank and consisted of a micro servo and moveable supportive parts for the rotatory motion of the pen. While the rotation of the motors for the x and y axes was analog–controlled by PWM signals from the respective motor driver (A4988) fitted to a CNC V3 shield atop the Arduino microcontroller board, the binary state of the SG-90 micro servo of the z-axis was controlled by a signal from the Z+ pin of the V3. As the Arduino UNO requires 5-12 volts DC and the CNC V3 requires up to 21 volts to supply the required power to the motors, we used a voltage divider setup using two 1 ohm-½ watt resistors organised on a breadboard. A 22V power adapter supplied regulated DC to the setup, from which 11V was fed to the Arduino UNO board from the node of the divided voltage while the original supply voltage was fed to the shield separately.

After receiving the feed execution command from the GRBL controller application through Bluetooth, the servo system drives each coordinate axis (feed mechanism) for the machine to move accurately in strict accordance with the command necessities and completes the process of the work. Throughout the displacement process, the detection feedback device quickly fed back the measured displacement numerical to the numerical control device for comparison with the command requirement, and then sent the compensation execution command to the servo system at rapid speed unless the measured value was consistent with the required command. There was a warning system to give safety reminders during various operations. In the method of axis displacement, if overtravel happened, the limiting device would send some over travel signals to the controller. Meanwhile, the numerical control system sent alarm signals through the execution and would send stop execution commands to the feed servo system to implement over travel protection. The writing machine works on this principle with the help of g-code as well as the direction of axes.

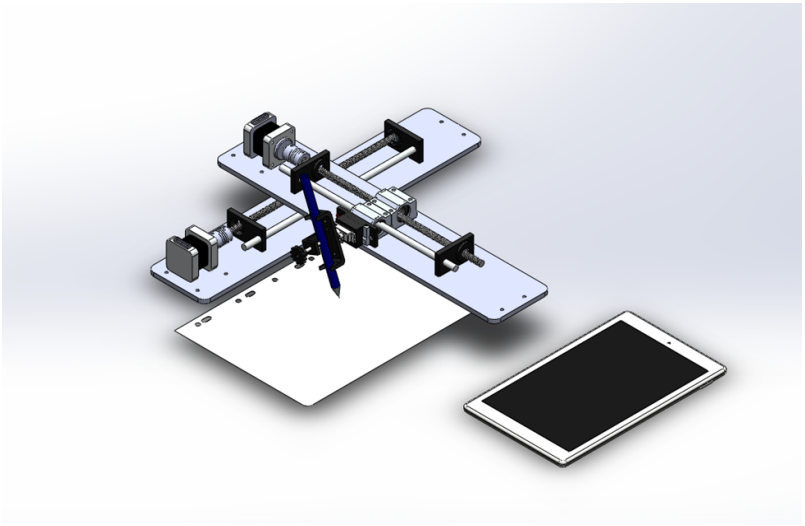


Fig. 14, Perspective view of the model

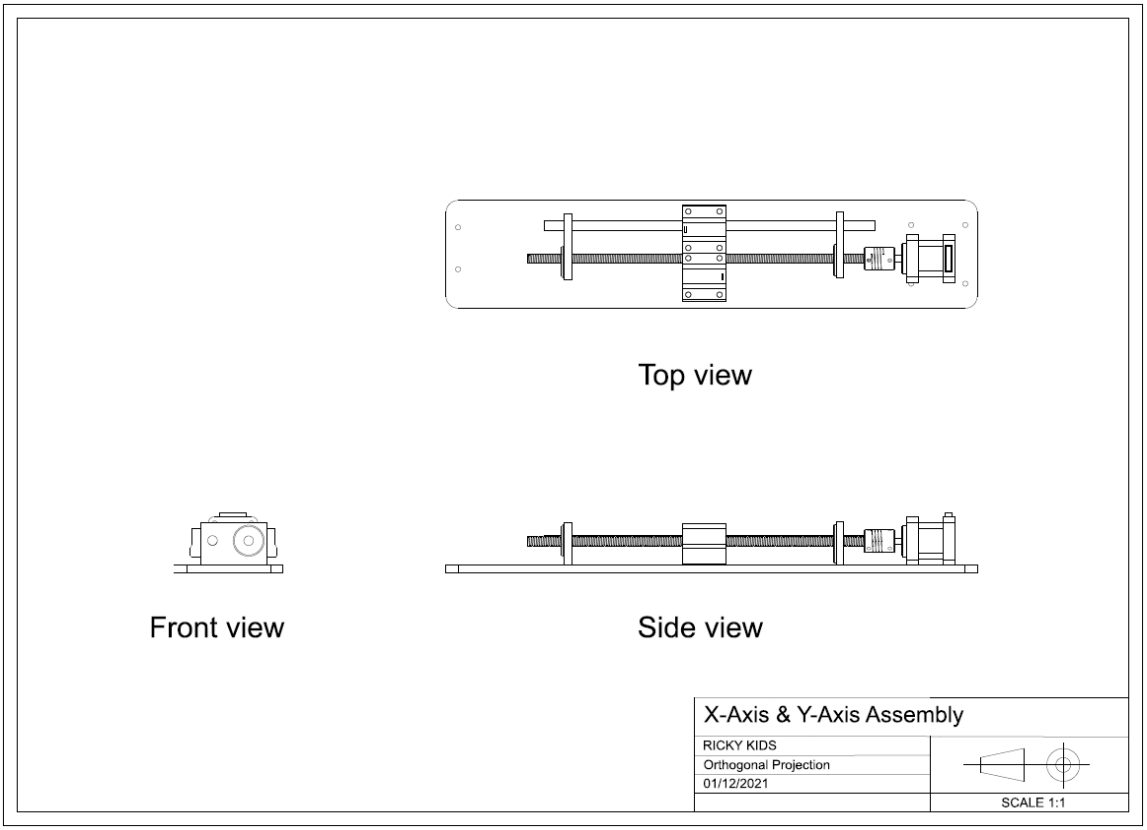


Fig. 15, Two Dimensional Representation of the Model

Result and Evaluation

The 2-axis setup was working as intended. When a g-code was fed by the "G-Code2GRBL" application in mobile via Bluetooth or by "Universal Gcode Sender" in computer via USB to the microcontroller, the x and y-axis stepper motors rotated just as much to produce the required linear motion in the respective glider. The resolution of the drawing can be scaled up or down by placing jumpers over the appropriate pair of pins underneath the motor driver modules on the CNC V3 shield. While scaling down made the drawing smaller, it benefitted the speed with which it was drawn.

The intention of using this device would be to learn the way the hand moves while writing a specific letter as well as to be able to write words, sentences or paragraphs for people who have motor neuron deficits. The application would be presented in a very appealing manner with audio-visual cues according to inputs from experts that will make the neurodiverse child interested to learn. In institutions and care centres, the application would be linked to tablets, PCs and projectors through WLAN that would allow a single mentor or teacher to cater to multiple subjects.

The present version of the project has a few limitations. It is quite bulky and difficult to carry, even though it is planned to be modular, that is, the different parts can be dismantled and fitted with ease. Writing a single letter would not require such long shafts and heavy motors. Another problem would surface when we try to use the application in one device to control multiple writing machines since Bluetooth provides wireless point-to-point

connectivity while we would require a multipoint connection. Apart from that, Bluetooth works on a 2.4 GHz radio band which is an unlicensed frequency used by various wireless devices, therefore, making it susceptible to heavy interference and has a higher chance of corrupting the data. It is also notorious for its range limitations (depending on Bluetooth versions). Those devices that are powered by a battery have an even low range thus making it slightly inconvenient to the operator.

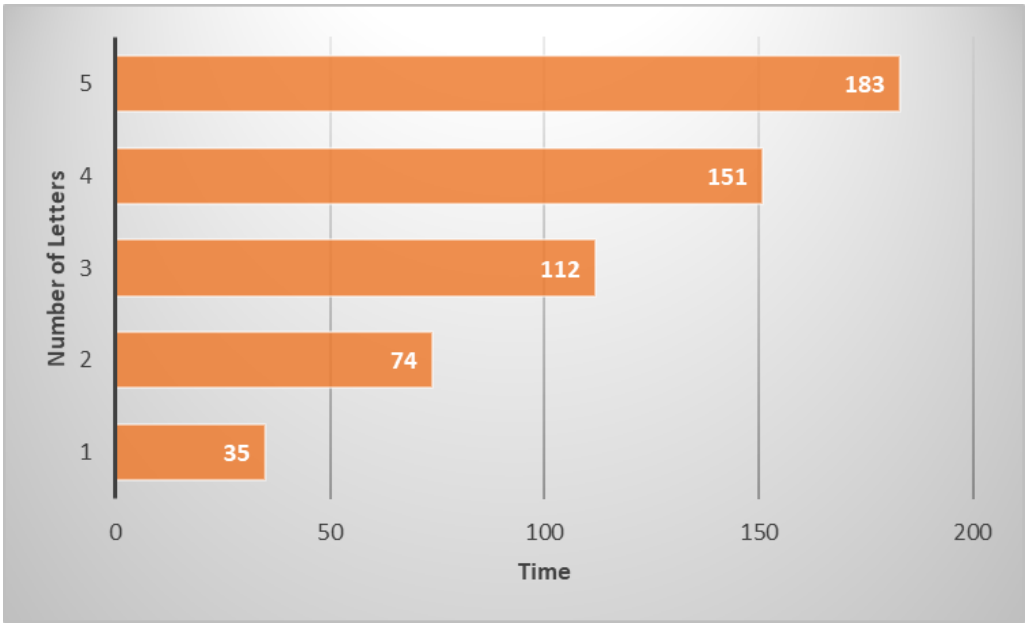


Fig. 16, Graphically Denoted No.of Letters v/s Time by the machine

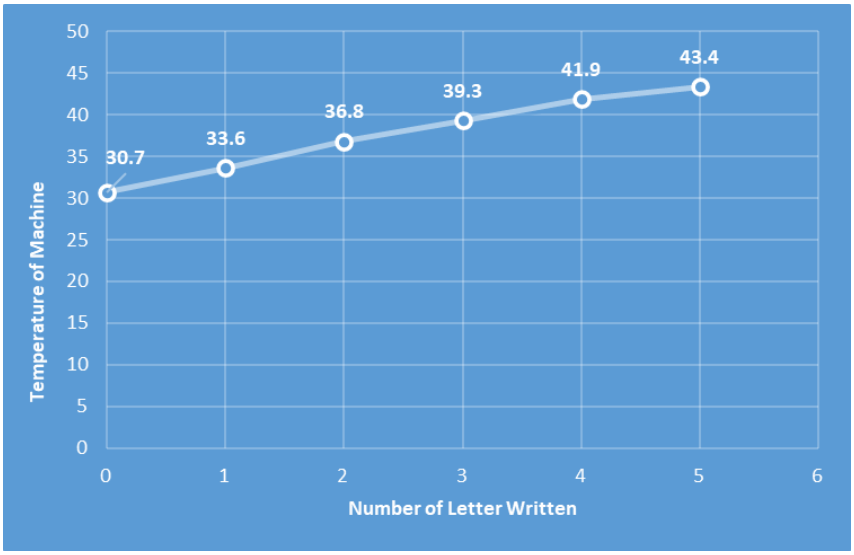


Fig. 17, Graphically Denoted No.of Letters v/s Temperature of the machine in (Celsius)

Future Directions

In the future, it will be extended in such a way that every single person with neurological problems can be benefitted from our machine. And when we expand and manufacture each

and every single component that we are using in our project then we are able to give it in a minimal amount. And when it comes to upgrading this machine, it will be made much easier and more comfortable to be used and for carrying with the users as a portable device, and its efficiency will be enhanced by giving the software updates regularly and troubleshooting the bugs if it is reported by the users with immediate support. The connectivity with the hardware will be more advanced with LTE/WiFi connections. The device will be made compact and easily portable by using small motors, shafts, drivers and custom PCBs for the electronics.

Conclusion

The product could be used as study material as well as a toy for an autistic child, or for persons with impairment in their motor nerves. The automated gliders acting together as a robotic arm would help them to write what they wanted to write by specifying the input simply in the supporting application. In contrast to this topic Make neuroscience to create an impact and make learning easy for every possible human being suffering from neurological problems. This machine is made with a budgeted amount, but as creatives we cannot stop ourselves from exploring and reaching out with the latest drivers, motors and other hardware materials. It is made in such a way to utilise and to make it 100% efficient in this design, in a neat and clean manner. And as it is integrated with the learning application platform it is much easier to use and operate our robotic arm and as it is preloaded with the contents it is much easier for the users to learn from it.

Reflections

Living in the 21st century where children are born and brought up in the age of technologies and the digital world, we must deal with such challenging problems that impair a child's ability to learn. Often people do have e-learning software but again, we fail to realise how it really affects the kids and also helps the kid to grow and evolve. Growth is a very essential part of life, and growing with just a digital interface is not what our duty is.To make it efficient and worth the time and money they have spent on their development. Through the surveys and the webinar, it has been found that the machine or an artificial hand has scope for neural science in future. It is known that not only autistic kids but many people face neurological problems where if they want to write they cannot do so but our machine, the robotic hand will automatically create an impact on the disabled person. The combination of the concepts of Mechatronic and neuroscience will create a huge impact and make learning very easy for every person suffering from neurological problems. Not only that, it will change the vision of a CNC handwriting machine which is only made for the purpose to print, but here many dots are connected together towards an environmental step in curing the neurological problem of an autistic kid , who has a writing problem. A highly recommended survey was made throughout the survey with a positive response for this TLM (Teaching Learning Material). Many questions were answered positively by the audience regarding the final product.

References

1. Catherine Lord, Mayada Elsabbagh, Gillian Baird, Jeremy Veenstra-Vanderweele. (2018). Autism spectrum disorder. *The Lancet*, 392(10146), 508-512.
2. Boria S, Fabbri-Destro M, Cattaneo L, Sparaci L, Sinigaglia C, Santelli E, et al. (2009). Intention Understanding in Autism. *PLoS ONE* 4(5): e5596.
3. Beecham, James & Seneff, Stephanie. (2016). Is there a link between autism and glyphosate-formulated herbicides?. *Journal of Autism*.
4. Michael L. Matson, Johnny L. Matson, Jennifer S. Beighley. (2011). Comorbidity of physical and motor problems in children with autism. *Research in Developmental Disabilities*, 32(6), 2304-2308.
5. Pan, C.-Y., Tsai, C.-L., & Chu, C.-H. (2009). Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. *Journal of Autism and Developmental Disorders*, 39, 1694–1705.
6. Lingam R, Simmons A, Andrews N, et al. (2003). Prevalence of autism and parentally reported triggers in a north east London population. *Archives of Disease in Childhood*.
7. Scott K. (2020, April 3). *Prevalence of Autism Increases by 10%, to 1 in 54 Children*. Southwest Autism Research & Resource Center(SARRC). Retrieved February 3, 2022, from https://autismcenter.org/prevalence-autism-increases-10-1-54-children
8. Sasson, N., Faso, D., Nugent, J. *et al.* (2017). Neurotypical Peers are Less Willing to Interact with Those with Autism based on Thin Slice Judgments. *Sci Rep* 7, 40700.
9. Banire, B., Al Thani, D., Qaraqe, M. *et al.* (2021). Impact of mainstream classroom setting on attention of children with autism spectrum disorder: an eye-tracking study. *Univ Access Inf Soc* 20, 785–795.
10. *Autism and Developmental Disabilities Monitoring (ADDM) Network*. Centers for Disease Control and Prevention(CDC). Retrieved February 3, 2022, from https://www.cdc.gov/ncbddd/autism/addm.html
11. ATMega328P Microcontroller Pinout, Pin Configuration, Features & Datasheet (components101.com)
12. *Arduino UNO + Arduino CNC Shield V3.0+A4988 Installation Guide*. (2017, April 7). https://osoyoo.com/2017/04/07/arduino-uno-cnc-shield-v3-0-a4988/
13. *BluetoothSocket*. (2021, June 9). Android Developers. Retrieved January 27, 2022, from https://developer.android.com/reference/android/bluetooth/BluetoothSocket
14. *Transfer Bluetooth data*. (2021, October 27). Android Developers. Retrieved January 27, 2022, from https://developer.android.com/guide/topics/connectivity/bluetooth/transfer-data

An Evolutionary Approach to Autistic Speech Therapy

Toys for Autism Kids

Authors

Poornaditya Mishra
(Automation & Robotics Department)
Haripriya Jagadeesh
(Automation & Robotics Department)
Kole Laxmi Shashikant
(Automation & Robotics Department)
Dr. Sujata S. Kotabagi
(School of Electronics & Communication)

KLE Technological University
Hubballi, India

ABSTRACT

Autism is one of the most widespread mental disorders. It can easily be detected among children at a very early age and relevant treatment can be begun soon to treat the affected children. Due to its easy detection and a large number of cases among children, toys have been employed on a large scale to tackle the problem. In this work, a simple and easy to use toy has been developed that can act as a supplement to speech therapies and can even by a substitute to speech therapies in some cases. It teaches the children how to pronounce words and shows them what it actually means. It is developed to appear like a fun game to the child, which he / she can play and create high scores. It works on the basic working principle of flashcards but makes it much more effective by presenting it in an attractive format of a fun time-based game.

ACKNOWLEDGEMENT

The success and final outcome of this work required a lot of guidance, supervision and assistance from many people and the team is extremely privileged to have received it all during the completion of this work.

The team is indebted to the Hubli Child Development Centre and Physiotherapy Clinic and their personnel for guiding and mentoring the team and giving them a first person perspective into autism, and for letting the team interact with the autistic children and their family members.

The team is highly grateful to Indo Universal Collaboration for Engineering Education (IUCEE) for giving such a great platform and opportunity. The team appreciates IUCEE for providing such a huge exposure to the concept of problem-based learning. The team thanks Dr. Prathiba Nagabhushan, Aditya Bhatnagar, Col. Raman Thapar for their guidance and mentoring.

The team also respects and thanks Dr. Sujata S Kotabagi, for providing her expert guidance and counsel for this work and for giving the team all the mentoring and assistance. The team is extremely thankful to her for providing her invaluable support and supervision despite her busy schedule.

Table of Contents

Table of Figures

INTRODUCTION

The word "autism" originates from the Greek word "autós," meaning "self." In 1908, a Swiss psychiatrist named Eugen Bleuler invented the term to characterise people with schizophrenia's detachment from reality. In 1943, the term autism was revised to encompass social isolation and linguistic difficulties in children who did not have schizophrenia or other known psychiatric diseases.

Autism is one of the most common neurodevelopmental disorders in childhood. It is a syndrome that affects the social behaviour and linguistic ability of the affected person. The degeneration of linguistic ability further makes it difficult for the affected person to interact with others and makes them uncomfortable in a social setting. Autism spectrum disorder is a neurobiological condition caused by hereditary and environmental factors that alter the developing brain.

Understanding the development of the child is very important as it allows one to effectively monitor the child's progress, identify delays or abnormalities in the development. Autism is one of the leading causes of disability among all mental disorders especially in children. The symptoms and the scale of autism varies a lot and hence it has been classified medically as Autism Spectrum Disorders (ASD). The qualitative impairments in social functioning and communication define neurodevelopmental disorders that come under ASD. Repetitive behavioural patterns often accompany such disorders. Understanding the sequence of development is very important as it allows effective monitoring of a child's progress, identifying delay or abnormalities in the development.

One of the most striking and distinguishable characteristics of autism is the social interaction. Autistic kids find it difficult to express their emotions verbally. They do not know how to react or get involved in social situations. Thus this makes their communication skills poor. So it is essential to help these autistic children know what type of behaviour is socially acceptable in various situations. As autism is very widespread among children, the most common way to treat and teach such children is by means of toys specially designed for such purposes.

BACKGROUND

Autism spectrum disorders (ASDs) are a class of neurodevelopmental disorders characterised by quality impairments in social functioning and communication, which are often accompanied by behavioural patterns and repetitive and abnormal interests. Autism is a developmental disorder characterised by difficulty in social networking and communication, as well as limited and repetitive behaviours. [1] The parent can normally notice these abnormalities before the child reaches the age of three years. [2] These symptoms usually develop slowly, although some autistic children experience a decline in their communication skills and social skills after development at a normal rate.[3]

Autism have encompassed a broad spectrum, ranging from people with severe disabilities — who may be quiet, badly disabled, and prone to repetitive behaviours such as clapping and shaking — to more active people who may be hyperactive.[4]

The Diagnostic and Statistical Manual of Mental Disorders (DSM) is a handbook used by health professionals all around the world as an authoritative guide for the diagnosis of mental disorders. The DSM contains definitions, and other methods for diagnosing mental disorders. It provides common language for doctors to talk about their patients and establishes consistent and reliable diagnoses that can be used in psychiatric research.[5]

The DSM-5 approach is perfect to identify autistic children because it recognizes both the underlying symptoms of ASD and the clinical features that are not specific to ASD. This method of sampling the characters will help researchers increase the likelihood of their research samples, thereby improving the interpretation of their work. The main goal is to identify small groups within ASD that's important in understanding biological mechanisms, clinical outcomes, and treatment people with ASD.[6]

To treat several such disorders, toys have been employed as the child can play with the toy while learning and improving. It also helps to gain their attention.

Fig1: Autistic kid learning using flashcards

[Courtesy: https://picturemypicture.com/flashcards-for-autism/]

Flash cards and visual support are powerful teaching strategies for children with autism or other special needs with language and communication challenges. Flashcards help our autistic children learn and make new vocabulary easier, and improve communication. Visual techniques, including cards, are essential teaching materials for autism classes and ABA programs [7].

Fig 2: Flashcards

[Courtesy: https://www.kidpid.com/visual-flashcards-for-autism/]

Several such toys exist in the market. But they require a parent or a caretaker to use them to teach the child and the child may lose interest in such toys after a while which makes them ineffective. Thus, these toys do not promote self-paced learning for the child and they end up just being a tool that can be used to teach such children.

SPECIFICATION AND DESIGN

The structure of the system is designed keeping in mind that it will be used by small children, the model is 3D printed using PLA (PolyLactic Acid). This material is basically a thermoplastic which is biodegradable and is inexpensive which proves to be safe to be used for kids toys. The model has no sharp edges and no harmful chemicals or components are used.

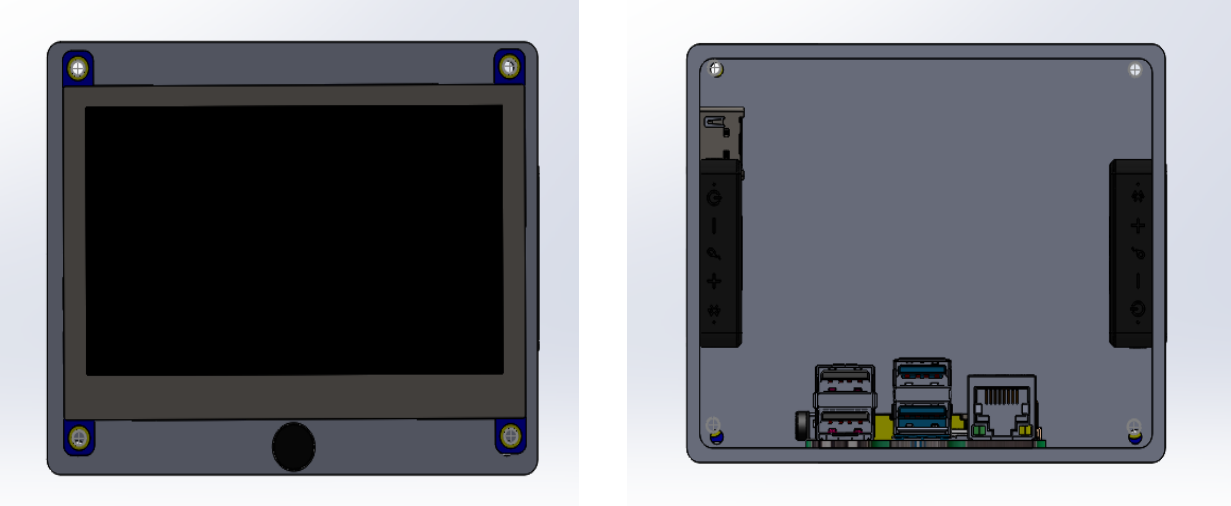


Fig 3 : Front and back view of the model

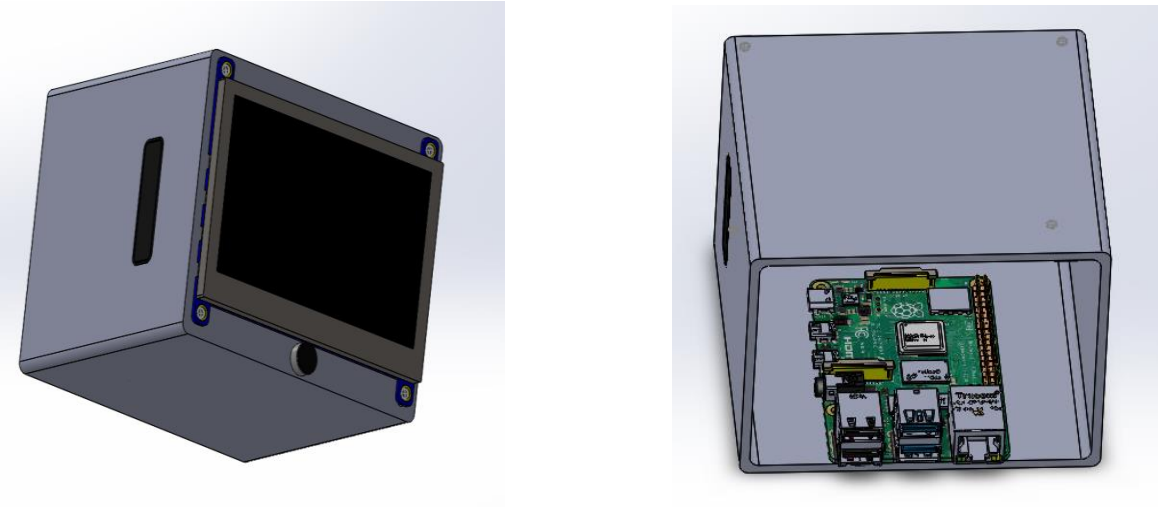


Fig 4: Isometric views of the model

The 1.011 centimetre cube is the total volume of the model with 112mm as its length, 105 mm as its width and 86mm as its height. The system consists of a speaker, microphone, Raspberry Pi 4 and a 7 inch LCD, along with a battery backup. This is the bill of materials for the system.

S No.	Name	Description	Cost
1	Raspberry Pi 3b+	1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE	2500
2	Display	7 inch capacitive touch screen	4500
3	Microphone	Waveshare USB to audio connector with microphone	500
4	Speaker	4ohm 5W speaker	80
5	Battery	INVENTO 5V 1800 Mah Polymer Ni-Mh Rechargeable Battery	600

Table 1: Bill of Materials

After conducting a market survey and analysis, the above mentioned components have been selected for the development of the prototype. The analysis is done on the factors such as safety, easy to use, availability and cost effectiveness. The main components are the raspberry pi which controls the entire system, a microphone and a peripheral speaker along with a touch display screen. Raspberry pi has ports for audio input and output as well as an HDMI port for the display which meets all the requirements for building the system. Considering its availability and cost it was chosen among other microprocessors available in the market. Through the LCD screen the flash cards and the mouth motions can be displayed to the children. The stereo speaker is used to produce the sounds for the pronunciation of a particular word or picture and the electret microphone is used to record the child's voice and send it to the controller.

IMPLEMENTATION

The structural design as well as the components of the product have been detailed above. The actual solution is implemented by means of a python application running on a native linux environment.Python 3.6 has been used to develop the solution. It offers a variety of packages and libraries that can be utilised to easily implement a variety of functionalities. Moreover, the solution is developed as a modular solution, which makes it easy to debug each module in isolation. Also, this approach allows easy integration of new functionalities and features down the line.

The user can interact with the solution in two ways, by means of the touch screen and by voice commands. Touch input is used to launch the app and for other basic functions, while voice commands are used to actually interact with the application. The product offers a basic supplement to the speech therapy of the autistic children. The idea behind the working of the solution is based upon Picture Exchange Communication System (PECS). It presents them with a variety of flashcards depicting a huge range of everyday objects. It then says out loud the correct pronunciation of the word shown in the flashcard, then the child is expected to repeat the word. To make it interesting and much more interactive for the child, the solution is presented as a game with a timer and a scoreboard. Once the system has spoken the word, the timer starts and the child has to repeat the word quickly. As soon as the word is pronounced correctly, the timer stops and the user is awarded points based on their quickness in responding.

If the correct pronunciation is not heard by the system in a set amount of time, then the system will repeat the word again and the cycle continues until the child is able to repeat the word properly. This functionality is achieved by utilising the concept of NLP (Natural Language Processing).The flashcards are arranged in various categories. The main categories are the broad classifications based on the difficulty level of the word. The difficulty is marked based on the length and popularity of the word, also it is based on the statistical data presenting the words which are generally difficult to pronounce. Sub-categorisation is done based on the theme of the flashcards, this allows the addition of seasonal flashcards corresponding to the relevant season and festival that is close to the time of play.

RESULT

A basic proof of concept had been developed to test out the idea and its functioning. Based on the analysis of the proof of concept, corrections and updations have been made. Keeping these in mind, the prototype is being developed to incorporate the updates and become better than its predecessor.

The developed solution was able to perform as expected and acted as a hand-held toy which the child can enjoy and use it to learn at their own pace. The toy could be played along with parents or caretakers, who help the child to operate the toy and make its expected functioning much more effective.

FUTURE WORKS

The presented solution is a proof of concept of the final intended product and requires a few upgrades. The speech to text and text to speech model is a basic version which can be upgraded to make it much more efficient and much faster.

The components that have been used to develop the system are off the shelf components and hence the final solution has a comparatively higher cost. This cost can be brought down substantially by in - house manufacturing of components and mass production.

Based on the inputs provided by professional speech therapists currently training and working with autistic children, visual inputs are necessary for the children and they learn by imitating the way of speaking of the person training them. They are taught to imitate lip movements and the correct way of pronunciation in this manner. This feature can be added in future versions of the product that can teach the children the correct way of speaking that they can replicate with ease.

CONCLUSION

The team has successfully built a toy for autistic kids. During the process of project based learning, what is autism, cause of autism, characteristics of the autistic kids, how different they are from the normal kids was studied through expert interaction and observation of such children, also through reading the research papers on autism the knowledge about it was gained.

The most common problems throughout autism were studied and it was found that linguistic ability(speech) is lacking in the autistic children from major age groups. Considering this a speech therapy toy has been built which acts as a toy as well as plays the role of speech therapist which can help the children to develop their linguistic ability.

REFLECTION

The team analysed the problem and gained a deeper understanding of the disorder, its effects and how it affects the people close to autistic children. The team worked closely with professionals treating the affected and interacted with such children, which motivated them to develop a fun solution for the betterment of such children. The scarcity of resources available for treating autistic children and its high costs motivated the team to develop an affordable and easy to use solution.

GLOSSARY

Autism - A neurobiological and developmental disorder that inhibits one's growth and hampers their ability to communicate and interact with others. It affects the nervous system and causes repetitive disorder. [8]

Autism Spectrum Disorder - Autism spectrum disorder (ASD) is a complex developmental disorder that involves challenges in social interactions, limited interests, and repetitive behaviours. Although autism is considered a lifelong disorder, the level of functional impairment due to these challenges varies among people with autism.[9]

TABLE OF ABBREVIATIONS

S No.	Abbreviation	Description
1	ASD	Autism Spectrum Disorder
2	DSM	Diagnostic and Statistical Manual of Mental Disorders
3	PECS	Picture Exchange Communication System
4	NLP	Natural Language Processing
5	PLA	PolyLactic Acid
6	LCD	Liquid Crystal Display
7	ABA	Applied Behavior Analysis
8	HDMI	High-Definition Multimedia Interface

Appendix

Component Specifications

Raspberry Pi 3b+ [10]

Property	**Description**
Processor	Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
RAM	1GB LPDDR2 SDRAM
WiFi	2.4GHz and 5GHz
USB	4 USB 2.0 ports

Display [11]

Property	**Description**
Manufacturer	Seeed Technology Co., Ltd
Size	7 inch
Connection	USB
Resolution	1024 x 600

Microphone [12]

Property	**Description**
Connection	USB
Microphone	2 MEMS microphones

Speaker [13]

Property	**Description**
Power	5W
Impedance	4 ohm

Battery [14]

Property	**Description**
Dimensions	8.5 x 8.5 x 0.3 cm
Voltage	5 volts
Capacity	1800 mAh

REFERENCES

[1] Autism Spectrum Disorder, 299.00 (F84.0). In: American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*. American Psychiatric Publishing; 2013.

[2]Landa RJ (2008). "Diagnosis of autism spectrum disorders in the first 3 years of life". *Nat Clin Pract Neurol*. 4 (3): 138–147. doi:10.1038/ncpneuro0731. PMID 18253102

[3]Stefanatos GA (2008). "Regression in autistic spectrum disorders". *Neuropsychol Rev*. 18 (4): 305–319

[4]Wikipedia contributors. (2022, January 25). Autism. In *Wikipedia, The Free Encyclopedia*. Retrieved 07:39, February 6, 2022, from https://en.wikipedia.org/w/index.php?title=Autism&oldid=1067928275

[5]American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub.

[6]Grzadzinski, R., Huerta, M., & Lord, C. (2013). DSM-5 and autism spectrum disorders (ASDs): an opportunity for identifying ASD subtypes. *Molecular autism*, *4*(1), 1-6.

[7]Zaffke, A., Jain, N., Johnson, N., Alam, M. A. U., Magiera, M., & Ahamed, S. I. (2014, June). ICanLearn: A mobile application for creating flashcards and social stories™ for children with autism. In *International Conference on Smart Homes and Health Telematics* (pp. 225-230). Springer, Cham.

[8]*What is autism?* Autism Speaks. (n.d.). Retrieved February 8, 2022, from https://www.autismspeaks.org/what-autism

[9]American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5). Arlington, VA: American Psychiatric Association Publishing. https://www.psychiatry.org/patients-families/autism/what-is-autism-spectrum-disorder

[10] *Buy A raspberry pi 3 model B*+. Raspberry Pi. (n.d.). Retrieved February 7, 2022, from https://www.raspberrypi.com/products/raspberry-pi-3-model-b-plus/

[11] *104060007*. DigiKey. (n.d.). Retrieved February 7, 2022, from https://www.digikey.in/en/products/detail/seeed-technology-co.,-ltd/104060007/7650470?cur=INR&lang=en&utm_adgroup=Zombie+SKUs&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_Product_Zombie+SKUS&utm_term=&productid=7650470&gclid=Cj0KCQiAgP6PBhDmARIsAPWMq6m13S4FZw94wM6mNx5xZRYLHY0PssT9CCpHyBxI0HMizOmj0Lo4q4AaAmaVEALw_wcB

[12] *USB sound card, driver-free, for Raspberry Pi / Jetson Nano*. Waveshare. (n.d.). Retrieved February 7, 2022, from https://www.waveshare.com/usb-to-audio.htm

[13] Doe, J. (2020, May 4). *4 ohm 5 watt speaker*. Hatchnhack Cart. Retrieved February 7, 2022, from https://www.hnhcart.com/products/02-speaker?variant=42271717949662¤cy=INR&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&gclid=CjwKCAiAo4OQBhBBEiwA5KWu_65WMX83135p1MYGrJKqMTccSxJ4zsIu38tzvi1oltt8_Ug9nxB6XBoCdEcQAvD_BwE

[14] *Invento 5V 1800 mah polymer Ni-MH rechargeable 4 aa cell battery pack with 5. 5MM DC jack adaptor port for uno toy car DIY project : Amazon.in: Industrial & Scientific*. INVENTO 5V 1800 Mah Polymer Ni-Mh Rechargeable 4 Aa Cell Battery Pack with 5. 5Mm Dc Jack Adaptor Port for Uno Toy Car Diy Project : Amazon.in: Industrial & Scientific. (n.d.). Retrieved February 7, 2022, from https://www.amazon.in/INVENTO-Polymer-Rechargeable-Battery-Adaptor/dp/B082FGZ66D

Gömball - Toy for Autistic Children

Sudhanshu Rai Kairavin Namaha Daksh Patel

School of Engineering and Applied Science, Ahmedabad University

ABSTRACT

Existing toys available for autistic children offer a narrow catering horizon which leaves out children lying on various regions of Autistic Spectrum Disorder (ASD). Hence the concept of *Gömball* was formulated by incorporating research methodology and combining monodisciplinary solutions which existed in form of various distinct toys and innovating a single toy that ideates the said solution in a multidisciplinary approach. In its essence, Gömball is a textured and transparent ball embodying an unconventional shape (Gömboc), which houses a haptic feedback-inducing vibratory motor, suspended in a medium of colourful liquid which adheres to a multifaceted approach for designing toys for children affected by ASD. It is designed to cater to children with sensory needs pertaining to proprioceptive, vestibular, tactile, and visual aspects.

Index terms: Mutli-disciplinary treatment · Early intervention · Sensory Integration

INTRODUCTION

Autism spectrum disorder (ASD) is a brain development condition that alters how an individual perceives and communicates with others around them, resulting in social interaction and communication issues. The term "spectrum" in ASD alludes to the disorder's wide range of symptoms and severity. ASD manifests itself early in childhood, causing affected children to struggle in social, educational, and vocational situations. Children with autism have learning difficulties, the majority of them having below-average Intelligence Quotients (IQ) (See Appendix). Others suffering from the disorder possess a normal level of intellect; they acquire knowledge rapidly but have difficulty communicating and putting what they have learned into practice, as well as adjusting to social situations.

Even though there is no cure for autism, treatments are available to mitigate its effects. Detection and intervention at a tender age is beneficial for behavior, abilities, and language development. To facilitate the same, the concept of a multi-disciplinary toy - *Gömball* was formulated to aid psychologists and special educators working towards the treatment of children suffering from ASD by replacing the presently used mono-disciplinary toys like sensory mats, reflective balls, rainmaker toys[1] etc. that do not cater to the overall development of a child's sensory growth.

LITERATURE REVIEW

The existing treatments for ASD aim to lessen symptoms that impede daily functioning as well as the general well-being of an individual. ASD impacts each person uniquely, implying that people affected have unique strengths and weaknesses, and thus subsequently unique treatment needs. As a result, therapy plans are usually interdisciplinary and custom-suited to the needs of each particular patient. Treatments are offered in a variety of domains, including academic, general wellness, society, and personal, or a mix of all these. To ensure that treatment objectives and progress are met, clinicians interact with one another as well as the person with ASD and their family. In addition to the administration of drugs like *Risperidone*, *Aripiprazole, Lurasidone among others*, psychosocial therapies like *Applied behavior analysis (ABA)* (Keenan, 2006), *Pivotal Response Treatment (PRT)* (Ona et al, 2020), *Cognitive behavior therapy (CBT)* (Lang et al, 2010) have been developed to address both the core and related symptoms of ASD (DeFilippis & Wagner, 2016).

Further, research has been conducted to collect information on how color preference for

[1] (2020, May 26). 24 Toys for Autistic Children | NowPsych | Online Psychiatry. Retrieved February 10, 2022, from https://nowpsych.com/toys-for-autistic-children/

children suffering from ASD varied from Typically Developing (TD) children. As per multiple studies conducted, children with ASD prefer neutral colors like brown and blue as opposed to the choice of red and yellow by TD children. These findings appear to be the outcome of ASD-related hyper-sensation, which causes children with ASD to interpret bright colors like yellow and red colors as sensory-overloading (Grandgeorge & Masataka, 2016).

SPECIFICATION AND DESIGN

Gömball was designed entirely to cater to multiple sensory inputs in children with ASD. If put in a single statement, "A textured-ball embodying an unconventional shape (Gömboc), consisting of a vibratory motor inducing haptic feedback, suspended in a medium of colorful liquid which adheres to a multifaceted approach for designing toys for children affected by ASD." To elaborate, the Gömball houses the atypical Gömboc which is responsible for generating movement in the ball. While most shapes have four equilibrium points, the Gömboc has just two - one stable and the other unstable. With no additional weight, the structure self-rights itself due to the virtue of its geometry. This property of Gömboc would promote the children to perceive balance and enhance their cognitive perception.

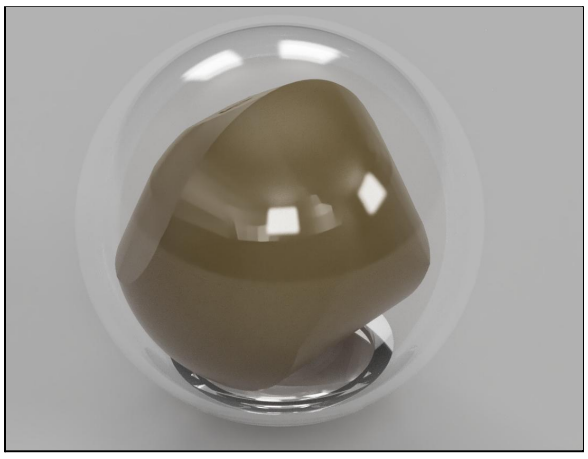


Figure I : CAD Rendering of Gömball

The plastic shell of the Gömball would possess different textures to generate mixed tactile sensations for the children. This would make them identify and understand the textures around the ball such as hardness and softness.

The liquid medium in the toy would serve as a visual stimulus to the children as the subtle colors would excite them and motivate them to play and interact with the toy. A mix of vibrant colors such as brown, black, and blue would be used in the medium. To provide haptic feedback through the toy, the Gömboc would embody a vibratory motor generating feeble vibrations to the children. An integrated circuit is introduced inside the Gömboc that would regulate the vibrations provided by the motor.

The Gömball would be 16 cm diameter in size encompassing a unique 8 x 7.5 x 7 cm Gömboc. The haptic feedback-inducing vibratory motor would be of 850 RPM capacity, so as not to harm the children in any way possible. A plastic shell with a hemisphere possessing a rough texture while the other with a soft one would help the children to identify various surfaces.

METHODS AND IMPLEMENTATION

The making of the toy started with mandatory research about ASD and its effects on children belonging to the age group 4-8 years. After acquiring an insight into the recent advancements in toys available in the Indian consumer space, the BA Psychology professors and students of Ahmedabad University were consulted to get a clear base idea of the disorder. With their inputs, the first design of the toy was formulated.

Attention to important specifications followed; including the shape of the toy, the extent of texture, as well as the capacity of the vibratory motor. After reading and implementing studies from various research papers, a visit to the BM Institute of Mental Health was essential to confirm and authorize the toy design with various Speech and Occupational therapists, Cognitive experts, and instructors who work

constantly with children suffering from ASD. Genuine concerns regarding the intensity of the vibrations, color preference of children, the overall size of the Gömball with appropriate playtime were explained by the director of BM Institute of Mental Health, Dr. Madhu Singh, and her team of experts. With their valuable insights, the final design of the toy was established.

Future plans include making a proper prototype of the toy and getting real-time feedback from children and instructors to better understand the engagement of the toy and improve its capabilities to cater well to the children.

RESULTS

Since its inception, the main objective of the Gömball was to achieve a multipurpose solution for children with ASD. The extensive research around existing toys in this field resulted in the toys being single sensory input-driven, i.e. they were able to favor only one mode of sensory input at a time. May it be sound, sight, or proprioception, only one of them was targeted through their toys. Since then, Gömball was focused on an incline towards multiple sensory inputs at a time; adopting a multidisciplinary approach towards the cause.

The Gömball has been under constant scrutiny from students, teachers, and experts in various stages of development and is still evolving. A render of the Gömball in Autodesk Fusion 360 helped visualize the placement of the Gömboc in the interior and finalize the placement of the vibratory motor inside the Gömboc. A constant and dynamic revision of the toy's design keeps the Gömball rich and fresh including all the vital components of play and treatment together.

SCOPE OF FUTURE WORK

The idea that has been put forward in the above-proposed solution needs to be modified in order to prolong the sustainability of Gömball. The Gömball is yet to be processed and be functional completely. Foremost, the idea is to add a haptic motor inside a Gömboc which would target the touch stimuli of the children and the Gömboc would be enclosed in a plastic shell with colorful fluid in order to target the visual stimuli of children. The entire housing including the Gömboc with haptic motor and fluid would be called Gömball. It is still in the initial stage which can be crafted into a real-life toy in order to help in the treatment of autistic children.

There are some design constraints that can be eliminated further to make Gömball even more sustainable and friendly. The improvements can be made in the design of the Gömball, by using a self-sustaining mechanism in order to provide haptic feedback to the child instead of using the electric motor and battery inside the Gömball considering the battery drain and variable voltage by an electric motor with time. In order to focus more on the sensory domain of the child, sound-emitting sources (speakers) can be enclosed within Gömball in order to engage the child to a higher extent by providing audio cues. In order to focus on the environmental aspect, the outer plastic shell of the Gömball can be substituted with some eco-friendly materials, which also would be safe for children. Further, in order to mitigate the cost of the Gömball, more emphasis could be laid upon the existing toys and the existing solutions. By tweaking the existing toys slightly we can bring fruition to our motive which in the long run cut off the cost while manufacturing in masses. According to the behavior and feedback of the children, modifications can be made to further improve the Gömball. These are some things which could be kept in mind and would help Gömball be a reality rather than just in papers and help the children.

CONCLUSION

The toys that the market offers for children with Autism are monodisciplinary and do not focus on multiple domains, which decreases the inclusion rate of the majority of Autistic Children. Autism Spectrum Disorder (ASD) is a brain developmental syndrome that affects children in their emotional and social balance.

The effect of ASD on children is varied and cannot be comparable as it varies from child to child. Thus, in order to cover the majority of children the idea of Gömball which is a uniquely fabricated textured toy keeping in mind the ability to serve multiple Autistic domains.

After researching and approaching experts, the Gömball was fabricated and tweaks were made in the design as and when it was required. Gömball houses an unevenly shaped Gömboc which has a vibrational motor in it surrounded by colorful fluid to give visual stimuli to the child. The haptic feedback that the motor produce would provide sensory stimulation to the child playing with Gömball.

Gömball being a toy that spreads the light on multiple domains would help to uplift the mood of the children and it is expected that the children would enjoy playing with it and it may help the child to socialize with other children and play with them.

REFLECTIONS

Autism Spectrum Disorder (ASD) has been prevailing for a very long time without the majority of people paying the attention to it, which it requires. In India, there is not much awareness about what Autism Spectrum Disorder is, and people wrongly correlate ASD with mental disorder and refrain from talking about ASD and have an acceptance of it.

As a group, when we were deciding upon which topic to work upon for the competition, we thought of taking 'Toys for Autistic Children', firstly as we wanted to explore the topic and know more about Autism. Second, we wanted to abolish the taboo and wanted the people to know that there is nothing wrong with ASD and to be ashamed of it. ASD is a brain development condition that, if diagnosed in time, can be treated well.

Throughout the process, we learned how to research a particular topic and propose a viable solution for it in order to serve the purpose. In the process of coming up with the solution, we interacted with many experts in the field which helped us understand and learn what you should ask them to extract the relevant information. While we were thinking of deciding on our toy, we came to know that no one toy can cater to all the needs. We can only target a few domains with our solution, so with Gömball, we have tried to satisfy multiple domains of Autism. Another takeaway would be that we learned how to design and manufacture toys that are both readily available and helpful to children. To design the toy keeping in mind the cost, we need to have a trade-off between price and the quality of the toy, so how to price the toy such that it is of good quality was also a valuable lesson.

ACKNOWLEDGEMENT

We express our utmost gratitude to our faculty mentor Dr. Jaina Mehta, Dr. Madhu Singh, and other faculties at BM Institute of Mental Health, Ahmedabad for their valuable inputs and suggestions and Indo Universal Collaboration for Engineering Education (IUCEE) who gave us this splendid opportunity to do this amazing project regarding the project Toys for Autistic Kids.

APPENDIX

The graph below shows the data on a study conducted to show the extent of prevalence of Intellectual disability in children in the age group of 5-10 years of age with ASD.
(Charman et al, 2011)

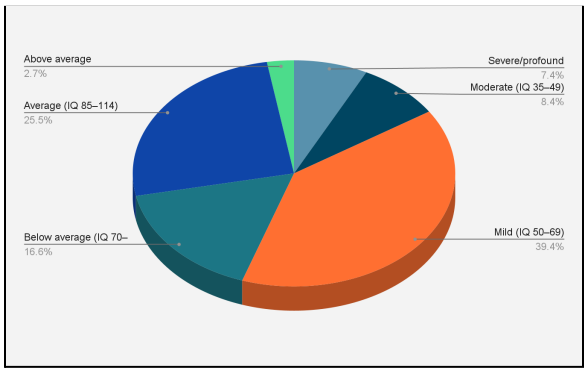


Figure II: Level of intellectual disability/ability in children with ASD

REFERENCES

1. *Centers for Disease Control and Prevention. (2020, March 25). Basics About Autism Spectrum Disorder (ASD) | NCBDDD | CDC.* https://www.cdc.gov/ncbddd/autism/facts.html
2. Landa R. (2007). *Early communication development and intervention for children with autism.* Mental retardation and developmental disabilities research reviews, 13(1), 16–25. https://doi.org/10.1002/mrdd.20134
3. DeFilippis M, Wagner KD. *Treatment of Autism Spectrum Disorder in Children and Adolescents*. Psychopharmacol Bull. 2016;46(2):18-41.
4. McPhilemy, C. and Dillenburger, K. (2013), *Parents' experiences of applied behavior analysis (ABA)-based interventions for children diagnosed with autistic spectrum disorder.* British Journal of Special Education, 40: 154-161. https://doi.org/10.1111/1467-8578.12038
5. Ona, H. N., Larsen, K., Nordheim, L. V., & Brurberg, K. G. (2020). *Effects of Pivotal Response Treatment (PRT) for children with autism spectrum disorders (ASD): A systematic review*. Review Journal of Autism and Developmental Disorders, 7(1), 78-90.
6. Lang, R., Regester, A., Lauderdale, S., Ashbaugh, K., & Haring, A. (2010). Treatment of anxiety in autism spectrum disorders using cognitive behavior therapy: A systematic review. Developmental neurorehabilitation, 13(1), 53-63.
7. Hyman, S. L., Levy, S. E., Myers, *S. M., & COUNCIL ON CHILDREN WITH DISABILITIES, SECTION ON DEVELOPMENTAL AND BEHAVIORAL PEDIATRICS (2020)*. Identification, Evaluation, and Management of Children With Autism Spectrum Disorder. Pediatrics, 145(1), e20193447. https://doi.org/10.1542/peds.2019-3447
8. Brezis, R. S., Weisner, T. S., Daley, T. C., Singhal, N., Barua, M., & Chollera, S. P. (2015). Parenting a child with autism in India: narratives before and after a parent-child intervention program. Culture, medicine and psychiatry, 39(2), 277–298. https://doi.org/10.1007/s11013-015-9434-y
9. Grandgeorge, M., & Masataka, N. (2016). *Atypical Color Preference in Children with Autism Spectrum Disorder.* Frontiers in psychology, 7, 1976. https://doi.org/10.3389/fpsyg.2016.01976
10. LaLonde, K. B., Jones, S., West, L., & Santman, C. (2019). *An Evaluation of a Game-Based Treatment Package on Intraverbals in Young Children with Autism*. Behavior analysis in practice, 13(1), 152–157. https://doi.org/10.1007/s40617-019-00397-8
11. Charman, T., Pickles, A., Simonoff, E., Chandler, S., Loucas, T., & Baird, G. (2011). *IQ in children with autism spectrum disorders*: data from the Special Needs and Autism Project (SNAP). Psychological medicine, 41(3), 619–627. https://doi.org/10.1017/S0033291710000991

Research paper

Topic : **Toys for Autistic Children**

Insititution Name **: Chitkara University, Punjab**

Faculty Guide **: Dr. Neha Tuli**
Contact :- 7837961699
Email :- neha.tuli@chitkara.edu.in

Team members

1)Prabhneet Kaur Sohanpal
Contact :-8968167591
Email :-prabhneetkaursohanpal@gmail.com

2)Harsh Vardhan Sikka
Contact :- 9357575767
Email :-harsh.sikka@gmail.com

3)Piyush Kumar
Contact :- 8340524577
Email :-piyushkumar2738@gmail.com

RESEARCH PAPER

ACKNOWLEDGEMENT

This paper and research that we have done would not have been possible without the support of our faculty advisor, Dr. Neha Tuli. Her guidance, knowledge, and attention to our venture are what kept us going and moving further in the research process and eventually led us in the making of this research paper.
We would like to thank the “Immersive and Interactive Technology Labs (IITL), Chitkara University”, for providing us with all the important information and knowledge about the technologies we were working with and what we needed for getting a practical idea about what we were building.
Further, we would like to thank the team of IUCEE for making this event possible and providing the undergraduate students a proper chance to research the implementations of the ideas they had in the form of a research paper which I believe would certainly boost the culture of research work in undergraduates.

ABSTRACT

With the prevalence of the Covid-19 pandemic; continuous research and constantly developing diagnosis mechanisms coupled with the rise in efficient telemedicine, autism diagnoses among children and adults alike have been on the rise. Factors also indicating a visible rise is anxiety in autistic people as a symptom. Over the years different methods were invented to diagnose and treat autism, but evidence and immediate problems of anxiety overlapping autism remain undiagnosed. Symptoms of anxiety are easily recognized in non-autistic patients however symptoms of anxiety are not easily detected in autistic children. The reason for this mainly lies in the tactical conclusion that autism’s manifestation and aftermath of anxiety tend to overlap each other. This project aims to include the latest technology advancements and bet on the future of Virtual Reality (VR) to provide a “metaverse” like the environment of simulations for children as an entertainment device whilst using diagnostic tools to provide key insights on responses generated by an autistic mind whilst exposed to divergent environments.

INTRODUCTION

Autism spectrum disorder(ASD) is a prenatal developmental disorder that is usually categorized by social communication along with repetitive, restrictive, behaviour or interests(RRBI). Here the term “spectrum” simply implies the different levels of severity. Autistic people usually do not differ in any form of physical appearance or physical making. The most common manifestation of autism is deficits in communication skills also significantly observed, they cannot comprehend others' emotions. Signs and symptoms of autism are visible in the early

stages of childhood and typically last through one's life. In 2021, the CDC (Centers for disease control and prevention) reported that approximately 1 in 44 children in the U.S are diagnosed with an autism spectrum disorder(ASD), according to 2-18 data with boys four times more likely to be diagnosed with autism than girls. Anxiety is very common in the ASD population where, unlike autism, anxiety can be cured if diagnosed and treated at an early age. The problem lies in the fact that 40% of people with autism have anxiety overlapping their prenatal illness, yet it remains undiscovered and untreated. This research paper proposes to use virtual-reality-based solutions to diagnose and cure anxiety in populations lying under the autism spectrum. This project aims to create/assemble a physical device that can provide aid to the population lying under the autism spectrum. We tend to use the technology of virtual reality to detect the presence of anxiety in the ASD population. The scope of this project also extends to deploying virtual reality to treat anxiety by replacing the traditional way of delivering CBT(cognitive behavioral therapy), ABA (applied behavior analysis), and PLAY therapy by using modified virtual reality experiences. This project aims at mainly preschool children with an early diagnosis of Autism also demonstrating the different extent of anxiety issues. Some of the basic assumptions around which this research is based include that the 'subject' in question is expected to be devoid of physical impairments like visual impairment, hearing impairment and the proceeding is being carried out in a perfectly isolated soundproof environment in presence of a psychological mentor and technical operator. By the end of this project, the reader will be able to distinguish between anxiety manifestation in people with autism and people without autism, and will also learn the reason to use Virtual-reality over traditional/existing methods to deliver CBT, ABA, PLAY therapy.

BACKGROUND INTRODUCTION

Autism is not an intellectual inability, but their inability to organize their life. The autistic brain has neurological differences that can present varied vitality and provocation. The main reason for using virtual reality is that the autistic brain often excels on visual perception tests and their brain shows visual dominance. Non-autistic people use their prefrontal cortex to plan and make decisions but autistic subjects use their visual processing region for both visual perception and planning. In layman's terms, while treating anxiety one cannot use the "will talk them out of it" method since they believe in what they see, their imagination is not as developed as a person with a normal self. In addition to this since the intensity of simulations can be controlled while using virtual reality, according to the subject in question this can provide them with a far greater extent of 'science of touch' and 'science of motion'. Some relative solutions to address the

problem of anxiety in autism include the use of Digital versatile Disc (DVD) and recreating many common anxiety and autism trigger situations physically, just like airports or any sort of stimulating environment. This research respects and is in accordance with the Social Motivation Hypothesis thus it rejects the physical arrangement to aid autism and also to treat anxiety in ASD fractions.

THE SPECIFICATION AND DESIGN

Components Required

This project delivers an intervention of a smartphone and Google Cardboard compatible app (Fig.1) & a VR headset device to demonstrate its expediency. Each intervention should be delivered by a trained speech-language pathologist in the presence of a psychological mentor, research assistant, and technical personnel. To amplify the effect and get a stronger and more accurate response we tend to integrate the arrangement so far with a 360-degree output sound device, a basic fitness band to display the general vitals of the subject, and at last to broaden our acceptability and field of testing eye tracking or eye gauze will be used.

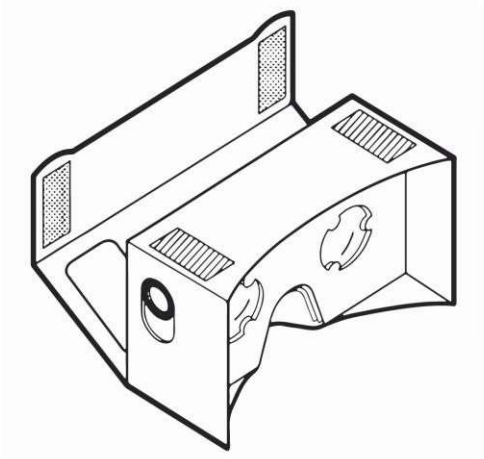


Fig.1: Google Cardboard

PROCEDURE

Participants of the experiment shall receive VR gaming simulation in an isolated session in presence of psychological and technical assistance. This shall include 20-minutes of “warm-up”: a period of familiarization and deadening to the clinical environment for the subject. After this period, the intercession shall be delivered according to the narrative script and modified with respect to individual subjects' ability to attend and adjust to VR simulation. Each intercession shall last for a total of 15 minutes.

All the data must be organized and analysed via a non-parametric test. Nonparametric tests are to be performed because the samples are believed to be non-normally distributed. These analyses are important to perform for both parental and clinical observations. The said arrangement is designed as an entertainment device whilst being a diagnostic tool for autism, with the ability to construct near-infinite amounts of simulations & include further development potential. With the inclusion of AI and machine learning algorithms, the project is expected to evolve over time as the standardized software is tested on a variety of patients around the world.

IMPLEMENTATION

This project implements its core idea by creating generalized simulation environments according to the subject's severity of anxiety. Deployment of which can be easily standardized through software and some technical training. Despite the best efforts, many shortcomings are covering the current theories and arrangements, the most significant of them being the absence of baseline physiological measures; needed to validate measurement materials specific to virtual reality. A hiccup was detected during the training session for VR despite the training is subjects finding it hard to cope with the new altered reality. All the faults and problems mentioned so far can be solved over time with adaptation and widespread use. One of the main and persisting shortcomings lies with autism itself. Treating anxiety while also knowing the cause is important, but due to a lack of functional communication, it is hard to pinpoint the origin.

THE RESULT AND EVALUATION

The initial idea to use virtual reality to diagnose the presence of anxiety and also to treat it remains concrete and well-founded. After thorough research, it is concluded that virtual reality or Puedo reality is the only safe way to create a reality, real enough to accommodate autistic minds but virtual enough to accommodate different needs. VR headset being equipped with eyetracking and running simulations making use of this feature is believed to be a boon to this entire arrangement. Adding on an external 360 degrees might counter the initial intent of cost-cutting, but it turns out to be the perfect way to inculcate 'science of motion' among the subject. Fitness way is the most common and economical way to keep a track of subjects' vitals, this is also believed to be capable enough to use as an output device for real-time monitoring. This research was able to pinpoint the link that connects autism with anxiety. The most common factor is psychological arousal and subjective feeling of worry or dread which is given during functional communication.

FUTURE WORK

This project was able to cover most aspects as intended. But The factor that makes a project perfect and productive is the ‘room for improvement’. Unlike any other project this project did aim at higher productivity, but due to limited time and knowledge, this research paper failed to deliver its best.

Provided enough time and specific knowledge in the field of psychology scope of this project might extend to develop a clinical parameter to analyze response for better judgment. Another approach this project was not able to achieve was the detailed graphics. Vivid simulations can be created with detailed and real-life inspired graphics.

CONCLUSION

Autism spectrum disorder (ASD) is a prenatal developmental disorder that is usually categorized by social communication along with repetitive, restrictive, behavior or interests (RRBI’S). Unlike Autism being a disorder, anxiety can be broadly described as the human body’s natural response to stress. Anxiety is a temporary phase or state of mind on the contrary autism is a permanent disorder. This research paper was able to pinpoint the link that connects autism with anxiety. The most common factor is psychological arousal and subjective feeling of worry or dread which is given during functional communication. This project aims to create/assemble a physical device that can provide aid to the population lying under the autism spectrum. We tend to use the technology of virtual reality to detect the presence of anxiety in the ASD population. The scope of this project also extends to deploying virtual reality to treat anxiety by replacing the traditional way of delivering CBT(cognitive behavioral therapy), ABA(applied behavior analysis), and PLAY therapy by modified virtual reality headset itself. Taking note of the theories and solutions presented before this paper and with the hope of broadening the scope of the solution presented; this project concludes by recognizing virtual reality as an effective tool for autism and anxiety not just in the present but also in the future.

REFERENCES USED

1)https://psychology.nottingham.ac.uk/research/art/research.htmL
2)https://www.healthline.com/health/aba-therapy#_noHeaderPrefixedContent
3)https://www.webmd.com/brain/autism/therapies-to-help-with-autism
4)https://www.wikihow.com/Distinguish-Between-Social-Anxiety-and-Autism

5)https://www.cdc.gov/ncbddd/autism/facts.html
6)https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6832622/
7)https://nasenjournals.onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9604.2009.01413.x
8)https://www.mdpi.com/2076-3417/11/10/4550/htm
9)https://sci-hub.mksa.top/10.1007/s40747-021-00447-1
10)https://www.liebertpub.com/doi/full/10.1089/cyber.2019.0093
11)https://www.scribbr.com/category/research-paper/
12)https://www.researchgate.net/figure/VR-headset-structure-A-VRhttps://www.researchgate.net/figure/VR-headset-structure-A-VR-headset-contains-a-display-a_fig2_323788480headsetcontains-a-display-a_fig2_323788480
13). American Psychiatric Association. (2013) Diagnostic and statistical manual of mental disorders. 5th ed. Washington, DC: American Psychiatric Publishing. Crossref, Google Scholar
14)Centers for Disease Control - National Center on Birth Defects and Developmental Disabilities (NICBDDD). (2018) What is autism spectrum disorder? www.cdc.gov/ncbddd/autism/facts.html (accessed May 3, 2019). Google Scholar
15)Jones CR, Simonoff R, Baird G, et al. The association between the theory of mind, executive function, and the symptoms of autism spectrum disorder. Autism Research 2017; 11:95–109. Crossref, Medline, Google Scholar
16)Pyers JE, Senghas A. Language promotes false-belief understanding. Psychological Science 2009; 20:805–812. Crossref, Medline, Google Scholar
17)Chamberlain B, Kasari C, Rotheram-Fuller E. Involvement or isolation? The Social Networks of Children with Autism in Regular Classrooms. Journal of Autism and Developmental Disorders 2006; 37:230–242. Crossref, Google Scholar
18)Sinha P, Kjelgaard MM, Gandhi TK, et al. Autism as a disorder of prediction. Proceedings of the National Academy of Sciences of the United States of America 2014; 111:15220–15225. Crossref, Medline, Google Scholar
19)Van de Cruys S, Evers K, Van der Hallen R, et al. Precise minds in uncertain worlds: predictive coding in autism. Psychological Review 2014; 121:649.

Crossref, Medline, Google Scholar
20) Baron-Cohen S. The cognitive neuroscience of autism. Journal of Neurology, Neurosurgery & Psychiatry 2004; 75:945–948. Crossref, Medline, Google Scholar
21)Frith U. The 38th Sir Frederick Bartlett Lecture Why we need cognitive explanations of autism. Quarterly Journal of Experimental Psychology 2012; 65:2073–2092. Crossref, Medline, Google Scholar
22)White S, Oswald D, Ollendick T, et al. Anxiety in children and adolescents with an autism spectrum disorder. Clinical Psychology Review 2017; 29:216–229. Crossref, Google Scholar

Application of IoT for Detecting Spoilt Fruits and Vegetables

Sankalp N V, Prajwal Prakash, Swati Negi , Dr Ramaa A

Department of Industrial Engineering and Management
RV College of Engineering
Bengaluru, India

***Abstract* -- India ranks second in the production of fruits and vegetables worldwide, still the performance of India in the agricultural exports is extremely poor. This is mainly due to the poor handling of fresh fruits and vegetables throughout the supply chain. The retail stores are found to contribute to the most amount of wastage, which is about 12-15%. Thus, an organized system is created for the continuous monitoring of fresh fruits and vegetables by setting up a smart way of detecting spoilage, thereby reducing wastage and leading to the minimized losses. The key parameters that affect the spoilage of fruits and vegetables in a particular environment, namely, temperature, shelf life, and relative humidity, were identified and the required data was collected and analyzed to design a smarter system for fruits and vegetables spoilage detection using the Internet of Things. Temperature sensors and alcohol sensors were used and the data collected using these sensors were fed into the IoT platform, where it was analyzed and compared against the preset values. The IoT platform provided real time data related to the spoilage of fruits and vegetables to the user, retail store managers or employees, to facilitate them in making quick decisions.**

I. INTRODUCTION

India is known as an agricultural economy as about 60 to 70 percent of the Indian population depends upon agriculture for earning their livelihood. As a result, the country is one of the leading producers of fruits and vegetables across the globe. India ranks second in the overall production of fruits and vegetables in the entire world. Despite this fact, the performance of India in the sector of agricultural exports is extremely poor. Facts show that while India produces about 100 million metric tons of fresh fruits and vegetables every year, it only exports about 4 million tons, which is only 4 percent of the total produce. This is mainly due to the poor handling of fresh fruits and vegetables throughout the supply chain. Due to the poor handling, the wastage and spoilage of the produce of fruits and vegetables occurs, which leads to the bad quality of the produce as well as the increased price for the end consumers.

The supply chain of fruits and vegetables includes procurement of the raw materials, machineries, and other required equipment for agriculture, and their conversion into the finished products in terms of the produce of fruits and vegetables, and then their transportation to the final destinations. In the entire supply chain, at every stage involved, there is a certain wastage of the produce that takes place. This wastage occurs mainly due to the complex nature of fruits and vegetables. The nature of the fruits and vegetables supply chain is complex because of the perishable nature of the produce, increasing consumer concerns for food safety & quality, high fluctuations in demand and prices, and dependence on climatic conditions. The traditional supply chain models for fruits and vegetables have too many intermediaries.

Thus, the supply chain models with fewer intermediaries or parties and organized retailers such as Hub and Spoke Model and Value Chain Model have been gaining popularity. These models can bring down the wastage to a certain level, but they are not the complete solution. This is so because the main reason for wastage is the poor handling of fruits and vegetables. It has been observed that 8 to 10 percent of wastage occurs at the farm, 5 to 6 percent of wastage occurs during the transport, 2 to 3 percent of the wastage occurs at the distribution centers, 12 to 15 percent of wastage occurs at the retail stores, and approximately 1 percent of the wastage occurs at the consumer end due to the poor handling, monitoring and storage of fruits and vegetables. Clearly, retail stores have a poor monitoring system for fruits and vegetables, due to which the wastage in retail stores is maximum.

In a highly dynamic supply chain of fruits and vegetables, which are perishable in nature and are prone to spoilage during various stages of supply chain, especially and specifically in the stage in which they are stored in the small scale retail stores with very few employees to monitor their condition, an organized system is needed for the continuous monitoring of fruits and vegetables, by setting up a smart way of detecting spoilage, thereby reducing wastage and leading to minimized losses and improved quality to the end consumer. Therefore, The main objectives of this project are identifying the key parameters or factors that affect the spoilage of fruits and vegetables and outlining and developing a smart system to detect the spoilage of fruits and vegetables efficiently in a cost effective manner.

II. LITERATURE REVIEW

India is one of the world’s largest producers of fresh fruits and vegetables but there is still a huge gap between the supply and per capita demand due to lot of wastage in the processes of post-harvest, storage and handling. The poor availability of cold chain facilities contributes to this and results in a great loss to the economy. Therefore, handling and storage of fruits and vegetables should be improved to make the country's demand for fruits and vegetables meet at lower cost [1].

Whole supply chain of fruits and vegetables is burdened with various challenges and issues in India. There is a very strong need to study the supply chain of fruits and vegetables in order to suggest the possible challenges and their solutions. Fragmented supply chain, cold chain facilities, linkages and integration between partners, infrastructure facilities, taxation issues, farmer's knowledge and awareness, cost of packaging material, technology and techniques, processing and value addition, quality and safety standards, supply chain inefficiency, farmer's income, supply chain wastage of fresh produce, transportation facilities, demand and market information, etc are the main factors which constitutes the issues and challenges. [2]

In India the retail sector is now coming across as one of the largest sectors in the economy. With the increase in Indian population, there is also an increase in the demand for fruits and vegetables. But this sector of the retail store industry is facing huge challenges because of the demand uncertainty and high wastage issues . In-store wastages , price fluctuations ,seasonality, fill rate issues, quality uncertainty, low shelf life, are the main challenges [3].The main points which are critical related to the distribution of fruits and vegetables are difficulties in guaranteeing the uniformity of the crop, the limited shelf life, lack of integration in the supply chain, high production cost and low volumes [4].

Fresh produce of fruits and vegetables is extremely perishable and it is quite natural that some sort of deterioration in terms of quality is bound to occur during the entire supply chain. This rate of deterioration will be dependent on the abuse or care put on or exerted on the produce of fruits and vegetables, during handling, harvesting, transport and storage. [5]

The organizational sustainability in the agri-fresh food Supply Chain quality (AFSCQ) has been given very less consideration in India. With the phases of collection of data, and analysis with the data refinement, the sustainability in the agri-fresh food industry, which includes fruits and vegetables, can be achieved. Organizational sustainability directly or indirectly enhances social and economic performance [6]. The pressure on governments and businesses is growing to pay attention to the environmental and resource consequences of the continuously increasing production, distribution and consumption of agricultural products like fruits and vegetables. [7]

New challenges keep getting introduced to the fruits and vegetables supply chain. The covid-19 pandemic has given birth to another challenge in the fruits and vegetables supply chain industry. The whole transportation is blocked. In such cases the wastage avoidance has become even more essential and careful storage facilities have become a necessity [8]. Along with the existing traditional challenges and issues in the fruits and vegetable supply chain industry, such additional challenges keep on occurring in unprecedented times, like that of COVID 19 pandemic, which has resulted in the change in customer demand, restrictions on movements for the workers, etc. [9]

A retailer is suggested to use a data-driven approach to optimize decisions and designs for grocery stores [10]. A retailer should also take a decision on how much shelf space should be assigned to items and how frequently the retail shelves should be replenished. Because of the limited space , these two are the interdependent decisions. This is called as the shelf-space and replenishment problem. [11]

The warehousing of fruits and vegetables in the right and appropriate manner is extremely important for meeting the growing customer demands. The warehousing environment factors are extremely important for the quality of fruits. Therefore, the parameters of the warehousing environment are extremely crucial for maintaining the quality of fruits and vegetables and ensuring their regulation and control [12].

Supply chain management is now using innovative concepts and theories to make itself more efficient. Advanced technologies are now being used in various processes involved in supply chain management [13]. Methods such as the Internet of Things are extremely useful for analysing the identified parameters by using sensors [12]. The disadvantage caused by the wastage and spoilage of fresh fruits and vegetables during the distribution and transportation can be avoided by implementing the continuous monitoring of fresh fruits and vegetables using Internet of Things. The quality of the fresh fruits and vegetables throughout the distribution process can be tracked by using various types of contact and non-contact sensors. Fresh fruits and vegetables are prone to getting spoiled easily by the fruit-borne and vegetable-borne diseases. This can be overcome with the use of internet of things based monitoring and sensing during the transaction approach using smart logistics. [14]

Ethylene is a plant's natural metabolism product. It is produced by almost all tissues of the higher plants. It is known as the natural aging and ripening hormone. It is quite active at even small traces. Humidity and temperature are the factors used to control the shelf-life of fruits and vegetables in the cold stores. Apt and appropriate relative humidity is necessary in order to control the decay development, water losses, uniformity of ripening, and incidence of some of the physiological disorders. These factors are useful for development of a monitoring system for better storage [5]

III. IMPLEMENTATION

To implement the IoT system, a model was built using sensors and other hardware to achieve it. LM35 sensor was used to measure temperature, MQ3 sensor was used to measure the alcohol content additionally we used Arduino Uno microcontroller board, Buzzer and LED. All the components were connected as shown in the circuit below.

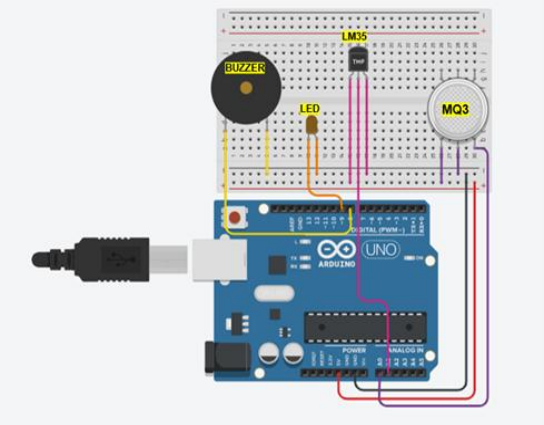


Fig. 1 Circuit of Implemented System

The system works on the principle that if detected sensor values exceed the threshold values, then action is triggered to notify the user. The sensor data from temperature and alcohol sensor is relayed and compared to the threshold value set in the code, and based on the comparison, the LED and Buzzer get triggered or not. The data can be reflected in the computer as Arduino Board is connected to it.

There are two coding aspects involved, the Arduino IDE code that is responsible for collection of data and comparing it with threshold and triggering necessary action if sensor data is above threshold value. And the other aspect is for making the dashboard. We display the dashboard is displayed on a webpage and node js is used to do this, where the data is collected from the sensors and is shown as output in the webpage dashboard along with condition whether it is okay or not okay.

IV. Conclusion

In this project, it was found that India being one of the leading producers of fresh fruits and vegetables in the world and holding the second rank has extremely poor performance in the sector of agricultural exports. This was mainly due to the poor handling and storage of fresh fruits and vegetables throughout the supply chain, because of which the wastage and spoilage of the produce of fruits and vegetables occurs. This led to the bad quality of the produce as well as the increased price for the end consumers. It was found that retail stores have the maximum contribution in the total wastage of fruits and vegetables, which is about 12 to 15 percent, that's why retail stores were targeted for problem solving.

It was observed that small retail stores lacked the appropriate monitoring system required to keep a check on the conditions of fruits and vegetables. Therefore, in this project, an organised system for the continuous monitoring of fruits and vegetables was developed, by setting up a smart way of detecting spoilage, thereby reducing wastage and leading to minimised losses and improved quality to the end consumer. This was done using the Internet of Things. The ideal storage conditions in terms of temperature, relative humidity and shelf life for various fruits and vegetables were identified and the data collected using sensors in terms of these parameters was analysed. The analysed data was compared against the predetermined threshold values and the appropriate action in case of detection of spoilage was triggered in terms of the buzzer sound or buzzer alarm. The user in the retail store can be provided with the real time data in order to facilitate him to take quick decisions regarding the spoilage with this system that was developed.

The project has successfully completed the development of a smart monitoring system which can detect the spoilage of fruits and vegetables and can give an alarm in case of spoilage. The project is also successful in providing the real time data to the retail store employees for better planning. The project outlined the importance of implementing advanced methods such as Internet of Things in the supply chain industry for improved processes of handling and storage.

V. Future Scope

1. The project had targeted the small scale retail stores for implementation of smart monitoring systems, but the scope of this project can also be expanded towards better storage and handling of fruits and vegetables in the big godowns and distribution centers. The implementation of this smart monitoring system will be able to reduce wastage at a bigger scale in those big godowns and distribution centres where huge amounts of fruits and vegetables produce is kept and stored.
2. With the data gathered using the sensors used in the monitoring system, a huge dataset can be formed, and this dataset, after normalizing the data, can be used for valuable and useful predictions using Machine Learning and Deep learning algorithms.
3. The monitoring system is extremely easy to implement, so it can be implemented even during the transportation of fruits and vegetables, to get the real time data related to their conditions in the transportation vehicle.
4. More sensors corresponding to other parameters of storage conditions can be added to the monitoring system to increase the accuracy of the system.

References

[1]. Rais M, Sheoran A, *Scope of Supply Chain Management in Fruits and Vegetables in India*, Journal of Food ,DOI: 10.4172/2157-7110.1000427

[2]. Saurav Negi, Neeraj Anand, *Issues and Challenges in the Supply Chain of Fruits & Vegetables Sector in India: A Review*, International Journal of Managing Value and Supply Chains · June 2015

[3]. Shilpa Sarvani Ravi, M. V. Ram Prasad, *Challenges and Innovations in Fruits and Vegetable Operations in Indian Organized Retail Industry*, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-6, March 2020

[4]. Elsa Bez ,*Logistic and distribution strategies in the fresh fruit supply chain: the case of kiwiberry from New Zealand*, MSC thesis

[5]. Gaetano Paltrinieri, *Agricultural Marketing Improvement*, Senior Food Technology and Agro-industries Officer FAO Retired Staff

[6]. Man Mohan Siddh (Malaviya National Institute of Technology Jaipur), Gunjan Soni (Malaviya National Institute of Technology Jaipur), Rakesh Jain (Malaviya National Institute of Technology Jaipur), Vinod Yadav (Manipal University Jaipur), *Agri-fresh food supply chain quality (AFSCQ): a literature review*, Industrial Management & Data Systems · October 2017, DOI: 10.1108/IMDS-10-2016-0427

[7]. Gopal Naik, D.N. Suresh, *Challenges of creating sustainable agri-retail supply chains*, ScienceDirect, received 9 August 2017; revised form 6 November 2017; accepted 10 January 2018; Available online 13 April 2018

[8]. Abhijit Barman , Rubi Das , Pijus Kanti De, *Impact of COVID-19 in food supply chain: Disruptions and recovery strategy*, Current Research in Behavioral Sciences 2 (2021) 100017

[9]. Serpil ADAY, Mehmet Seckin ADAY, *Impacts of COVID-19 on Food Supply Chain*, Canakkale Onsekiz Mart University, Vocational School of Biga, Food Processing Department, Canakkale, Turkey

[10]. Elif Ozgormus, Alice E. Smith, *A data-driven approach to grocery store block layout*, Computers & Industrial Engineering, Volume 139, 2020, 105562, ISSN 0360-8352

[11]. Tobias Düsterhöft, Alexander Hübner, Kai Schaal,A practical approach to the shelf-space allocation and replenishment problem with heterogeneously sized shelves, European Journal of Operational Research, Volume 282, Issue 1, 2020, Pages 252-266, ISSN 0377-2217

[12]. Sowmya T K Shreya V Agadi, Saraswathi K G Puneeth B Nirvani, Prajwal S, "Implementation of IoT based Smart Warehouse Monitoring System", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, ICRTT - 2018 Conference Proceedings

[13]. Hokey Min (Bowling Green State University), *Emerging Trends of Supply Chain Management: Where Are We Going?*, Korean Journal of Logistics · March 2016, DOI: 10.15735/kls.2016.24.1.001

[14]. Elavarasi, G. & Gurusamy, Murugaboopathi & Kathirvel, S.. (2019). Fresh Fruit Supply Chain Sensing and Transaction Using IoT. 1-4. 10.1109/INCOS45849.2019.8951326

[15]. Rao, C. G. (2015). Engineering *for Storage of Fruits and Vegetables: Cold Storage, Controlled Atmosphere Storage*, Modified Atmosphere Storage. India: Elsevier Science.

[16]. Bogardus, R. K. (1961). Wholesale *Fruit and Vegetable Warehouses: Guides for Layout and Design*. United States: U.S. Department of Agriculture, Agricultural Marketing Service, Transportation and Facilities Research Division.

[17]. Miguel Horta, Fábio Coelho, Susana Relvas, Layout design modelling for a real world just-in-time warehouse, Computers & Industrial Engineering, Volume 101, 2016, Pages 1-9, ISSN 0360-8352,

[18]. Nurgül Demirtaş, Umut R. Tuzkaya, Strategic Planning of Layout of the Distribution Center: an Approach for Fruits and Vegetables Hall, Procedia - Social and Behavioral Sciences, Volume 58, 2012, Pages 159-168, ISSN 1877-0428,

[19]. Halder Piali, Pati Simayan, *A Need For Paradigm Shift to Improve Supply Chain Management of Fruits & Vegetables in India*, 2011-09, DOI: 10.22004/ag.econ.197925, Asian Journal of Agriculture and Rural Development

[20]. Ali Osman Kuşakcı , Related information, "Retailer layout design: a novel hybrid approach with association rules mining and MCRAFT", 6 July 2020, International Journal of Industrial and Systems Engineering

[21]. Xing Wan, Xingquan Zuo, Xiaodong Li, Xinchao Zhao. (2020) A hybrid multiobjective GRASP for a multi-row facility layout problem with extra clearances. International Journal of Production Research 0:0, pages 1-20.

[22]. Ibrahim Cil, Consumption universes based supermarket layout through association rule mining and multidimensional scaling, Expert Systems with Applications, Volume 39, Issue 10, 2012, Pages 8611-8625, ISSN 0957-4174

Waste Management of Perishable fruits and vegetables using RFID technology and AI/ML algorithm

Ajay Patel
Department of ETE
BMS College of Engineering
Bangalore, India
ajaypatel.te19@bmsce.ac.in

Kshitij Sharma
Department of ETE
BMS College of Engineering
Bangalore, India
kshitij.te19@bmsce.ac.in

rajeshwari.hedge@gmail.com
Prasansa Bhagat
Department of ETE
BMS College of Engineering
Bangalore, India
prasansa.te19@bmsce.ac.in

Dr. Rajeshwari M Hegde
Department of ETE
BMS College of Engineering
Bangalore, India

Abstract- **Fruits and vegetables wastes occur throughout the supply chain and vary widely depending on its processing. The fruit and vegetable processing industries generate 30-60% waste or by-products in both solid and liquid form, managing fruits and vegetables waste becomes a serious concern. The present article deals with the studies conducted on waste management of perishable fruits and vegetables and a solution that uses RFID technology and AI/ML that aims at reducing the waste of fruits and vegetables.**

Keywords: Fruits and vegetables waste, Rfid

I. INTRODUCTION

The Indian economy is based on agriculture and the agricultural sector contributes around 15% to the total GDP of the country. Agricultural sector accounts for around 50% of the country's workforce [A]. Research shows that in India, 30-40 percent of vegetables and fruits, as well as 10 percent of total agricultural produce, is wasted. It can help the farmers to double their income if the products are preserved properly. [B]. Cold storage, food safety, and food waste are closely linked. Perishable foods, including fruits and vegetables, should be kept chilled or frozen throughout the entire supply chain. The insufficient refrigeration of perishable foods can stimulate the growth of pathogens and spoilage microorganisms and render the product inedible. Unknown or unreported safety risks can cause foodborne illnesses, which have significant societal costs (C)

According to a study by the World Bank Group and the The Netherlands government, India is hit by food borne diseases at a rate of $28 billion (Rs1,78,100 crore) a year, or 0.5% of the country's GDP [D].

As a result of poor refrigeration of perishable fruits and vegetables, they are discarded, leading to waste.

Perishable fruits and vegetables have shorter shelf life, the shelf life depends on factors such as temperature, humidity, CO_2 gas, and ethylene gas.

Some of the perishable fruits are apples, pomegranates, lemons and limes, some perishable vegetables are cabbage, potato, carrots, etc.

In India, 40% of fruits and vegetables are being wasted every year and it costs a total of 13,300 crores annually. The major symptoms are hunger crisis, high demands of certain items which lead to increased prices. It poses environmental problems including overall economic loss which worsens the hunger issue already prevailing. The demand-supply chain of the market is impacted, the main causes being the sudden increase in demand due to population explosion and sudden natural calamities. The technology could help the farmers decide what to charge for their vegetables and fruits according to the shelf life, helping them live a more prosperous life. In this paper, an attempt is made to develop a model that would help farmers to decide pricing based on shelf-life.

Some traditional methods are followed in India in order to reduce fruits and vegetables waste. Processing the fruits and vegetables culls to separate juice from pulp is one method but this requires proper working infrastructure and huge storage facilities. A tank is necessary for storing and transferring fruits and vegetables juices to the location to be used for the production of ethanol or anaerobic digestion. Like this several other methods exist but every method has some or other problem.

The paper is organized as follows. Section 2 deals with the related work. Section 3 deals with the methodology

used. Section 4 deals with the results and discussion. The paper is concluded in section 5.

II. RELATED WORK

In this section, the work carried out by various researchers have been discussed. Jaekwon Chung[E] studied the potential impacts of different pricing by considering consumer demand and no discount policy.

Using machine learning techniques, Iveren Blessing Iorliam et al [F] have predicted the shelf life of ladies finger, which is harmful if consumed after its shelf life. The machine learning model used parameters such as weight loss, firmness, titratable acid, total soluble solids, Vitamin C/Ascorbic acid content, and pH as inputs. Logistic Regression and K-Nearest Neighbor produced accuracy of 88.89% and 88.33%, respectively. With Support Vector Machine, Na*ve Bayes, and Decision Trees, 100% accuracy could also be achieved.

PASTEUR [G] has developed a wireless sensor platform that is able to monitor a far-wider range of environmental parameters than was previously possible, and extend environmental monitoring to crates and boxes of perishable goods along the logistics supply chain.

S. Nath et al [H] have developed an Evaporative Cooling Storage (ECS) facility with the aim to reduce the post harvest loss of fresh fruits and Vegetables.
Daily relative humidity and temperatures of 6 types of vegetables and 3 types of fruits were recorded along with the weight loss. Prior to, during, and before the products reached their point of termination, the chemical analysis for nutrient content, especially vitamins A and C, was conducted. It was found that the ECS efficiently maintained the shelf life of fresh produce by reducing respiration, lowering the temperature between 5 and 80C, slowing respiration, and maintaining a favorable environment, and reducing water loss by maintaining a relative humidity range of 90 to 93%.
Several research articles have been reviewed and summarized by Mona Haji et a [I]l, who identified different characteristics of the perishable food supply chain.
Among the technologies used in various phases of the food supply chain were radio frequency identification (RFID), the Internet of Things (IoT), blockchain, three-dimensional printing (3DP), autonomous vehicles, and unmanned aerial vehicles
(UAVs). According to the study, technological implementation enhances the efficiency and sustainability of the food supply chain and helps to retain the characteristics of perishable foods.

Pat Doody, and Patrick Moriarty [J] developed a sensor kit to improve conventional food storage and transportation, as well as extend product shelf life. The sensor kit is transported within the FreshBox container and it monitors the ambient environmental conditions to which the produce is exposed. A smart phone app subsequently uploads the CO2, O2, temperature and humidity data to the cloud. Locally recorded data is stored on a memory card and uploaded to the cloud later. This unit has been tested during the transport of fresh fruit and vegetables between Spain and Germany.

III. METHODOLOGY

This section consists of the detailed methodology used to carry out the work. The circuit was implemented using proteus software. Proteus is a proprietary software, used for electronic design automation. The hardware is implemented using an Arduino board and sensors are interfaced to measure the parameters such as Temperature, humidity, CO2 gas, ethylene gas. The sensors used in this model are:

1. DHT11 sensor

DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc… to measure humidity and temperature instantaneously. DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.

2. MQ135 and MQ2 sensor

MQ135 is a gas sensor which detects gasses like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gasses and smoke. The air quality sensor has a small potentiometer that permits the adjustment of the load resistance of the sensor circuit. MQ2 is a metal oxide semiconductor type gas sensor. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations anywhere from 200 to 10000ppm.

3. RFID

Radio Frequency Identification (RFID) refers to a wireless system comprising two components: tags and readers. The reader is a device that has one or more

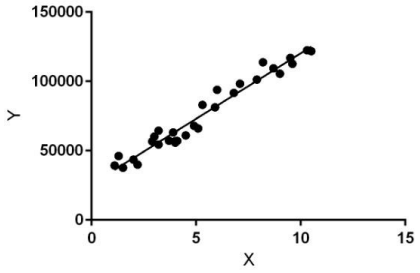
antennas that emit radio waves and receive signals back from the RFID tag. Tags, which use radio waves to communicate their identity and other information to nearby readers, can be passive or active. Passive RFID tags are powered by the reader and do not have a battery. Active RFID tags are powered by batteries. RFID tags can store a range of information from one serial number to several pages of data. Readers can be mobile so that they can be carried by hand, or they can be mounted on a post or overhead. Reader systems can also be built into the architecture of a cabinet, room, or building.

4. Arduino Uno

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output. The Arduino Uno has a number of facilities for communicating with a computer, another Arduino board, or other microcontrollers. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer. A SoftwareSerial library allows serial communication on any of the Uno's digital pins.

5. AL/ML MODEL

Linear regression performs the task to predict a dependent variable value (y) based on a given independent variable (x). So, this regression technique finds out a linear relationship between x (input) and y(output). Hence, the name is Linear Regression.



In the figure above, X (input) is the work experience and Y (output) is the salary of a person. The regression line is the best fit line for our model.

$$y = \theta_1 + \theta_2.x$$

While training the model we are given :

x: input training data (univariate – one input variable(parameter))

y: labels to data (supervised learning)

When training the model – it fits the best line to predict the value of y for a given value of x. The model gets the best regression fit line by finding the best θ1 and θ2 values.

θ1: intercept

θ2: coefficient of x

Once we find the best θ1 and θ2 values, we get the best fit line. So when we are finally using our model for prediction, it will predict the value of y for the input value of x.

Cost Function (J):

By achieving the best-fit regression line, the model aims to predict y value such that the error difference between predicted value and true value is minimum. So, it is very important to update the θ1 and θ2 values, to reach the best value that minimizes the error between predicted y value (pred) and true y value (y).

$$minimize \frac{1}{n}\sum_{i=1}^{n}(pred_i - y_i)^2$$

$$J = \frac{1}{n}\sum_{i=1}^{n}(pred_i - y_i)^2$$

Cost function(J) of Linear Regression is the Root Mean Squared Error (RMSE) between predicted y value (pred) and true y value (y).

Gradient Descent:

To update θ1 and θ2 values in order to reduce Cost function (minimizing RMSE value) and achieve the best fit line the model uses Gradient Descent. The idea is to start with random θ1 and θ2 values and then iteratively update the values, reaching minimum cost.

IV. RESULTS AND DISCUSSION

The entire methodology in brief:

At first the sensors are used to collect the data of the parameters like temperature, humidity, and gasses like ethylene and CO2, then the data collected are used along with the AI model trained using existing data sets. The RFID sensor tag is used to store the information from the various sensors in the model. The tags are then collected individually and information is extracted from them and given to the model which was trained earlier using the existing data sets. It will help in predicting the shelf life of the fruit/vegetable and dynamically calculate the price of the item. As the item is nearing its end of shelf life, the price is reduced so that it sells off quickly, hence reducing the wastage.

V. CONCLUSION

Some advantages of waste management concluded from the above method are:

- Wastage is reduced at each level of the supply chain.
- Prevention of environmental pollution.
- Problem of food scarcity can be solved.
- Good quality products will be available to all.

ACKNOWLEDGEMENTS

Authors would like to thank Mr. Suyash Bhatt, CEO and Co-founder FoodBud, Cambridge,UK for the constant support and guidance.

REFERENCES

B. 40% vegetables, fruits get wasted in India: IARI Director , available at : https://www.nationalheraldindia.com/national/40-vegetables-fruits-get-wasted-in-india-iari-director

1. Saurav Negi , Neeraj Anand, “Factors leading to losses and wastage in the supply chain of fruits and vegetables sector in India”,International Conference on Management of Infrastructure (ICMI) 2016 Energy, Infrastructure and Transportation:Challenges and Way Forward,pp I 89-I 105, 2016

2. Mason-D'Croz D, Bogard JR, Sulser TB, Cenacchi N, Dunston S, Herrero M, Wiebe K. “Gaps between fruit and vegetable production, demand, and recommended consumption at global and national levels: an integrated modeling study”, Lancet Planet Health. 2019 Jul;3(7):e318-e329. doi: 10.1016/S2542-5196(19)30095-6. PMID: 31326072; PMCID: PMC6637854.

3. Iveren Blessing Iorliam, Barnabas Achakpa Ikyo, Aamo Iorliam, Emmanuel Odeh Okube, Kenneth Dekera Kwaghtyo, Yahaya I. Shehu," Application of Machine Learning Techniques for Okra Shelf Life Prediction", Journal of Data Analysis and Information Processing, 2021, 9, pp 136-150

[D] Anika Sulania , “Food-borne diseases cost India US$ 15 billion in 2018”, THE NATIONAL MEDICAL JOURNAL OF INDIA VOL. 32, NO. 3, 2019

[J] Integrated sensors kit for investigation of perishable produce shelf-life extension

Increasing the shelf life of lemons and beetroots using chemical and drying methods

*Easha Rathnamala , Nidhi P Maniyal , Niharika A , Rashmi SS**

Department of Biotechnology, B.M.S College of Engineering, Bangalore, India

**Correspondence to:*

Tel: +91-9611581712

Mail to: rashmi66@gmail.com (Dr Rashmi S Shenoy)

Abstract

Fresh and minimally-processed fruits and vegetables (MPFVs) have seen tremendous growth in recent years as a consequence of a shift in customer views as a result of their increased use in mixed salads for fresh, healthful, and convenient eating. Handling and mechanical cutting and peeling activities cause injuries and the release of cellular contents on-site, which encourage the growth of hazardous microorganisms. There is a pressing need to develop innovative methods for preserving the quality of fruits and vegetables for extended periods of time.Although numerous technologies and chemicals may be employed to achieve a similar reduction in microbe counts without producing toxic compounds or harming the quality of fresh produce, the food industry has only accepted a small number of them. In this context, we investigated the impact of chemical and drying processes on the shelf life of beetroot slices and lemon juice. Both sets of samples were freeze-dried and then dried in a hot air oven.After that, the samples were pulverized and nutritional analysis for various components was carried out. According to the findings, freeze-drying was more successful in the preservation of beetroot, whereas pasteurization was more effective in the preservation of lemon juice.

Keywords: Hot-air oven drying, freeze-drying, pasteurization, Sodium benzoate, Potassium metabisulphite, shelf life, drying, beetroot, lemon**.**

1. Introduction

The biological activity of red beetroot (*Beta vulgaris rubra*) and its potential utility as a health promoting and illness-preventing functional food has sparked interest in recent years. The numerous nutrients in this plant have attracted scientists' interest. Betalains, glycine betaine, polyphenols, betacyanins, nitrates, flavonoids, saponins, vitamins, carotenoids, minerals, folates, and ascorbic acids are only a few of the active chemicals found in beetroot [1-2]. Antioxidant, anti depressant, anti-microbial, antifungal, anti-inflammatory, diuretic, expectorant, and carminative are only a few of the medical properties of this plant. It is a natural diet that stimulates energy in athletes since it contains one of the highest levels of nitrates and sugar of any plant. [3]

Due to its abundant source of nitrate (NO^{3-}), a chemical with possible therapeutic effects on cardiovascular illnesses through the endogenous generation of nitric oxide (NO)[4], beetroot has gained a significant amount of scientific interest among vegetables. The recent beetroot craze has centered on dietary sources of betalain, which have been shown to provide considerable health advantages. Because of these health benefits, betalains are used in the food industry as natural nutritional supplements, colorants, or food additives. Betalains, for example, have been used in a variety of culinary products (such as juice, sweets, and yogurt) that are mostly made from economically exploited red beetroot [4]. The large amounts of betalains in beetroots give them their vivid red colour. Betalains are natural colourants utilised in the food business, but they are also gaining popularity due to potential health advantages in humans, particularly their antioxidant and anti-inflammatory properties. Betacyanins and betaxanthins are the two most common betalains identified in beetroot [3]. Aside from the bioactivities listed above, betalain can also help to avoid cardiovascular illnesses and disorders caused by chronic inflammation [4].

Lemon (*Citrus limon Burm. f.*) is a medicinal plant that belongs to the Rutaceae family. After orange and mandarin, lemon is the third most significant citrus fruit. Lemon plant fruits are prized for their rich flavonoid, vitamin C, citric acid, and mineral content. Lemons are preferred by many customers throughout the world as a fruit because of their great flavour and acidity, as well as the potential applications of lemons in value-added food products. Due to its pleasant taste and therapeutic properties, lemon juice in the form of a beverage is liked by people of all ages, including youngsters and the elderly. Because lemon fruit is sensitive to chilling injury and has a short shelf life, it is necessary to prepare it as juice to reduce the surplus in the market during its

peak season of production. Fruit preservation in the form of juices has emerged as a significant business activity, with countries with abundant fruit resources and short harvesting seasons focusing more on established storage to maintain fruit quality, extend shelf life, and preserve fruit juices for off-season availability [6].

The goal of this project was to identify the most efficient method of increasing the shelf lives of lemon and beetroots for the consumers to exercise the benefits they offer completely. In this project, comparative studies have been conducted to arrive at the best method of increasing the shelf life of lemons and beetroots.

1.1 Background information

Fruit and vegetable drying is one of the oldest ways of food preservation known to man, and it is also the most crucial procedure for food preservation because it has a significant impact on the quality of dried items. The main goal of drying agricultural products is to reduce the moisture content to a level that permits them to be stored safely for an extended length of time. It also results in significant weight and volume reductions, lowering packing, storage, and shipping costs. Beetroot was dried using two different methods: freeze-drying and hot air drying.

One of the most regularly utilised drying processes is hot air drying. It has several advantages, including great drying efficiency, ease of operation, low cost, and minimal environmental impact. There hasn't been much investigation into the effects of various hot air-drying temperatures on the drying characteristics and physicochemical qualities of beetroot slices. The drying rate curve, colour, betalains and total phenol content, and antioxidant capacity of beetroot slices dried at various drying temperatures were studied for this purpose [1].

Freeze-drying is based on the dehydration of a frozen substance through sublimation. Most degradation and microbiological reactions are stopped due to the lack of liquid water and the low temperatures required for the procedure, resulting in a final product of good quality. During freeze drying, the solid state of water protects the primary structure and shape of the products while reducing the volume to a minimum [5].

Two methods were used to preserve lemon juice: the first was to utilize chemical preservatives, and the second was to pasteurise the juice. With the rising cost of producing new chemicals and regulatory limits on current ones, interest in heating procedures such as pasteurisation has grown again [7]. Thermal pasteurisation is a gentle form of heat treatment that is used to inactivate heat

sensitive microorganisms that cause food deterioration or food poisoning, such as vegetative bacteria, yeasts, and moulds [8]. Food preservatives are chemical additions that prevent food from deteriorating due to enzymes, bacteria, or oxygen exposure. All chemical preservatives must be nontoxic and easily soluble, have no off-flavours, have antibacterial capabilities over the pH range of the food, and be cost-effective and practical [9]. These food preservative compounds provide significant benefits to humans, not only in terms of food preservation and palatability, but also in terms of protecting against the harmful consequences of reactive oxygen species (ROS), which are linked to cancer, cardiovascular disease, and aging [10].

The design constraints encountered in our project are: For beetroot, it is expected to retain the shelf life up to 12 months, beyond which the quality deteriorates. Experimental errors could lead to inaccurate results. Drying should be done at a temperature of 70 ± 2°C. While storing, the beetroot powder should not be exposed to moisture. For lemons, it is expected to retain the shelf life up to 90 days, beyond which the quality deteriorates. Experimental errors could lead to inaccurate results. Pasteurization must be carried out in inappropriate conditions. The lemon juice should be stored at 4° C.

1.2 Specification and Design

There are several ways employed in the waste management of perishable fruits and vegetables. The most popular approach is increasing their shelf lives. The various methods used to increase the shelf of fruits and vegetables are shown in the flowchart below.

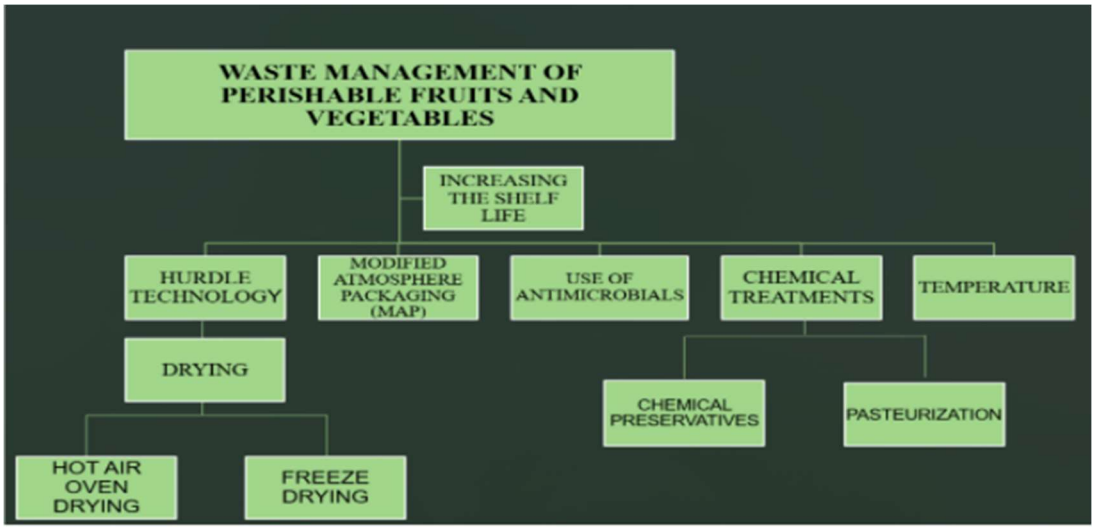


Figure 1: Various techniques used to increase the shelf life of beetroot and lemons

The people who are impacted by this issue are farmers, distributors, transporters and consumers. This is because perishable fruits and vegetables are greatly impacted by temperature. If the temperature is too high it can lead to an increase in the growth of microorganisms resulting in spoilage of fruits and vegetables, if the temperature is low it can create cold injuries thus making the product unmarketable [11]. The low shelf life of the food can cause bruises, discolouration, slimy patches and unpleasant odor and taste [12]. After the harvest, there are chances of diseases being caused to the crop by bacteria and fungi.

The methods used in this project to increase the shelf life of beetroots are hot air oven drying and freeze-drying and for lemons are chemical preservation and pasteurization. The drying methods are industrially very efficient and cost-effective techniques. The use of drying offer many advantages such as the increased market value of the higher quality product assured income due to reduced weather risk and higher income from being able to process a higher amount of product in a particular period. The chemicals preservatives are beneficial to the health as well in terms of cost. Pasteurization treatment is a beneficial alternative to conventional thermal processing in lemon juice pasteurization, since appropriate inactivation levels of pathogenic and spoilage microorganisms can be reached while better preserving the quality attributes of fresh juice throughout its shelf-life [13].

Figure 2 A - The lemon sample after pasteurization and chemical method

B - The beetroot sample before hot air drying and freeze-drying

C - The beetroot sample after deep freeze-drying

2 Material and Methods

2.1 Sample Preparation

The recent beetroots (Beta vulgaris) were purchased from the native vegetable market within the town of Bengaluru and hold on at four four till use. Beetroots were washed with cold water stainless-steel knives. The peeled beetroots were sliced into five millimeter slices and therefore the slices were unfold equally for decent air drying. The slices were placed in stainless-steel trays and dried to constant weight at 60±2.0°C for six hours. For the Freeze drying method, the sliced product was placed in a deep-freeze for twenty-four hours at a temperature of - 85°C so transferred into a freeze appliance at a temperature of -107°C for six hours. The dried sample was then powdered in a mixer.

2.1.1 Total Phenolic Content Determination

Folin-colorimetric Ciocalteu's method was used to assess total phenolic content, as previously[14]. The Folin-phenol Ciocalteu's reagent (0.15 ml) was added after the methanolic extracted solution (0.1 ml) was placed in a test tube and the volume was increased to (0.5 ml) using distilled water. The contents were vortex combined and mixed with 0.5 mL saturated sodium carbonate solution, then distilled water was added to make the volume 5 mL. Vortexing was used to fully mix the substances in the tubes. The tubes were left at room temperature for 5 minutes until the typical blue colour appeared.The control was made in the same way, but distilled water was used instead of the extracted solution (0.5 ml). A spectrophotometer was used to measure the absorbance of the clear supernatants at 690 nm (Genesys 10S UV-VIS). Total phenolic content was determined and represented as mg Gallic acid equivalent per gm sample using gallic acid as a standard. All of the analyses were carried out in duplicate.

2.1.2 Total Flavonoids Determination

The total flavonoids content of beetroot extracts was determined using a colorimetric method described by Kumar. P. T et al [15]. Ethanolic extraction solution (0.1 ml) was placed in a test tube, and the volume was increased to (0.5 ml) by adding methanol and 0.1 ml of 10% aluminum chloride. The contents were vortex combined and mixed with 0.1 mL saturated sodium acetate

solution, then methanol was used to adjust the volume to 5 mL. Vortexing was used to fully mix the substances in the tubes. In the dark, tubes were allowed to stand at room temperature for 45 minutes. The control was made in the same way as the experimental group, except the extracted solution was replaced with methanol (0.5 ml). A colorimeter was used to test the absorbance of the clear supernatants at 420 nm (Genesys 10S UV-VIS). Total flavonoid concentration was determined and represented as mg quercetin in methanol equivalent per gm sample using quercetin in methanol as a standard. All of the analyses were carried out in duplicate.

2.1.3 Determination of Betalains Compounds.

0.1 gm of the materials were dissolved in 10 ml of 70% ethanol, agitated for 10 seconds, and the homogenate centrifuged for 10 minutes at 6000 rpm. After centrifugation, the supernatant was collected as is, and the process was performed two more times to guarantee maximum betalains extraction. The supernatant was also utilised to determine the amount of betalains in the sample. Using a UV-Vis spectrometer, the amount of betaxanthins and betacyanins in the extracts was assessed spectrophotometrically at 538 nm and 480 nm, respectively, according to Stintzing and Carle's procedures.[16]. For each sample, the absorbance reading was used to compute the betalain concentration. Betacyanins and betaxanthins were added together to make total betalains. The results are given in milligrammes of total betalains per gramme of dry weight.

2.1.4 Determination of Moisture Content

The hot air oven drying method was used to assess the initial moisture content of fresh beetroot. For 10 minutes, a precisely weighed sample of beetroot (100 gm) was baked in a laboratory oven at a constant temperature of 60°C. Every 10 minutes, the samples were weighed until a consistent value was achieved. The average moisture content and loss of drying value were calculated using three replications.

$$\% \text{ MC} = \frac{weight\ of\ water\ in\ the\ sample}{weight\ of\ dry\ sample} \text{X100}$$

$$\% \text{ LOD} = \frac{weight\ of\ water\ in\ the\ sample}{Total\ weight\ of\ wet\ sample} \text{ X100}$$

2.2 Preparation of Sample

Fresh lemons were purchased by the local market from Bengaluru. Only sound lemon fruits were taken for juice extraction after being washed completely with water to eliminate dirt and debris and carefully assessed for size and shape. Fruits were split in half and juice was collected by pressing the fruit pieces in a citrus juice machine that was controlled manually. To remove the sediments and pulp elements, the expressed juice was passed through a single layer of muslin fabric. Filtered juice was poured into glass bottles that had been sterilized.

Preservation of juice was done by two methods using chemical preservatives and pasteurization.Chemical preservatives such as potassium metabisulphite (0.1%) and sodium benzoate (0.1%) were added to filtered juice. Juice in sealed bottles was heated to 80^{o} C for 15 minutes before being cooled under running tap water. A control sample of untreated juice was taken. The juice samples, both processed and controlled, were labelled and kept at 4°C for 30 days.

2.2.1 Determination of Ascorbic acid

The sample was combined with 50mL of a 5% metaphosphoric acid acetic acid solution before being transferred to a 250mL conical flask. The flask was then filled with the remaining 50ml of phosphoric acid solution. The solution was then filtered with Whatman filter paper, and the filtrate was collected for vitamin C analysis.

A few drops of bromine solution were added to the filtered sample solution and stirred. To prevent access to the bromine solution, a few drops of thiourea solution were added to the sample solution. The sample solution and all of the standard calibration curves (5,10,15,20,25g/ml) were then given 1ml of 2,4 DNPH solution.The 2,4 DNPH solution causes the coupling process. All of the standards and sample solutions were maintained at 37°C for 3 hours to complete the reaction. After 3 hours, the solutions were chilled in an ice bath before adding 5ml of H2SO4. According to the procedures of Anal Parimal Desai and Shuchi Desai, coloured solutions were created whose absorbance was measured at a certain wavelength [17].

2.2.2 Determination of Citric Acid

A workable solution (0.1M) was generated after sodium hydroxide pellets were calibrated against

sodium hydrogen sulfate. Anhydrous citric acid was employed, and it was calibrated against NaOH. In each titration experiment, the phenolphthalein indicator solution (3–4 drops) was utilized throughout the investigation. The citric acid content in all samples was determined using acid-base titration [18].

2.2.3 Determination of Tannins

250 mg of lemon juice sample was extracted with 10 ml of 100% methanol and left it overnight. The volume was brought up to 25 ml with 100 percent methanol and filtered through Whatman filter paper. 5 ml of 4 percent vanillin + 8 percent HCl solution was added to 1 ml of aliquot and left for 5-10 minutes. All other readings were subtracted from a blank of the same composition but without the extract. [19]

2.2.4 Determination of Total Soluble Solids

A refractometer was used to determine the total soluble solids. A few drops of the sample were dropped between the prisms of a refractometer, the Brix measurement was recorded, and the percent sucrose or TSS was calculated using the International Temperature Correction Table, 1936.

2.2.5 Determination of Reducing Sugars

Transfer equal quantities of solution A and solution B into a dry flask and thoroughly combine when Fehling's solution is required. Only make enough to meet your immediate needs because this solution will degrade over time. 1.25 grams of pure anhydrous glucose, accurately weighed and dissolved in water You can make up to 250cm3 in a standard flask. Fill a burette halfway with this solution. Fill the conical flask halfway with Fehling's solution and 25cm3 of Fehling's solution. 25cm3 distilled water should be used to dilute. The red copper (I) oxide will settle if the solution is allowed to cool at regular intervals.Then, against a white backdrop, tilt the flask to one side and study the solution. Bring the glucose solution to a boil each time you add Fehling's solution. Based on the results of the titration, the equivalent amount of glucose that reacts with 1cm3 of Fehling's solution was estimated.

3. Results

Table I shows the effect of different drying methods on bioactive compounds of beetroot slices. Oven drying of the slices significantly reduced the total betalain but freeze-drying did not have a significant effect on betalain contents. The total phenolics of fresh beetroot was significantly increased after oven drying. However, freeze-drying did not have a significant effect on total phenolics.

Table 1 - Nutritional Analysis of Beetroot

S. NO	SAMPLE	BETALAIN CONTENT (mg/100gm)	TOTAL PHENOLIC CONTENT (mg GAE /gm)	TOTAL FLAVONOIDS (mg QE/gm)
1	FRESH	123.*26* ± 0.59	33.48 ± 0.40	38.72 ± 0.48
2	OVEN DRYING	120.23 ± 0.48	43.70 ± 0.37	34.49 ± *0.39*
3	FREEZE DRYING	122.60 ± *0.41*	34.39 ±*0.27*	38.67 ± *0.46*

Table II shows the effect of pasteurization and chemical preservatives on the bioactive compounds of lemon juice. There was an increase in the total reducing sugars in both the pasteurized and chemically treated samples as compared to the fresh samples but there was no significant change in the level of tannins in both the samples.

Table II- Nutritional Analysis of Lemon juice

S .NO	SAMPLE	REDUCING SUGARS (mg /100ml)	TANNIN CONTENT (mg/100ml)
1	FRESH	620.91 ±0.12	53.51 ± 0.41
2	SODIUM BENZOATE + POTASSIUM METABISULPHITE	700.51 ± 0.21	54.94 ± 0.32
3	PASTEURIZATION	690.13 ± 0.39	54.64 ± 0.24

4 Discussion

Table I shows that betalains reduced significantly as a result of drying which is consistent with prior research indicating that these compounds are sensitive to high temperatures [20]. It has been reported that the thermal stability of betalains is influenced by a variety of physicochemical variables, the most important of which are heating conditions [20]. Betalains are extremely sensitive to light, heat, and oxygen. The amount of betalain in whole beet powder and its antioxidant activities are affected by the drying temperature [21]. However, freeze-drying was found to be an ideal way of drying in this study because it requires a low temperature. The results for total phenolics in this study showed that increasing the temperature during drying
increased total phenolics in beetroot.

Hydrolysis of starch to sugars in the juice during storage could explain the rise in lowering sugars. Earlier research reported an increase in sugars in lemon and orange juice after storage [22]. The findings were similar to those of other research, which found a considerable rise in reducing sugars in pomegranate juice stored at room temperature. Tannins in juice may have been reduced due to their condensation into brown pigments during storage. These findings matched earlier research that showed a decrease in tannin content in kinnow-RTS after 24 weeks of storage at ambient temperature [23].

5 Conclusion

In the present study, it was noticed that the chemical properties of beetroot and lemon juice were affected by different preservation treatments, storage temperature and storage periods. The findings of the present investigation suggest that the untreated beetroot and lemon juice cannot be stored at room temperature for more than a week. But by using drying and pasteurization, they are expected to have a shelf life of a year and 90 days, respectively.

Based on the results obtained from this project, novel techniques of increasing the shelf life of beetroots and lemons can be developed by using the effective pre-existing methods as a foundation for the same. Future research can be based on developing drying methods that use natural resources to preserve beetroots. Freeze-drying is more efficient and hence drying techniques can be developed which maintain similar conditions as that of freeze-drying and also employ the use of natural resources to the maximum.

Pasteurization has proven to be the more efficient method to preserve lemons. In the future, this technique can be modified in order to improve the shelf life of lemons.

Due to the global pandemic of Covid 19 prevailing, the time available for the conduction of wet lab experiments for this project was limited. This gives an opportunity for future researchers to work on the areas which could not be covered during this project.

6 References

[1] Liu, Yan, Zhenhua Duan, and Sergey Sabadash. "Effect of hot air drying temperatures on drying characteristics and physicochemical properties of beetroot (Beta vulgaris) slices." In *IOP Conference Series: Earth and Environmental Science*, vol. 615, no. 1, p. 012099. IOP Publishing, 2020.

[2] Clifford, Tom, Glyn Howatson, Daniel J. West, and Emma J. Stevenson. "The potential benefits of red beetroot supplementation in health and disease." *Nutrients* 7, no. 4 (2015): 2801- 2822.

[3] Chawla, Harsh, Milind Parle, Kailash Sharma, and Monu Yadav. "Beetroot: A health promoting functional food." *Inventi Rapid: Nutraceuticals* 1, no. 1 (2016): 0976-3872.

[4] Kale, R., A. Sawate, R. Kshirsagar, B. Patil, and R. Mane. "Studies on evaluation of physical and chemical composition of beetroot (Beta vulgaris L.)." *International journal of chemical studies*

6, no. 2 (2018): 2977-2979

[5] Hammami, Chokri, and Frédéric René. "Determination of freeze-drying process variables for strawberries." *Journal of food engineering* 32, no. 2 (1997): 133-154.

[6] Sindhu, Ritu, and Bhupendar Singh Khatkar. "Preservation and storage of Lemon (Citrus Limon) Juice." *International Journal of Advanced Engineering Research and Science* 5, no. 3 (2018): 237408.

[7] Amin, Md Nurul, and Md Mosharraf Hossain. "Reduction of postharvest loss and prolong the shelf-life of banana through hot water treatment." *Journal of Chemical Engineering* 27 (2012): 42-47.

[8] Ağçam, Erdal, Asiye Akyıldız, and Burcu Dündar. "Thermal pasteurization and microbial inactivation of fruit juices." In *Fruit juices*, pp. 309-339. Academic Press, 2018.

[9] Ruth MacDonald, Cheryll Reitmeier. “Understanding Food Systems” Academic Press, 2017.

[10] Parke, D. V., and D. F. V. Lewis. "Safety aspects of food preservatives." *Food Additives & Contaminants* 9, no. 5 (1992): 561-577.

[11] Mercier, Samuel, Martin Mondor, Ultan McCarthy, Sebastien Villeneuve, Graciela Alvarez, and Ismail Uysal. "Optimized cold chain to save food." *Saving food* (2019): 203-226.

[12] Kilcast, David, and Persis Subramaniam, eds. "The stability and shelf-life of food." (2000).

[13] Kaya, Zehra, Semanur Yıldız, and Sevcan Ünlütürk. "Effect of UV-C irradiation and heat treatment on the shelf life stability of a lemon–melon juice blend: multivariate statistical approach." *Innovative Food Science & Emerging Technologies* 29 (2015): 230-239.

[14] Guo, Xu-Dan, Yu-Jie Ma, John Parry, Jin-Ming Gao, Liang-Li Yu, and Min Wang. "Phenolics content and antioxidant activity of tartary buckwheat from different locations." *Molecules* 16, no. 12 (2011): 9850-9867

[15] Kumar, P. T., P. Kalita, T. K. Barman, T. K. Chatterjee, and S. Maity. "Quantification of total flavonoid content and antioxidant activity in comparison to a reference flavonoid as in vitro quality evaluation parameter for assessing bioactivity of biomarkers in herbal extracts or formulations." *JPR: BioMedRx: An International Journal* 1, no. 8 (2013): 757-766.

[16] Herbach, K. M., F. C. Stintzing, and Reinhold Carle. "Impact of thermal treatment on color and pigment pattern of red beet (Beta vulgaris L.) preparations." *Journal of Food Science* 69, no. 6 (2004): C491-C498.

[17] Manyazewal, Tewodros, and Tesfaye Walelgn. "UV Spectroscopic Method for Determination of Vitamin C (Ascorbic Acid) Content in Different Fruits in South Gujarat Region." *International Journal of Environmental Sciences & Natural Resources* 21, no. 2 (2019): 45-50.

[18] Brima, Eid I., and Anass M. Abbas. "Determination of citric acid in soft drinks, juice drinks and energy drinks using titration." *Int J Chem Stud* 1 (2014): 30-34.

[19] Gupta, Chitra, and Rohit Verma. "Visual estimation and spectrophotometric determination of tannin content and antioxidant activity of three common vegetable." *International Journal of Pharmaceutical Sciences and Research* 2, no. 1 (2011): 175.

[20] Ravichandran, Kavitha, Nay Min Min Thaw Saw, Adel AA Mohdaly, Ahmed MM Gabr, Anja Kastell, Heidi Riedel, Zhenzhen Cai, Dietrich Knorr, and Iryna Smetanska. "Impact of processing of red beet on betalain content and antioxidant activity." *Food research international* 50, no. 2 (2013): 670-675.

[21] Gokhale, S. V., and S. S. Lele. "Betalain content and antioxidant activity of Beta vulgaris: effect of hot air convective drying and storage." *Journal of Food Processing and Preservation* 38, no. 1 (2014): 585-590.

[22] Kowalski, S. J., and J. Szadzińska. "Kinetics and quality aspects of beetroots dried in non stationary conditions." *Drying Technology* 32, no. 11 (2014): 1310-1318.

Modernization of Traditional Cold Storage to Increase Shelf Life of Perishable Fruits & Vegetables

Thanush Gowda R
UG Scholar
Vidyavardhaka College of Engineering
Mysuru, Karnataka

Sneha Sanjeev Yalamalli
UG Scholar
Vidyavardhaka College of Engineering
Mysuru, Karnataka

Bhargavi K
Assistant Professor
Vidyavardhaka College of Engineering
Mysuru, Karnataka

Sapna H M
UG Scholar
Vidyavardhaka College of Engineering
Mysuru, Karnataka

Abstract: **The entire Fruits and Vegetables supply chain in India is riddled with problems and challenges. In growing markets like India, wastage in the perishable fresh produce fruits and vegetables supply chain from harvest to consumer is quite high. So, in this paper, we will explore the management of India's perishable fruits and vegetables business, as well as the difficulties that it faces. This study was conducted using descriptive research. The Fruits and Vegetables supply chain has been outlined, and an attempt has been made to identify the challenges influencing the sector's supply chain. The current work conducts a thorough analysis of the available basic and modern literature and attempts to explain it.**

I. INTRODUCTION

The farmers producing perishable fruits and vegetables are not being sold completely within the shelf life,the half of the crop produced is being sold while the other half is being wasted due to less shelf life therefore, the profit is not gained.When the produce is more, the demand is less thus selling the produce is lesson, which is leading to depression to farmers.The problem is observed in each and every farmer's life, but we have considered Mysore, Karnataka as location. The main victims are the farmers then the wholesalers, but the customers are less impacted.The problem is being observed since the day one of the farming.The problem can be observed by talking to the farmers because of lack of profit the farmers have lesson harvesting and cultivation . coming to the wholesalers, the stock is being left in the storage room which is being spoiled. Every time a farmer tries to cultivate perishable fruits and vegetable, the problem is being observed. since it's ongoing process it is observed on the daily basis.

As per the problem statement, by using traditional method the excessive produce will be utilized in the best ways:

i) By vacuum sealing.
ii) Cold storage method.
iii) Value addition.
iv) Cryogenic preservation of seeds.

By these methods, the shelf-life of fresh produce will be extended/prolonged and will be environmentally sustainable.These methodswould lead us to make maximum profit as well or to take complete advantage of the produce.

II. LITERATURE SURVEY

Aloe Vera is a succulent plant species of genus Aloe having over 500 variants. Aloe Vera extract may be used as bio-preservative for many fruits and Vegetables for maintain freshness and to increase its storage capacity. There are many advantages of using Aloe Vera gel as a key supplement to store fruits and vegetables. The main reason to use Aloe Vera as bio-preservative is because it made a huge loss while transporting and storing it in more sunny areas. To maintain this, food colours were used which eventually led to its damage. The rate at which water is lost depends on the difference in the vapor pressure between plant is atmosphere called as vapor pressure deficit (VPD). There is a huge decrement in product loss when survey was conducted in San Jorge only 10-20% of them were being wasted & used their regular routine in maintain products. Finally, Aloe Vera is used as moisture capture agent & keeps the product fresh and clean and which ultimately acts as effective bio preservative. Coming to the methods and material used in the process,

Fruit or vegetable sample quantity becomes the main Priority. After this cleaning is done and they are processed to further treatments.

Extraction of Aloe Vera gel happened to use several internal processing's like flaking, slicing, crushing, and separating to extract gel.

Treatment and designing happens in (RCBD) with some statistical values. They are divided into 3 factors. a) sampled, b) level of aloe Vera, c) Length of dipping time.

After the testing is done, data collection becomes the most crucial thing to note down it's on basis of percentage of ripened, weight loss, colour and live visibility, pH, acidity& many more.

After the treatment and statistical designing, discussion on comparing and making it to an average Value on statistical analysis is done based on the previous steps. Similarly, all the individual fruits and vegetables are now assigned with their treatment parameters and approximation is done using bar graphs. As keeping weight loss and gain of the product as major criteria , conclusion can I be delivered as 25-50% Aloe Vera extract with water can lower the weight loss , fast ripening is hindered ,soluble solids , acidity , appearance defect all are reduced to keep fruits and vegetables fresh and

healthy. This is how bio- preservatives act as a boon to conserve resources as well as to keep a man healthy. [1].

Using Aloe Vera gel as a Novel Edible Coating should be observed keenly because it is consumed directly. Many researchers have taken place declaring the use of enzymes, polysaccharides and other starches as effective natural Coating but aloe Vera seemed to be an interesting yet thinkable to use on fruits to maintain its storage capacity and early ageing. Synthetic films are not as good as edible films So people prefer to use edible films which is under great demand and researchers are working on it using many trial & error components to delay the spoilage offruit qualities. Aloe Vera is a succulent plant species of genus Aloe which means "Herb" it has many benefits on human body. Aloe Vera is a water reluctant plant with outer thick leafy layer and inner gel. It includes many nutrients &active compounds which also act as a diet supplement to overcome food allergies. Aloe Vera has 2 components based on class and compound, where class contain all the essentials like vitamin, amino acids, enzymes etc.--and the compounds contain the contents present in that class. Aloe Vera gel matrix is available as the second layer of the aloe Vera leaf which is parenchyma tic in nature. The gel is taken to remove fibre and then pasteurized. Aloe Vera gel acts as an antimicrobial agent by preventing the growth of fungus, bacteria (both the types appearing purple on gram staining and reddish on gram staining), virus and parasites on fruits. Aloe Vera gel is an alternative to Synthetic film coating because people are being fooled by using many harmful synthetic chemicals which can cause a threat to life. But Aloe Vera gel is colourless, doesn't smell bad and free from toxics which makes fruits to look fresh and healthier. Aloe Vera gel has all positive effects on fruits with their reactivity pattern,

- Taking weight loss into consideration it acts as protective shield to lock moisture and avoid water loss from fruits.
- Delay percentage drastically reduced when it is coated by aloe Vera gel preventing the growth of microbes.
- colour plays a major role in detecting fruit's freshness. when aloe Vera coating is done it delays the discoloration of fruits due to moisture locking Capacity.
- Firmness matters a lot while purchasing fruits because we can feel its texture, smoothness and hardness and can decide its lifetime. This can be kept even fresh by aloe gel coating.
- Respiration rate is one of the main factors influencing the growth and development. As temperature is high, due to transpiration high respiration takes place which causes damage.

To conclude with the efficiency of fruit Consumption is very high and due to all these negative factors, there should not be any imbalance in the economy. So keeping all these factors in mind one has to take initiative in making things go easy, affordable and healthy by using plants like Aloe Vera as edible coating and keeping the health and economy rich by balancing the fruit's shelf life requirements. [2].

This paper details the process of designing, testing and developing an integrated sensors kit for recording a range of environmental parameters within a newly developed transportation unit called Fresh Box. It has been designed to extend product shelf life as well as other improvements on conventional food storage and transportation. The sensors kit is transported within the Fresh Box container and monitors the ambient environmental features to which the produce is exposed. CO2, O2, temperature and humidity levels are all recorded locally on a memory card and uploaded to the cloud at a later stage via a smart phone app.

Sensor's functionality and initial findings, the optimum range for CO2 sensitivity should be 0-20%. CO2 sensor technology ranges from non-dispersive (NDIR) sensors for gas detection to heating elements with solid electrolyte. A total of seventeen sensors were shortlisted with three in particular identified as being very suitable for the project. The optimum range for O2 sensitivity should be 1-20%. A set of oxygen sensors was shortlisted, all of which work on a galvanic cell system. Using this system, the sensors do not impinge on the oxygen atmosphere. Communications Protocol, Low-power Wi-Fi and Bluetooth smart modules were proposed as communications protocols for Fresh box. Bluetooth smart was selected ahead of Bluetooth classic v2.1 as the former uses 20 to 100 times less power. Data transfer rates and functionality met with the requirements for Fresh box also. Another feature worth monitoring was Ethylene.an effective method of Ethylene level recording was through the measurement of Methane in the range 0-3%. by measuring Methane gas levels, a correlated measurement of Ethylene could be asserted. The development of a fully integrated sensors kit was completed. The kits have been deployed in the field and the data has been collected and analysed. A new circuit board may be added to the existing P.C.B. to replace the existing components for the advancement of the kit. [3]

Automation has came an important part of moment's world for which IOT has surfaced as an excellent platform furnishing connectivity between various sensors, controllers and internet that enables remote monitoring and controlling of different environments subject to automation. and internet that enables remote monitoring and controlling of different surroundings subject to robotization. Inventory Management System grounded on light- weight MQTT protocol which enables the stoner to cover and control the storehouse conditions of fruits/ vegetables all the time through the web runner access for perishable fruits and vegetables storing storages. This includes an overview and relative results of two implicit M2M communication protocols, MQTT and COAP, in terms of bandwidth consumption and network quiescence. There's an enormous advancement in the world of robotization. IoT is used to make the Machine-To- Machine (M-2-M) communication easy and flexible exercising bias, detectors to record environmental conditions of areas under robotization, covering their affair, acquiring immediate data and

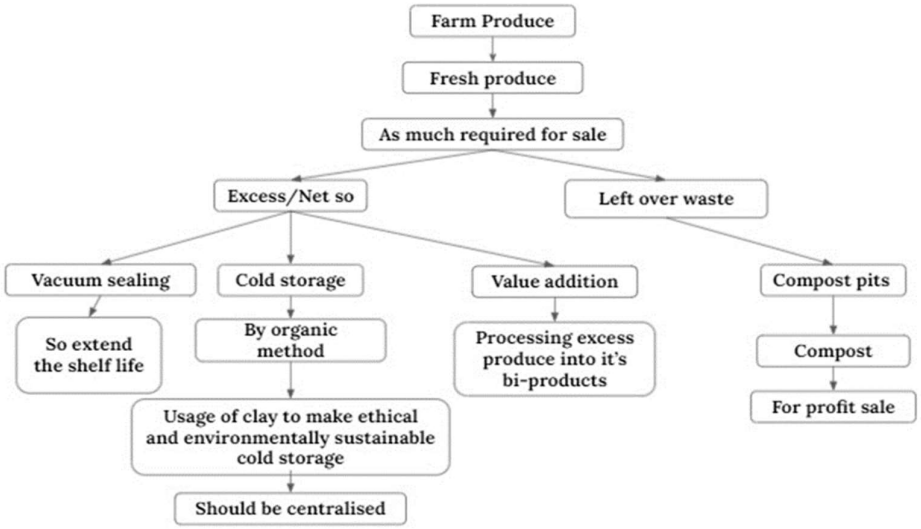


Figure 1: Different methods of managing perishable fruits

modernize it to internet. Reflects the operation of Light weight MQTT-IOT protocol in the design of automated storehouse system which will enable one to ever manage his Storehouse from anywhere, anytime using jeer pi as a network gateway. This system enables remote monitoring of temperature and moisture content of storehouse and provides rotting discovery of fruits/ vegetable by seeing the quantum of ethylene content in air along with the dynamic database updates which ensures an effective storehouse system design. MQTT and COAP protocols are reviewed and tested. Methodology The enforced system is shown in which the detectors similar as DHT11 and RFID label anthology are directly interfaced to the Raspberry Pi and are mounted at the entrance of the particular area/ rack whereas the ethylene gas sensor is wirelessly connected through ZigBee so as to keep inside the area/ rack in real time script to get precise ethylene position readings. When the new sack/ box is brought to storehouse its ID is scrutinized by RFID anthology and transferred to R-Pi which records the time of appearance of the Sack/ Box. Also the temp and moisture readings along with the ethylene situations are collected and are being transferred to the separate subscriber. We can improve the storage system by adding some controlling part using the publish/ subscribe armature of MQTT. This will evolve to make MQTT subscriber to act as publisher also so as to control the conditions in storehouse. The system can be made further secured by using secure interpretation of MQTT called secure MQTT which runs on harbourage number 8883. [4].

Papua New Guinea, (PNG) is basically an agricultural country and most of the population depends on subsistence agriculture. As the adoption of improved farming techniques in the highlands of Papua New Guinea, many rural farmers are farming fresh fruits and vegetables at a commercial and semi-commercial production level in order to meet the demand of growing population. Since there are four regions, among them these highlands contributed a lot, the production of fruits and vegetables is labour intensive work in PNG but quite remunerative for small and marginal farmers. Unfortunately, the storage facility for fresh fruits and vegetables at the rural farmer's level is non-existent and the produce is mainly transported on heads, open trucks and as baggage in buses. Since it was high loss of fresh produce encountered due to lack of proper post-harvest techniques. The storage facility caused mechanical damage and the produce overheats causing further damage to produce. This situation forced the farmers to adopt distress sale of the produce. According to Jobling, (2000), failure to sort or otherwise damaged produce creates problem in the subsequent handling and marketing of the produce. Fresh fruits and vegetables are extremely perishable and have a relatively short shelf life. They are living biological systems and they deteriorate after harvest, and they are respiring product that also senesce and dye after harvest. The Freshly harvested fruits and vegetables are mostly comprised of water with most having 90 - 95% moisture content. One of the most serious post harvest conditions was water loss after harvest. There was a need to reduce the effects of these naturally occurring processes if the quality of harvested produce is to be maintained to the consumers liking. In order to reduce the post harvest loss of fresh fruits and vegetables, an evaporative cooling storage (ECS) facility was developed. [5].

The produce is harvested (fresh produce) and transported to the market for sale. The left-over produce is vacuum sealed and kept in the cold storage to increase shelf life. The cold storage is a traditional form mad out of clay and it should be centralised. Value addition refers to co verting the produce into by products. For example, excess lemon can be made into pickle, excess tomato into paste, excess strawberry into jam. Produce left even after all the above steps can be fed to compost pits and made into manure.

III. METHODOLOGY

As per the problem statement, by using traditional method the excessive produce will be utilized in the best ways

i) By vacuum sealing.
ii) Cold storage method.
iii) Value addition.
iv) Cryogenic preservation of seeds.

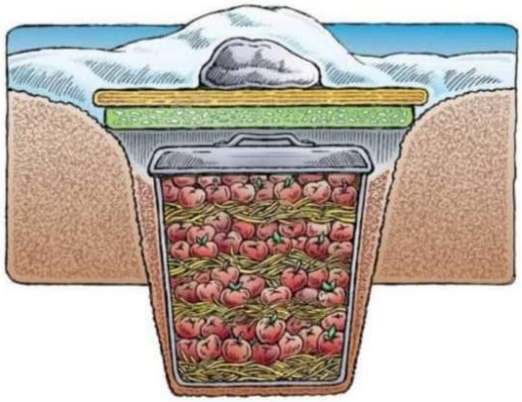


Figure 2. Proposed Cold storage model

By these methods, the shelf-life of fresh produce will be extended/prolonged and will be environmentally sustainable. These methods would lead us to make maximum profit as well or to take complete advantage of the produce. Method: Primarily stored at room temperature until it's shelf life is yet to get over. Later shifted to the cold storage we have designed. (Either kept as it is or vacuum sealed) Shelf-life increased Value addition such as processing the items into by products, Cryopreservation, Biogas and compost the cold storage what we have designed consists of the following layers:

- Layer 1: mud pot Layer.
- Layer 2: wet sand Layer.
- Layer 3: a smaller pot to store the items.

Two layers of mud reduces heat exchange and acts like a cooler. The pore present on the pot helps to keep the items inside cool with the help of wet sand. Large scale implementationof our cold storage.

- Clay soil has been used instead of earth pots.
- First a hole in the ground was dug up with the following dimensions radius 100 cm,height 500cm
- The inner surface of the cylindrical hole is covered with two fine layers of clay , then we made an another cylindrical well inside the cylindrical hole we dug up using clay as well ,filled up sand in between the two clay layers , we wet the sand frequently and we used this as small scale storage ,in order to cover up this whole setup we used a wooden circular disc. we made the disc such that it was an exact fit the hole dimensions . later,edges were sealed with the clay soil.
- As a result of our case study,aloe vera gel is used to extract as a bio preservative for our fruits and vegetables.
- the results were impressive, and we were able to preserve the samples for a longer period.

IV. RESULTS & OBSERVATIONS

TABLE 1. SMALL SCALE EXPERIMENT OBSERVATION

Fruits /Vegetables	No. of Days of Shelf life			Temperature (Achieved by our experiment)
	Room temperature	Refrigeration	Cold storage	
Banana	6	12	9	
Tomato	7	14	10	
Spinach	3	7	5	18^0C
Strawberry	2	7	5	

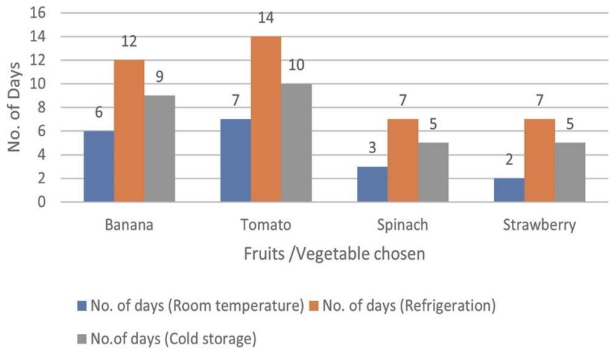


Figure 3. Small scale experimental observation

TABLE 2. LARGE SCALE EXPERIMENT OBSERVATION

Fruits /Vegetables	No. of Days of Shelf life			Temperature (Achieved by our experiment)
	Room temperature	Refrigeration	Cold storage	
Banana	6	12	8	
Tomato	7	14	13	
Spinach	3	7	5	16.4^0C
Strawberry	2	7	6	

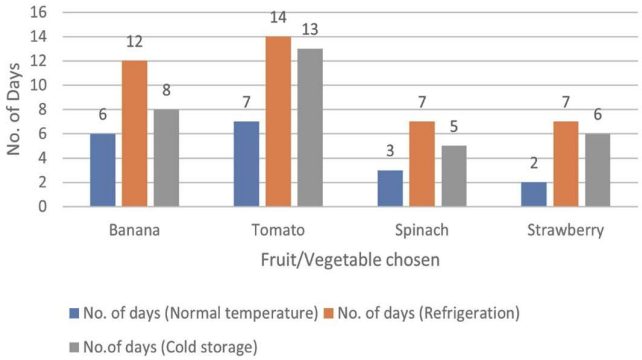


Figure 4. Large scale experimental observation

(a) (b)

Figure 5. (a) Filling up the pot with fruits and vegetables (b) Closing up the pot for close storage

V. CONCLUSION

The shelf life of the perishable fruits and vegetables can be increased by effective implementation of our environmentally sustainable cold storage. By doing so we can take maximum advantage of the produce and also make by products in turn using the produce effectively.

REFERENCES

[1]. Feleciano Bejar,Reynaldo Aquino, Jessie Sabijon, Elvie Bejar, Lagrito Ebert Mante, Ramil Corrales, Ma. Lourdes Afable . Aloe vera Extract as Bio-preservative to Selected Perishable Fruits and Vegetables Northwest Samar State University – San Jorge Campus. San Jorge, Samar, Philippines
ISSN: 18158129 E-ISSN: 18151027,Volume 16, Issue 06, June, 2020.

[2]. Jawadul Misir, Fatema H. Brishti, M. M. Hoqu ,Aloe vera gel as a Novel Edible Coating for Fresh Fruits: A Review . Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology. Sylhet, Bangladesh American Journal of Food Science and Technology, 2014, Vol. 2, No. 3, 93-97 © Science and Education Publishing, DOI:10.12691/ajfst-2-3-3

[3]. Padraic Moriarty, Dr. Pat Doody Integrated Sensors Kit for Investigation of Perishable , Produce Shelf-Life Extension Intelligent Mechatronics and RFID (IMaR), Institute of Technology, Tralee, Co. Kerry, Ireland. 978-1-5386-1046-6/17/©2017 IEEE

[4]. Priyanka Ramesh Deshmukh, Prof.Dr.Dipashree Bhalerao An Implementation of MQTT through the application of Warehouse Management System for climacteric Fruits and Vegetables. Dept. of Electronics and Telecommunication ,Sinhgad College of Engineering, SCOE , Pune, India Proceedings of the 2nd International Conference on Communication and Electronics Systems (ICCES 2017), IEEE Xplore Compliant - Part Number:CFP17AWO-ART, ISBN:978-1-5090-5013-0

[5]. S. Nath, F, Vidinamo , J. Spriggs Preservation and storage of Perishable fruits and vegetables in the highlands of Papua New Guinea. Department of Agriculture, University of Technology, PMB, LAE, Papua New Guinea; Australian Institute for Sustainable Communities, Division of Communication and Education, University of Canberra, ACT, 2601, Australia

THEME :- (WASTE) MANAGEMENT OF PERISHABLE FRUITS AND VEGETABLES

TITLE:- IMPROVED EFFICIENCY IN HARVEST AND POST-HARVEST OF PERISHABLE VEGETABLES

Sneha M C [1] Moulya K [2] Kiran Gayakwad D N [3] Surendra H J [4]

[1,2,3] Students, Department of Civil Engineering, ATRIA Institute of Technology, Bengaluru, Karnataka , India

[4] Professor, Department of Civil Engineering, ATRIA Institute of Technology, Bengaluru, Karnataka , India

snehamc29092000@gmail.com [1] moulyakrishnappa28@gmail.com [2] kirangayakwaddn@gmail.com [3] surendra@atria.edu [4]

Corresponding author: Surendra H J, surendra@atria.edu, 9945015853

ABSTRACT:-

Perishable fruits and vegetables are those which have finite shelf life post-harvest or production as moisture content is more. Maintaining the required grade is very important and necessary till the products are sold as well as consumed by consumers. The loss is observed much during the handling, transportation and storage. More carefully the fruits and vegetables are handled and transported slower is the deterioration process. Some of the possible ways for the reduction of these losses are optimizing the transportation routes, packing materials, segregating the waste. In general packaging materials of unsuitable quality such as large sacks, rough wooden boxes are liable to cause the fruits and vegetables to suffer from crushing and puncturing. The perishable fruits and vegetables wastes decay quickly which leads to serious problem like causing rats and flies around. Here in this paper the mostly grown vegetable worldwide namely Tomato which is linked with many health benefits is considered for the studies. The main causes and reasons for the loss of tomato are briefed. Different methods of tomato transporting and storing conditions were implemented whereas result of these methods has shown reduction in the loss. The waste which is generated during this cycle can be used as organic manure /fertilizer, animal feed and also as energy production.

Keywords: - waste management, perishable, tomato, shelf life, transportation, storing, packing.

INTRODUCTION:-

As the population in increasing there is a need in large production of fruits and vegetables. India being the largest producer of fruits and vegetables it ranks second in position in the tomato production. In India Andhra Pradesh stands first then comes Karnataka in the tomato production. The total area and production of tomato from 2015-2018 is shown in Table 1. Kolar being first in the position and other major districts area and production of tomato statistics of 2016-2017 are shown in Table 2. Tomato which can be eaten as raw vegetable and in the form of salad and many other forms is the most perished vegetable as it contains more amount of moisture content the losses seen quantity is high. Because of this reason before harvesting and after harvesting they must be transported, stored and packed under the suitable climatic conditions more carefully.

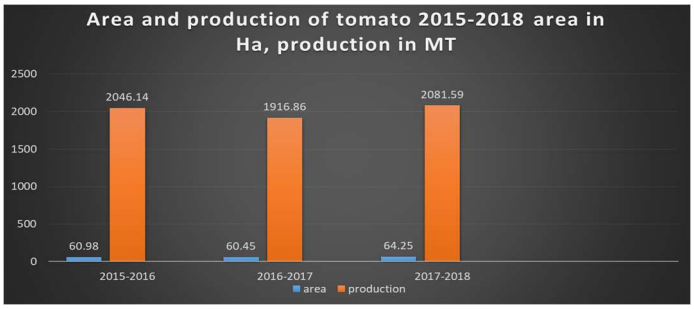


Table 1. Karnataka's area and production of tomato from 2015-2018. Statistical data collected from Horticultural Statistics at a Glance 2018 Ministry of Agriculture and Farmers Welfare Government of India.

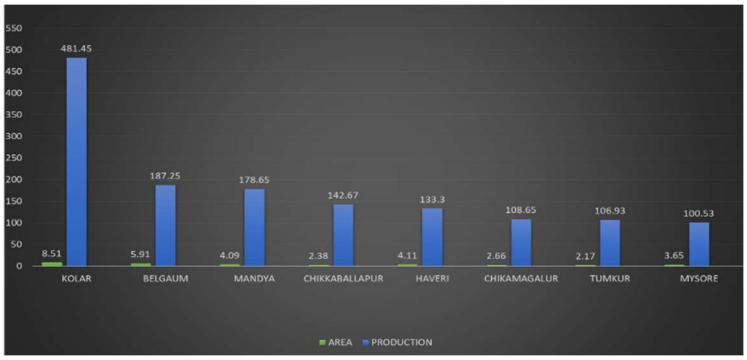


Table 2. Area and production of tomato of major producing districts statistics OF 2016-2017. Area in Ha Production in MT. Statistical data collected from Horticultural Statistics at a Glance 2018 Ministry of Agriculture and Farmers Welfare Government of India.

Few researches have said some of the techniques for preserving and storing the fruits and vegetables, some among them are mentioned. S Nath et al. (2007) With the intention to reduce the loss of fresh fruits and vegetables seen in the post-harvest period an Evaporative Cooling Storage (ECS) was installed. To evaluate this facility few fruits and vegetables were stored and relative humidity and temperatures were recorded daily. For the nutrient content evaluation some vitamins like Vitamin A and C were analyzed before and during the storage by chemical analysis. The results obtained from these were very successful in prolonging the shelf life of fruits and vegetables. Adeyeba Alice Olunike(2014) The main causes for spoilage of food are due to enzymatic actions and chemical reactions and due to micro-organisms and insects. The main reasons for preserving food preserving food are to prevent the spoilage, avoid waste, to extend the shelf life. Various methods for preserving the food like smoking, salting, drying, bagging, fermentation, drying and heating are briefed. As a result of these methods the waste generation was reduced and the intention of increasing the shelf life of food can be achieved. Stella Plazzotta et al.(2017) Fruits and Vegetables Waste(FVW) management is the process of reducing, collecting, transporting, disposing, recycling and reusing. The reduction of waste can be reduced by using different strategies like producing the derivatives of fruits and vegetables like juices, jams. In the recycling strategy the whole obtained waste can be recycled by composting method and by aerobic composting which converts organic waste to organic manure. By reusing the waste fruits and vegetables as animal feed. By applying all these strategies for the waste management process it would reduce the impact on environment and large amount of waste.

STUDY AREA

Khajikallahalli is a small village in Narasapura post, Kolar taluk and district. This Khajikallahalli belongs to a Bangalore division which is located 17km towards west from the headquarters of Kolar district and 54km away from the capital of the state, Bangalore. Location coordinates of khajikallahalli village is of Latitude 13.1227° or 13° 7' 21.7" north, Longitude 78.0052° or 78° 0' 18.9" east. This area is chosen for the study because of its convenience to travel to the place and survey about the crop details to travel. The type of soil where this plantation is grown is red soil. Study are is shown in the figure 1. Tomato plantations in the site is shown in the figure 2.

Fig 1. study area details

Fig 2. Site visited pictures of tomato plantation

METHODOLOGY

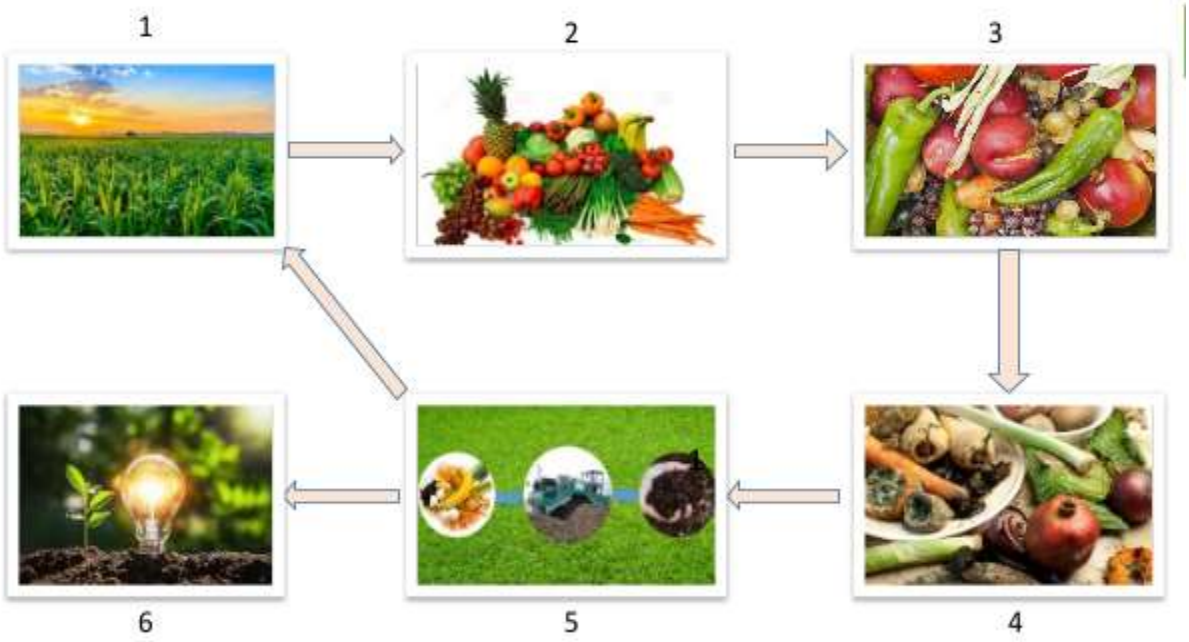


Fig 3. Methodology adopted

Steps Involved in the process:

1. Agricultural field
2. Fresh fruits and vegetables
3. Change in texture, quality and appearance
4. Rotten fruits and vegetables
5. Waste from fruits and vegetables to manure
6. Energy production

The figure 3 represents the methodology adopted during the waste generation process. The fresh fruits and vegetables are initially collected from the agricultural field and then they are transported to the market area. While transporting these fruits and vegetables they tends to physical damages which in order changes its texture, quality and appearance. Due to enzymatic action these fruits and vegetables rotten. The waste generated from these damages can be converted into manure by composting process and used in the energy production.

PROBLEM IDENTIFICATION

Reasons and causes for the loss

1. **Nitrogen deficiency**: When nitrogen deficiency is seen in the leaves, the leaves of the crop appears to be small and pale green to yellow in color. If the deficiency is severe leaves may turn brown and fall off the plant. This deficiency is observed in soil which has either high or low ph. One of the other reasons may be due to heavy irrigation or heavy rainfall. Nitrogen deficiency is shown in the figure 4.

2. **Loss due to heavy rainfall**: Tomatoes causes losses due to heavy rainfall. It also develops a bacterial wilt in the plants after heavy rainfall. Because of the heavy rainfall the fertility of the soil decreases and plant growth will also be reduced. Figure 5 represents the corresponding figure related to heavy rainfall.

3. **Loss due to diseased tomatoes in the plant before harvesting**: When these diseased tomatoes are left in the plant itself they affect the plant growth and causes reduction in the crop production. Figure 6 shows the diseased tomato.

4. **Loss due to fully ripened tomatoes in the plant**: When the fully ripened tomatoes are not plucked at the right time they lead to losses. If these tomatoes are plucked from the plant before

the last stage itself then losses can be reduced while transporting and storing processes. Figure 7 shows the fully ripened tomato.

5. **Bacterial stem and fruit canker**: This disease appears on the leaves, stems and fruits and also wilting of leaves occurs. Cracks develops in streaks and they from cankers. Figure 8 shows the Bacterial stem and fruit canker

Fig 4.Nitrogen deficiency

Fig 5. Heavy rainfall

Fig 6. Diseased tomatoes

Fig 7. fully ripened tomatoes

Fig 8. Bacterial stem and fruit canker

RESULTS AND DISCUSSION

Postharvest handling practices and techniques for tomatoes

During post harvesting process the physical or rough handling of tomatoes leads to reduction in quality and shelf life of tomatoes. It is necessary to know the appropriate methods to sustain the better quality and to extend the shelf life of tomatoes. Some of the handling processes are harvesting, packaging, transportation and storage.

Harvesting : While harvesting tomatoes, the time of harvest becomes one of the important factor. Utmost care must be taken when to harvest to obtain the finest quality. As tomato is climacteric fruit it can be harvested in any of the three stages like matured stage, partially ripe or ripe stage. If these tomatoes are harvested when they are fully ripened then they become feasible to injuries and also may result in shorter shelf life. Harvesting should be done early morning time or during the late hours of the day, it should not be done when the weather is sunny.

Packaging: Packaging is the one of the important component in the post harvesting process. And it is also the one of the reason for the losses that occur in the process. Selection of best packaging method protects the tomatoes from the mechanical damages, contamination from the physical, biological, chemical sources and tampering. Packaging material or container with the sharp edges should be rejected in order to prevent contuse and puncturing of tomatoes. Unsuitable packaging leads to losses. Some of the most used packaging materials are wooden crates, plastic crates, bamboo woven basket, nylon sacks and jute sacks. Figure 9 shows the packing in plastic carts and figure 10 shows the packing in bamboo woven basket

Fig 9 packing in plastic crates

Fig 10. packing in bamboo woven basket

Storing: As tomatoes have high moisture content, it is very hard to store them at ambient temperature for longer duration. For short time storage these tomatoes can be stored in place where there is enough ventilation to decrease the accumulation of heat from respiration. For long term storage they should be stored at temperature of about 10-15^{o}C and 85-95% relative humidity.

Techniques adopted to obtain the extended shelf life and best quality:

Storing tomatoes in the small basket with enough ventilation for 20 days under usual day temperature and storing tomatoes in the refrigerator for 20 days. After 20 days when we checked the quality of tomatoes without refrigeration and with refrigeration, some of the tomatoes placed in a basket without refrigeration were spoilt and the tomatoes in the refrigerators were in same condition in which they were kept. Here are some of the proofs for the experiments. Figure 11 and figure 12 show the tomatoes without and with refrigerator. Figure 13 shows the spoiled tomato without refrigeration after 20 days. Figure 14 shows the good quality tomato without refrigeration after 20 days.

Fig11. Tomatoes without refrigeration Before 20 days

Fig12.tomatoes in refrigerator before 20 days

Fig13. After 20 days

Fig14. After 20 days

One of the other technique we experimented is buying tomatoes at the unripen stage and ripening them by placing unripen banana with the unripen tomatoes for few days to obtain a best quality and increase the shelf life.. After few days the tomatoes will be ripen naturally. Figure 15 shows the tomato in unripen stage and figure 16 shows the tomato ripen stage after few days.

Fig15. Unripen stage

Fig16.ripen stage after few days

Transportation: In many of the places the production area of tomatoes are far from the marketing centers and in some of the places they are not accessible by roads. Transporting the tomatoes on the bad road network condition leads to losses and availability of refrigerated vans is one of the challenge. This challenge causes transportation delay to the marketers. Some of the modes of transportation include human labor, public transport, rented trucks, lorries and pickup vans. The packaging should be done in such way that while transporting there should not be any excessive movement leading to damages of tomatoes. Refrigerated containers are most efficient transporting mode to reduce the losses.

According to a research of Gulzar Ahmad Nayik and Khalid Muzaffar (2014) using active packaging systems such as oxygen scavengers and ethylene absorbers may extend the shelf life

of fruits and vegetables. Oxygen scavengers are active additives which are used in packing process to absorb the excess residual oxygen from the product once the package is sealed. They absorb the excess residue by means of chemical reaction. Commonly used substances in this scavengers are iron powder and ascorbic acid. Ethylene absorbers are used in case climacteric fruits where ethylene is responsible for ripening of fruit. Controlling ethylene concentration helps in increasing the shelf life of an product.

According to a research of P K Omre et al. (2018) the waste material which have been obtained from the damages must be used in such a way that there should be no harm to anyone or environment. The waste obtained can be used for composting and landfill, biogas production, animal feed and production of value added products. The manure prepared from the composting process can be used for crop cultivation. Normally, biogas is composed of 45-70% methane, 30-45% carbon dioxide, 0.5-1.0% hydrogen sulphide, 1-5% water vapor, and a small amount of other gases. The wastes obtained can be fed as animal feed. We can also obtain the production of value added products such as edible oils, pigments, food additives, fermented edible products.

CONCLUSION

The results obtained from the experimented conducted is that if we store the tomatoes at ambient temperature for instance like in refrigerators, the shelf life of the tomatoes will be increased and perishing of fruits and vegetables can be reduced. From the literature we can say that using the active packaging system leads in improvement of shelf life. The waste obtained from the perished fruits and vegetables can be used as manure or in the energy production.

The quality and the shelf life of fruits and vegetables depend on the handling procedure and treatment which will be done after harvest. Though the quality cannot be improved after harvesting but It can be maintained by using appropriate techniques. By selecting best approach the shelf life can also be extended. If we fail to do so then it might lead to huge amount of loss. Active and intelligent packaging proved to be an effective tool for maintaining freshness and safety of fruits or vegetables. But using these active packaging systems are not cost effective. The waste which is reutilized can help in preventing the environmental pollution; it can also become a good source of nutrients and increases the soil fertility.

REFERENCES

1. Horticultural Statistics at a Glance 2018, Government of India
2. S. Nath, F. Vidinamo and J. Spriggs (2007) "Preservation and Storage of Perishable Fresh Fruits and Vegetables in the highlands of PAPUA NEW GUINEA." Proceedings of the Biennial Conference of the Australian society of Engineering.
3. (Mrs.)Adeyeba Alice Olunike "Storage, Preservation and Processing of Farm Produce" Food Science and Quality Management.
4. Stella Plazzotta, Lara Manzocco , Maria Cristina Nicoli "Fruit and vegetable waste management and the challenge of fresh-cut salad." https://doi.org/10.1016/j.tifs.2017.02.013
5. Gulzar Ahmad Nayik, Khalid Muzaffer(2014) "Developments in Packaging of fresh fruits –Shelf life Perspective : A Review." American journal of food science and Nutrition research,1,34-39.
6. P.K.Omre, Shikhangi Singh, Shikha (2018)"Waste utilization of fruits and vegetables-A review." South Asian Journal of Food Technology and Environment, 4(1): 605-615.
7. Isaac Kojo Arah, Gerald K. Ahorbo, Etornam Kosi Anku, Ernest Kodzo Kumah, and Harrison Amaglo (2016) "Postharvest Handling Practices and Treatment Methods for Tomato Handlers in Developing Countries: A Mini Review" Hindawi Publishing Corporation Advances in Agriculture.

AGRO-ETHER CHAIN: SCM application in agriculture powered by Ethereum

Medha Madhusudhan, Sudeshna Bhushan, Ritvika Singh Rathore, Lohith J J

Department of CSE, BMS College of Engineering

Abstract

“ Truth and honesty are an investment you put in people``. Honesty and integrity form a crucial part of our society. Yet, people tend to take advantage of individuals for their personal gains and especially so in businesses. The following project aims to create a supply chain management system for crops that ensures a reliable platform for farmers and all other actors involved to sell the crops. Up and coming technologies such as blockchain rely on security, transparency and trustlessness which add a great level of integrity to applications built on those platforms. This project makes use of blockchain technology as well as IPFS to create a decentralised supply chain management system for fruits, vegetables and other crops.

Acknowledgement

We, the members of this team, are extremely grateful and privileged to have gotten this opportunity to participate in such a prestigious competition. We are thankful to our mentor Mr Lohith J J and our institution, BMS College of Engineering for constantly supporting us throughout our journey as well as our senior Mr Nikhil C for his guidance. Lastly, we would like to thank Ms Sampada Pachaury and the entire IUCEE team for guiding us through the process.

Table of Contents

Table of Figures

1. Introduction

Supply Chain Management is defined as the management of the entire flow of services or goods right from the starting stages where the service or product is created up to the stage where the good gets sold off to customers. Supply chain Management or SCM for short is responsible for storage and processing of raw materials, storage and transport of processed goods, management of people involved in production, consumption and transportation among many other things. This project aims to leverage Supply Chain Management to simplify the process of storing, managing, transporting and retailing farm produce in India. The products that have been taken into consideration (grains, fruits and vegetables) from here onwards will be referred to as crops. Since the advent of the industrial revolution, farmers in India have seen a drastic shift in the way crops are being sold. The process includes a middleman, who will buy all the crops from the farmer at a wholesale price, sell it to retailers at a surplus price and make a profit for themselves, taking advantage of all the effort that the farmers have put in while leaving them with mostly nothing. This project is determined to overcome this very problem that farmers in India are facing today. The project makes use of advanced technology such as Blockchain along with certain other tools such as IPFS, etc to create a decentralised application that gives us a better solution. In addition to the above-mentioned problem, it enables the consumer to track the status of their purchased goods.

2. Background

As mentioned earlier in section 1, the main problem this project tries to tackle is the lack of transparency among middlemen during the process of selling crops. As a result of this, farmers to date are not getting fair wages for their crops and this puts them in a vicious cycle of poverty and debt. In addition to this, customers or end-users have no means to know the quality of the crops purchased, let alone track the order. The project aims to provide a means to overcome this issue. This section further goes on to describe the context of the project, the stakeholders involved, the relevant theory associated with the problem area and the existing solutions for the problem.

2.1. Context of the Project

The project aims to tackle the issues that are being faced by farmers in India with the help of a Blockchain-based supply chain management system. This project is applicable to the farming process in India.

2.2. Stakeholders

All the stakeholders involved and responsible for the different phases of SCM are described in this subsection. The stakeholders discussed include Farmers, Agro-Consultants, Suppliers, Distributors, Transporters, Investors, Retailers, FSSAI personnel and Storage Providers. In addition to the earlier mentioned stakeholders, one must remember that customers (consumers) are also vital stakeholders.

2.2.1. Farmer

Farmers are the backbone of the entire supply chain mechanism. They are responsible for producing the crops that will move through different stages of the supply chain to eventually reach the customers. The crops that are being taken into consideration are lentils, rice, wheat, fruits, and vegetables. Farmers obtain their raw materials from Suppliers. All crops produced are stored in warehouses provided by storage providers. Transporters transport the crops between different actors. Crops are sold to Retailers who then finally sell the crops to day-to-day customers. Farmers can also avail any kind of monetary support from investors.

2.2.2. Agriculture Consultant

The agriculture consultant is responsible for evaluating the quality of the crops at every stage, helping out the farmer with technical/ operational difficulties, and updating the status of the crop at every step.

2.2.3. Supplier

Supplier is responsible for providing the farmer with raw materials such as seeds, pesticides, insecticides, manure, etc.

2.2.4. Distributor

The distributor is responsible for purchasing (wholesale) crops from the farmer and selling it to the Retailers. The distributor makes use of a transport facility provided by the transporter to carry the crops.

2.2.5. Transporter

Transporter acts as a medium to transport crops from one point to another at each phase of the SCM process. Farmers/ Distributors/ Suppliers can make use of the transport system.

2.2.6. Retailer

Retailer takes on the responsibility of buying the crops produced by the farmer from the retailer and selling them to customers. The retailer may select certain crops from a variety of farmers/ distributors. Retailers make use of the services provided by the transporter in availing the crops stored in warehouses as well as services provided by storage providers for storage of crops.

2.2.8. Storage Providers

Storage providers are responsible for providing warehouses to the retailers as per their requirements. Services provided may include refrigeration, preservation or just empty space to stack up the crops.

2.2.9. FSSAI Personnel

All crops produced in India must adhere to certain standards. In order to maintain these standards, crops go through a variety of quality checks before reaching markets from where it is consumed. FSSAI is the governing body in India that ensures quality control among food commodities. FSSAI personnel are appointed to perform this task in the SCM process.

2.2.10. Investor

Investors directly interact with farmers and provide them with monetary support for their crops if required. A certain amount however must be deposited by the farmer for security purposes in case of losses.

2.3. Relevant Theory Associated with the Project

2.3.1. Blockchain

In simple terms, Blockchain can be defined as a distributed and immutable ledger that keeps track of transactions. When a new transaction takes place, a new block gets added. Blockchain is built on the following principles: decentralisation, security and scalability and these form the pillars of blockchain. Today, Blockchain is being used in cryptocurrencies, healthcare, supply chain management, digital identification among various other things.

2.3.2. InterPlanetary File Systems

InterPlanetary file systems or IPFS provides a decentralised mechanism for users to store and access data in various forms. Unlike location-based addressing that is used by traditional websites, IPFS assigns addresses to each file based on the contents of the file itself. This is known as content-based addressing. In addition to content-based addressing, hashing is made use

of in order to ensure the proper identification of each file.

2.4. Existing Solutions

Two existing solutions that have inspired the project are Walmart's supply chain management as well as IBM Blockchain for supply chain solutions. The brief workings of these two systems, mainly Walmart's supply chain management will be discussed in this subsection.

2.4.1. Walmart's Supply Chain Management

Walmart is one company that has always been ahead of the game in terms of understanding customer requirements through analytics, providing customers with goods that are in demand as well as maintaining a detailed mechanism to track and manage the products throughout its consumption lifecycle. Walmart's SCM divides the process into the following steps: keeping track of suppliers, purchasing the products from the suppliers, keeping track of the quality of items, management of damaged goods/ in-demand goods that suddenly have a huge customer base/ goods that are delivered at the last minute, and distribution.

2.4.2. IBM Blockchain for Supply Chain Management

IBM provides its blockchain services to companies that are interested in supply chain management. One of the most prominent users of IBM's SCM is Walmart.

2.5. Methods and Tools Utilised

The project makes use of blockchain technology, mainly Ethereum blockchain. In order to make use of the Ethereum blockchain, tools such as Ganache and Metamask are used. Ganache provides a private blockchain and Metamask acts as a wallet for maintaining Ethereum accounts. Other technologies such as Truffle, React JS and Web3 are used. These tools and technologies are discussed in detail in this subsection.

2.5.1 Ethereum Blockchain

Ethereum is a decentralised blockchain that builds on bitcoin's functionalities but with some major differences. One of the main differences is that Ethereum provides an additional functionality known as smart contracts. Smart contracts can be defined as self-executing code that can be used to lay down a set of rules based on which the application will work. It is open-source, which makes it one of the most popular choices among those who make use of blockchain technology for transactions. Some properties of Ethereum are high security and rapid development time. It also provides a mechanism by which various applications can interact with ease.

2.5.2 Ganache

Ganache is a personal blockchain that provides a platform for the rapid development of distributed Ethereum applications. Ganache can be used across various phases of application development namely development/ programming, testing and deployment. Ganache is available to users in two flavours namely, command-line interface and user interface. Ganache UI is being used for the sake of application development in this project.

2.5.3 Metamask

Metamask provides users with a wallet that interacts with Ethereum Blockchain in order to perform transactions. In order to make use of metamask, users must download it as an extension on their browser and register.

2.5.4 React JS

React JS also known as React is a free and open-source front end JavaScript library that is

declarative in nature. It helps speed up the process of creating a user interface for projects. React library simplifies the process of user interface development by introducing various features such as components, JSX, and React hooks.

2.5.5 Truffle

Truffle is an integrated development environment that simplifies the process of building blockchain-based decentralised applications on Ethereum. Some of its features include smart contracts compilation, testing, and deploying to public/ private networks. Truffle is a part of the Truffle Suite that includes Truffle, Ganache and Drizzle, all of which provide certain functionalities to create and use blockchain-based decentralised applications.

2.5.6 Web3

Web3 is the third iteration of the web that introduces the concept of decentralisation that acts as a basis for blockchain applications. In addition to this, Web3 makes the web trust-less, verifiable, and distributed. Web3 makes use of decentralisation mainly in the aspects of building applications (DApps, or decentralised applications) and managing finance (Defi, or decentralised finance).

3. Specification and Design

The purpose of this project is to produce a mechanism that allows various actors to communicate with each other easily and ensure that each actor gets their fair share of the money. The following section goes on to describe how the project is designed. A brief description of each of the actors was given in sub-section 2.2. This section describes the functionalities of each of the actors and how they are built to interact with each other. Figure 1 provides a simple pictorial representation of the relationship between each of the actors.

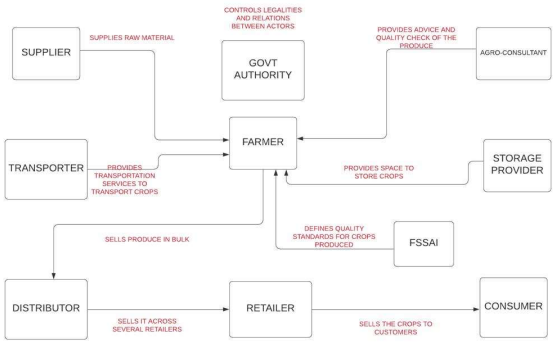


Figure 1: relationship between the actors

A. Farmer

- Grow crops/ create new crops. New crop created with the following details: id, variant, type, duration, consultant ID, public funding availed (yes/ no).
- Get consultation and ratings from consultants by paying a certain amount of money.
- Post-harvest, crops are sold to distributors.
- The farmer may ask for funding from investors when a crop is being created. For this, the farmer must deposit a certain amount for security purposes.

B. Agriculture Consultant

- Consult the farmers and address any queries/ questions asked by the farmers.
- Inspect and rate the quality of the crop at 3 stages: pre/ mid/ post-harvest.
- After harvesting is complete, the consultant must assign a rating to the farmer as well.
- Payment is only made to the consultant once the crop reaches the ‘ready to sell’ stage from the ‘post-harvest’ stage.

C. Supplier

- Communicates with the farmer and provides the farmer with seeds, pesticides, fertilisers, manure, etc.
- Each supplier provides its list of supplies and each of its prices.
- Supplier details are available for the farmers to go through on the website.
- The supplier can add/ update/ delete goods to the already existing list of commodities.

D. Distributor

- Post harvesting, crops reach the 'ready to sell' state. At this point, distributors can buy the crops of their choice from farmers.
- Direct amount transfer takes place from the distributor to the corresponding farmer upon purchase of crops.
- Distributors can avail transport facilities to transport goods to retailers.
- Distributor keeps track of contact details of the transporter as well as details of the crop being transported such as crop id, weight in kgs, etc.

E. Transporter

- Each distributor is assigned a transporter who is responsible for transferring crops to interested retailers.
- Cold storage truck facility is provided if required.
- Distance to be travelled, the quantity (in kg) of crops to be transported are kept track of.

F. Retailer

- Purchases crops from the distributor
- Can choose a variety of crops from different distributors
- Money is transferred to the distributor after the transporter delivers the crops

G. Storage Provider

- Provides storage facilities to the retailer
- Cold storage/ bulk storage options are provided in the warehouses

H. FSSAI Personnel

- Directly interacts with the farmer to check if crops in the post-harvest stage meet the quality requirements.

I. Investor

- Investor is responsible for providing funding to farmers if the farmers are interested in availing some monetary support for certain crops.
- A certain amount of money should be kept aside by the farmer as a 'Security Deposit' in case of crop failure/ loss.
- Investors must keep track of the deadline and status of the crop at each stage.

J. Common Functionalities

- Before signing in to the platform, each individual must sign up according to the role they are performing (Farmer/ Distributor/ Retailer/ etc.). While

performing registration, the user must specify first name, last name, email, password, address, public key and contact details along with documents for verification. After signing up, the admin verifies user documents before approving the user account. Once the user has been approved, they can sign in.

4. Implementation

User Interface

Currently, the project is in the development stage and the website can be accessed using the 'npm start' command in the folder where the code is placed. Once the website is loaded, the landing page is displayed.

The landing page consists of a navigation bar that provides links to navigate to the following pages: home page (landing page), signup – farmer/ agro consultant/ investor/ distributor/ supplier/ transporter/ retailer/ fssai personnel, login page, contact us and instructions to use the website.

In order to log in through an existing account, one must use their public key and password.

Smart Contracts

Separate smart contracts have been created to address different functionalities provided by the project. The smart contracts that have currently been implemented have been listed below:

- ConsultationContract.sol
- Crops.sol
- Ratings.sol
- Migrations.sol
- Scm.sol
- SecurityDeposit.sol
- Supplier.sol
- Transportation.sol
- UserData.sol

5. Results and Evaluation

The project was created to have the user interface as shown in the screenshot attached to the homepage (figure 2). One can access any of the links included in the navbar.

Figure 2: user interface - home page

The user must first sign up as one of the actors by giving all details as shown in Figure 3. In Figure 3, the signup page for a farmer is shown. All the details that are being asked by the form must be mandatorily filled in. Otherwise, the form will not be submitted due to validation failure.

Figure 3: farmer sign-up form

Once a signup request has been sent, the user must wait until an admin/ governing authority approves the request for an account after which the farmer can log in using his/ her public key as username and password. After logging in, the user can perform their tasks according to their role. Figure 4 displays the screenshot of the form

to add a new crop to the already existing list of crops produced by the farmer.

Figure 4: form to add a new crop

The farmer may opt for financial support in order to grow the crop and may thus have to add a security deposit. The form for adding a security deposit is shown in Figure 5.

Figure 5: adding a security deposit

The farmer can also see a list of all the crops that he/ she is growing. This is depicted in Figure 6.

Figure 6: all the crops under a farmer

6. Future Work

A certain portion of the project work has been left out and this includes smart contracts (relating to the transactions) as well as registration functionality for storage providers, retailers, fssai personnel. In addition to this test files (using chai js) in order to evaluate the contracts must be created for a few of the smart contracts. The team plans on completing the above tasks as well as improving on some aspects of the front end of the website and deployment in the near future.

7. Conclusion

The work that was aimed for completion has been successfully completed by the team. A supply chain management system using blockchain and IPFS that hopes to eliminate the problems faced by farmers and other actors involved in the process of selling crops has been devised. In addition to this, a user-friendly interface has been set up for ease of use and access. However, the implementation is not foolproof and complete. In order to make it so, all the functionalities mentioned in 6 must be included. The team plans on adding all the aforementioned functionalities.

8. Reflections

This journey has taught us various new skills which would with no doubt be useful throughout our lives. This includes teamwork, coordination, communication, writing skills as well as knowledge in a new field i.e., blockchain. During our journey, we have had the privilege of coming across world-class technologies and companies and the work they do (e.g., Walmart and IBM). Through this journey, each of us has learnt the importance of consistency in terms of both learning and working. For this, we would like to thank IUCEE.

References

Buterin, V. (2014). A next-generation smart contract and decentralised application platform. *white paper*, *3*(37).

Nikhil C, Hetav Pabari, Abhishek H, Bharath Kumar, Lohith J. J, ”A Review on Supply Chain Management In Agriculture Empowered by Ethereum And IPFS”, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH TECHNOLOGY (IJERT), 2021.

Madhumitha, S., Ranjani, P. S., Vandhana, U., & Venmuhilan, B. (2019, May). A theoretical implementation: Agriculture-food supply chain management using blockchain technology. In *2019 TEQIP III Sponsored International Conference on Microwave Integrated Circuits, Photonics and Wireless Networks (EPICPW)* (pp. 174-178). IEEE.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralised Business Review*, 21260.

Bibliography

https://www.ibm.com/topics/what-is-blockchain

https://ethereum.org/en/what-is-ethereum/

https://trufflesuite.com/ganache/

https://ipfs.io/

https://reactjs.org/

BLOCKCHAIN TRACKING OF DAIRY MILK

NEELA SAI HARSHITHA*, PANIPADU HIMA CHANDANA*, VALLEPU VAMSI KRISHNA*, ATMAKURI PRASHANT#

* III B.TECH CSE STUDENTS, VASIREDDY VENKATADRI INSTITUTE OF TECHNOLOGY.

ASSISTANT PROFESSOR, DEPARTMENT OF CSE, VASIREDDY VENKATADRI INSTITUTE OF TECHNOLOGY.

ABSTRACT:

Traceability has become a vital element in supply chain management, particularly in safety-sensitive sectors like food, pharmaceuticals, etc. Supply chain management members need to store and handle traceability-related information to provide proof of regulatory compliance to state authorities and more demanding customers [5]. To trace the milk and milk products' journey via various routes – production to its final consumption, Dairy Traceability plays a vital role. There has been a decline in the connection between dairy producers, processors/manufacturers, merchants, and buyers in today's system. Unlike the western countries, milk producers in India remain highly unorganized, resulting in incompatible milk quality and composition. Very little or no information reaches consumers. Data was recorded manually (in books) at each stage, with several limitations. Although the dairy supply chain members retain different data, they mostly lack communication and coordination. Blockchain technology can ensure reliable tracking of every batch in the milk chain. Some Researches show that consumers are more likely to buy a product that provides more detailed information.

ACKNOWLEDGEMENT:

We take this opportunity to express our deepest gratitude and appreciation to all those people who made this project work easier with words of encouragement, motivation, discipline, and faith by offering different places to look to expand my ideas and help me towards the successful completion of this project work.

We pay our deep sense of gratitude to Dr. Krishna Vedula, Ms. Sampada Pachaury of IUCEE whose vision is to improve the quality and global relevance of engineering education in India.

We express our deep gratitude to Mr. Vasireddy Vidya Sagar, Chairman, Vasireddy Venkatadri Institute of Technology for providing the necessary facilities.

We express my sincere thanks to Dr. Y. Mallikarjuna Reddy, Principal, Vasireddy Venkatadri Institute of Technology for his constant support and cooperation throughout the project.

We express my sincere gratitude to Dr. R. Eswaraiah, Professor & HOD, Computer Science & Engineering, Vasireddy Venkatadri Institute of Technology for his constant encouragement, motivation, and faith by offering different places to look to expand my ideas.

We would like to express our sincere gratefulness to our mentors Mr. A. Prashant, Assistant Professor and Mr. J. Madhu Babu Associate Professor, Dept of CSE, Vasireddy Venkatadri Institute of Technology for their insightful advice, motivating suggestions, invaluable guidance, help, and support in the successful completion of this project.

TABLE OF CONTENTS:

TABLE OF FIGURES:

INTRODUCTION:

Milk has its prominent place in necessities around the world. Milk consumption is a widely debated topic in the nutrition world, as one might wonder if it is harmful or healthy. Milk is known for its excellent source of vitamins and minerals, including "nutrients of concern".

Traceability has become a vital element in supply chain management, particularly in safety-sensitive sectors like food, pharmaceuticals, etc. Supply chain management need to store and handle traceability-related information to provide proof of regulatory compliance to state authorities and more demanding customers.

Unlike years ago, there has been a decline in the connection between dairy producers, processors/manufacturers, merchants, and buyers. Very little or no information reaches consumers.

Although the dairy supply chain members retain different data (max manually), they mostly lack communication and coordination. Such a lack of interaction amongst the farmers and consumers, accompanied by the dairy industry's globalization, has raised a demand for a better traceability system for India's milk and milk products.

Not only about communication, but also there is a dilemma over the quality of the product (a milk product). Many malpractices are involved in the production phase, which causes severe damage to human health. Around sixty-eight per cent of milk and milk products sold in our country violate the standards laid down by the FSSAI (Food Safety and Standards Authority of India) [6].

As we all know, milk products are the top source of fat, incredibly saturated fat, which increases the risk of many cancers and contributes to heart diseases, type-2 diabetes, and Alzheimer's disease. So, there is a need to control and trace fat content in milk products.

Unlike the western countries, milk producers in India remain highly unorganized, resulting in incompatible milk quality and composition. India being the world's largest milk producer, with 22 per cent of global production, there is an urgent need to enhance product quality, connectivity and transparency. All the problems and situations mentioned will be improved for a healthy tomorrow.

BACKGROUND:

Traditionally, the food supply chain management and interactions are unidirectional. Most of the participants in the supply chain can only connect with entities immediately downstream, which means upstream agents can communicate with downstream agents, e.g., a manufacturer can share with a restaurant. Still, the restaurant cannot communicate with the manufacturer.

Tracing the origin of a problem is ordinarily difficult in conventional systems since no single entity possesses all the information, and some information can be confusing because of trade secrets. Therefore, in current supply chains, the process of tracing the origin of an issue may be time-consuming, labour-intensive, inefficient, and sometimes inconclusive. Because of this, many food safety issues are ignored or under-reported since consumers might hesitate to attempt to determine the source of a particular problem since the process is lengthy and often inconclusive.

Manual records are used to store the data collected at every stage. This data is dropped into computer systems through humans. This process has been continuing till now. There was a chance of quickly modifying data in the database. Usually, every organization or working industry had a database to maintain all the information from starting till the end of manufacturing. People working in the industry or any strangers or hackers have the chance of damaging data.

There should be a strategy for data security to avoid unnecessary actions. In other words, they had the chance to manipulate data, resulting in adverse effects such as further processing of products in wrong evaluation, packaging of products, etc.

Due to unethical issues involved, several incidents occurred in the past, which resulted in the spreading of diseases to consumers. The present system had to implement methods to find the cause for every problem.

To provide qualitative products to consumers and eliminate malnutrition in food, especially in dairy chain supply management, Blockchain promises immutability, transparency, security, and fault tolerance of data. Hence, many of the problems can be identified.

STEPS IN DEFINING SPECIFICATION AND DESIGN:

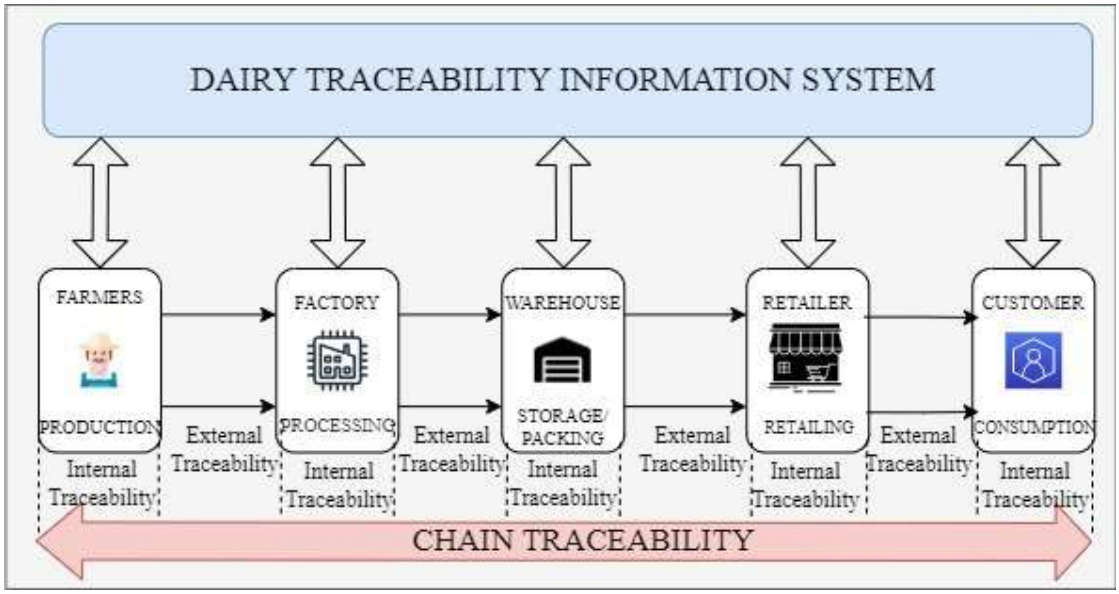


Figure 1: Dairy traceability information system

Any process in a supply chain consists of a sequence of individual steps, which a manageable number of general activities shall describe. The dairy traceability system includes five significant steps as shown in *Figure 1*.

1. Production
2. Processing
3. Storage/ Packing
4. Retailing
5. Consumption

Data at each stage is different, so data is traced at each step individually. A Blockchain network is used instead of a database to store data. The information includes the following attributes.

- Production: farmer ID, Type of Milk, fat per cent, SNF, quantity and time.
- Processing: quantity, collections centre ID, starting time, ending time, fat per cent, SNF.
- Storage/ Packing: quantity, number of packets, arrival time, departure time, agent id(retailer)
- Retailing: number of packets, time of arrival, time of sale.

Database, a centralized system, is eliminated by replacing it with a blockchain network, a decentralized network, during the whole process. Data is sent into the blockchain network with the help of a smart contract and transferred between stages with the help of a QR code, thereby providing better data security and making it immutable.

The milk collection from farmers took place at a milk collection centre, and required data is stored in the network. Then the milk is transported to the factory for processing along with a

QR containing the data. The authorities at the factory scan the QR code and allow the milk for processing once the milk passes the required quality tests. This process repeats for every stage.

Whenever any fault occurs in the end product, the authorities can backtrack to find the reason in the proposed system. With the proposed method, adulteration is not possible to the maximum extent.

IMPLEMENTATION:

Implementing this idea in the real world requires a suitable network to store the data securely. Ethereum is the ideal network in this context. Ethereum is the community-run technology powering the crypto currency ether (ETH) and thousands of decentralized applications. Through smart contracts, a decentralized application can be developed. A computer program or a transaction protocol is a smart contract intended to execute, automatically control, or document legally relevant events and actions according to a contract or an agreement. Smart contracts are written in Solidity.

Every stage mentioned in the previous section requires an individual smart contract. Once the smart contracts are built, they are deployed into the Ethereum network. But it requires a library for deploying and interacting with smart contracts on the network. The popular libraries for interacting with dApps are web3.js, ether.js, and web3.py. Individual page of each stage are shown in *Figure 2, Figure3 and Figure4.*

web3.js and ether.js are JavaScript libraries, whereas web3.py is a Python library. Since web3.js has more outstanding community support, many developers prefer it over web3.py and ether.js. As Ethereum uses EVM (Ethereum Virtual Machine) as the heart of the system, smart contract code, written in Solidity, needs to be compiled into EVM bytecode and Contract ABI to be run [8]. EMV Bytecode is an executable code on EVM, and Contract ABI is an interface to interact with EVM bytecode. The bytecode is deployed into the Ethereum network, and by using ABI and JavaScript, one can interact with the bytecode.

Solidity has many functions that can perform every action. Executing/calling a function in smart contracts is called a transaction. Every transaction requires some amount of ether to run successfully. The exact cost of ether needed to run an operation depends on the complexity of the corresponding function. A sample bill of a transaction is shown in *Figure5.* It's a hectic process to develop smart contract functions with less complexity. Developers are spending a significant time writing fewer complex functions. Even deploying a smart contract costs a lot. These are some significant problems in smart contracts and dApps.

Solidity used to write smart contracts is in its initial stage. It doesn’t support float data type to deal with decimals. Lack of libraries is one of the main drawbacks, causing a developer to write every code from scratch. Crossing all these obstacles, we built a prototype to simulate the project idea.

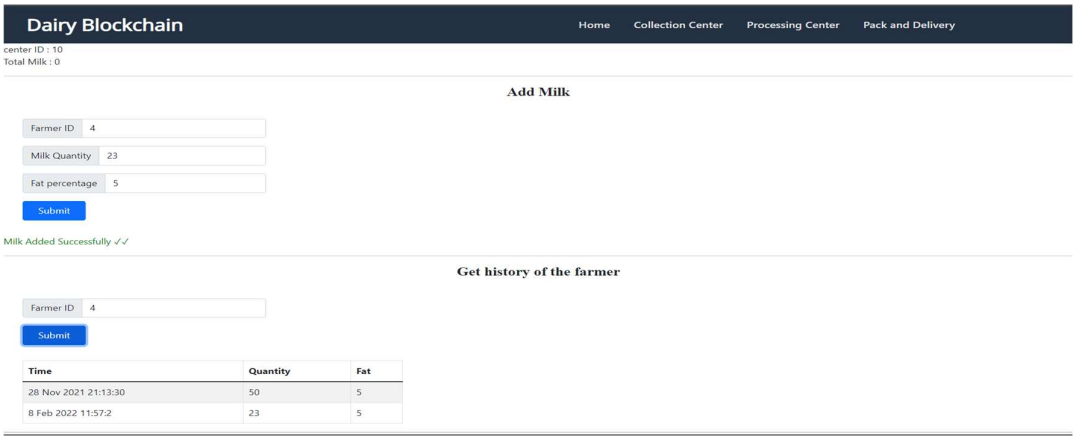


Figure 2: Collection Centre page in dApp (prototype)

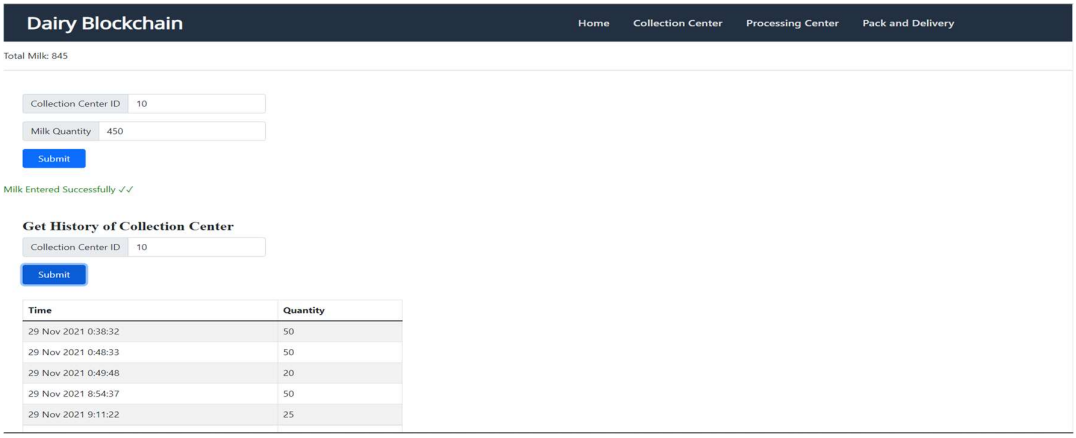


Figure 3: Processing Centre Page in dApp (prototype)

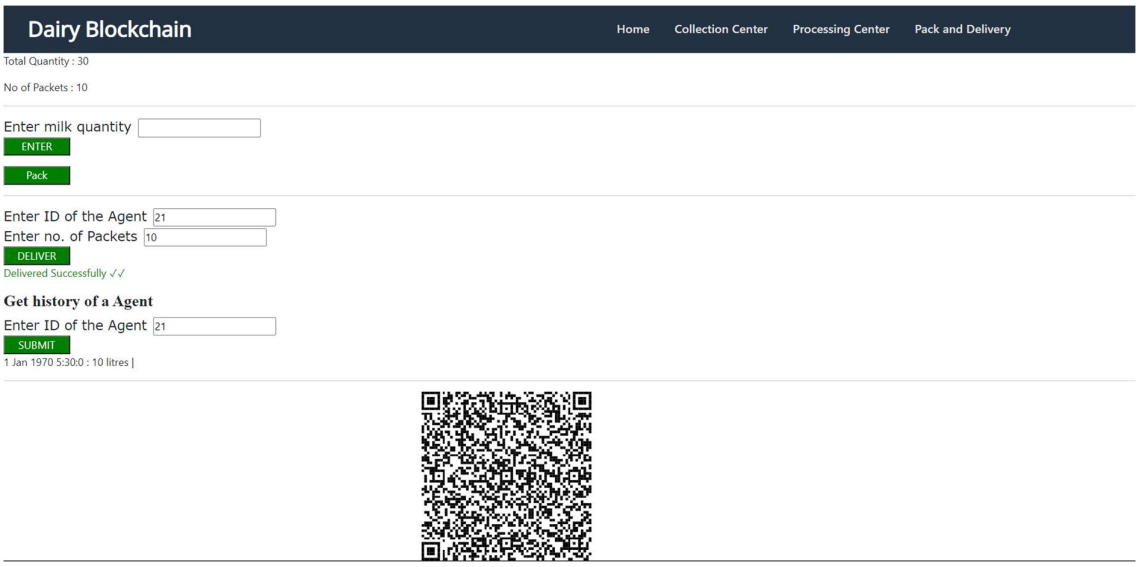


Figure 4: Pack and Delivery in dApp (prototype)

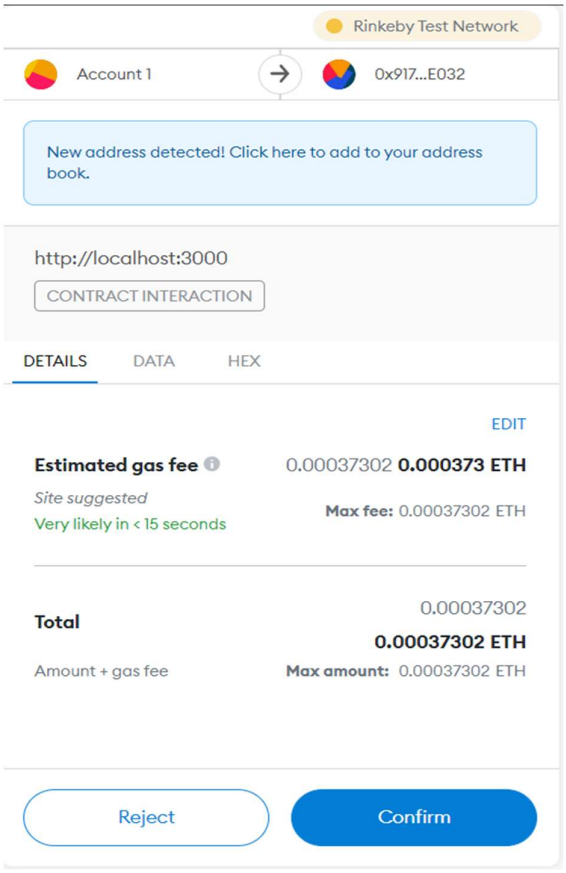


Figure 5: Bill of a transaction

Repository of the prototype: [vamsivallepu/Dairy-Blockchain-Contracts (github.com)]

RESULTS AND EVALUATION:

As Digitization continuously grows, the IoT platform enables the industry to have a real-time environment. Blockchain technology is adopted in the IoT industry due to its proven security and tracking.

It is becoming essential to concentrate on human health and maintain batches with high efficiencies to increase the quality of the product. The demand for traceability increased, thus increasing the need for quality control, control of infectious diseases, medication, and its effects on the environment and consumer health.

With the help of a QR code presented on the milk packet, information tracked at every step can be displayed. The present model developed showcases information stored at every stage. Milk that reaches the dairy processing plant undergoes various processes. Milk from collection centres reached out to bulk chilling milk centres before manufacturing.

Adulteration tests were performed only when receiving the milk (i.e., at the RMRD section). The Milk packet after processing is not tested to determine the adulteration issues.

The standard temperature for heating milk was 72°C. Due to climatic conditions at the place of production; the milk was heated to 78°C+3°C. Primarily it was heated to 82°C.

At the production stage, parameters considered were farmer Id, Type of milk (Cow Milk/Buffalo Milk), SNF (Solid Not Fats), time at which milk was produced, the quantity of milk considered. Production was the first and most crucial stage, which reflects further enhancements.

The further step was the processing of milk which played a vital role in the quality determination of the entire product. *Figure 6* depicts this step [1].

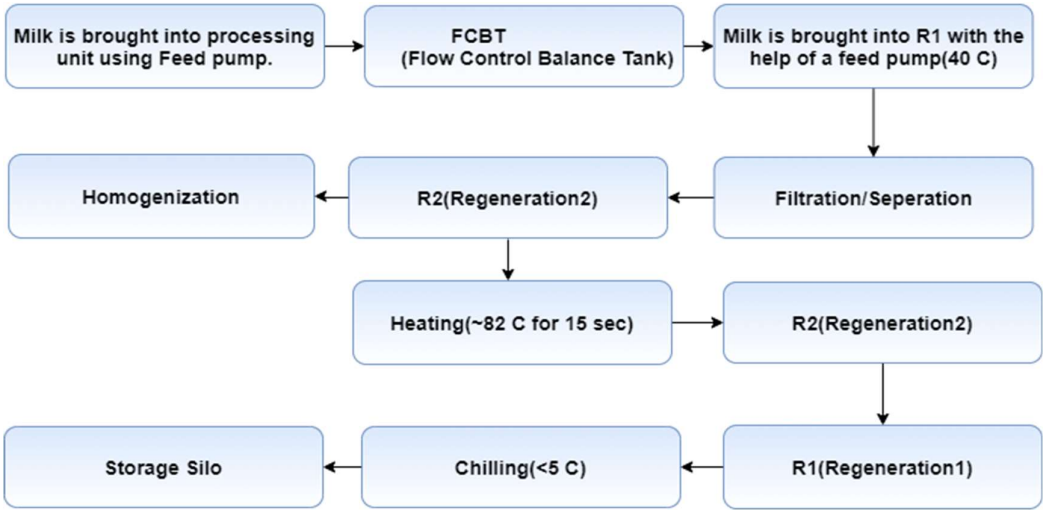


Figure 6: Phases inside a processing unit

There are four different ways to process milk which are listed below.

1. Pasteurization – pasteurized milk was raw milk heated to a specified temperature and time to kill pathogens present in the raw milk.
2. Homogenization – Homogenization is a process used to reduce the size of the fat droplets present in milk into smaller portions dispersed evenly throughout the milk.
3. Separation – separating milk into cream and skim milk
4. Standardization - Standardization of milk refers to the adjustment, which means raising or lowering fat and solids, not fat levels of milk. Standardization of milk is vital in market milk supply and case of the manufacture of milk products

This processed milk can be stored in seven silos based on the process and fat content. The price of the milk packet was fixed based on the fat content present in the processed milk.

Pre- Pack	Fat%	SNF%
Toned Milk (TM)	3.0	8.64
Full Cream Milk (FCM)	6.0	9.0
Double Toned Milk (DTM)	1.6	9.0
Premium	4.5	9.0

Pasteurized Gold^{+} (PG^{+})	6.6	9.0
Homogenized Gold^{+} (HG^{+})	6.6	9.0
Tea Special	6.0	9.0

Table1: Classification of Milk processed inside a Dairy based on Fat% and SNF% [1]

All milk packets should undergo leak verification tests before storing them in tubs. Packets that do not pass the test will be cut open. The milk packets transported from dairy were sent with complimentary packs and the maintenance of transportation issues. In case of any damage, packets were replaced.

Milk was received at the RMRD unit. A sample has 200ml of milk. Below were tests performed on raw milk at this unit are-

1. Temperature Test
2. Organoleptic Test
3. Protein Stability Test
4. Acidity Test
5. Fat
6. CLR
7. Adulteration Test

Many tests are conducted before, after, and during the milk processing at the Quality Assurance lab. They include

1. Temperature test – To maintain the Shelf life of milk, milk should be stored at below 5C.
2. Organoleptic test - This was manual testing. Testing was based on Taste, Smell, and Appearance. This was a basic test performed at each phase inside a dairy.
3. COB Test – Clot and boiling test (If the results yield +ve, the milk is spoiled).
4. Dry Sterilization
5. Acidity Test – Testing was done to know the percentage of lactic acid present in the milk. Generally, the standard reading is 0.140.
6. Fat test – Two tests were performed to know the fat percentage present in the milk. The first one was using Gerber (manual standard chemical method to check fat). Another one was done using an electronic milko tester (used for immediate fat checking).
7. CLR (Corrected Lactometer Reading) - To determine the fundamental nature of milk and decide the nature of adulteration, this test was performed.
8. SNF (Solid Non-Fats) – SNF was calculated with the obtained readings of fat% and CLR.

$$SNF = ((CLR/4) + (0.21*fat\ \%) + 0.36)$$

9. Alcohol Test – The standard reading for Buffalo milk is 65, and the standard reading for Cow milk is 70 - 75.
10. Heat / Protein Stability Test - In this test, the time required for particles of coagulated protein to become visible throughout a 2·5-ml sample of separated milk maintained at 135°C in a glass tube rocking at 8 c/min is taken as a measure of stability.
11. MBRT test – Methylene Blue Reduction Test and used to test the quality of raw and pasteurized milk.

12. Phosphatase Test - Phosphatase test was used to indicate whether milk had been adequately pasteurized or whether it had been contaminated with raw milk after pasteurization.

THE FUTURE W0RK:

The dairy traceability system can help the dairy firms to operate more effectively and deliver higher service levels to the downstream stakeholders [10]. Any failure of conforming to quality and safety standards from upstream parties will be detected and seen through the system.

Blockchain is a promising technology with multidimensional benefits. If used along with the IoT, we can establish a transparent supply chain management of food reduce food fraud and build consumer trust [7]. Further enhancements in developing this project lead to the complete nutrition diet in dairy food.

CONCLUSIONS:

By the end of this project, encrypted data is stored successfully in a blockchain network. Transparency is achieved through the extensive use of QR codes to transfer data between different production phases. Even though the model described is costly to implement, it’s very effective in solving the problem discovered.

The significant achievements in this model include improvement in data security, integrity and transparency. In addition to the information provided in the QR codes printed on today's milk packets, much other important information like quality factors, time and every additional minor detail from dairy farmers to retailers are included.

The cost to implement this can be further reduced by using our private blockchain network. As Solidity is in its initial stage of development, there is a high possibility for enhancements. These include adding predefined library functions and supporting many other data types like float, etc.; the complexity of functions can be reduced exponentially, thereby reducing the transaction fee.

Unlike databases, Blockchain has unlimited storage. Therefore, even when a lot of data is stored, there will be no decrease in its performance. It works as efficient as it was in its initial days. The more efficient data that reaches the end customer, the more there would be an increase in its brand value.

REFLECTIONS:

Blockchain is most popularly known for its security. Irrespective of the data, any data that enters the block becomes immutable. Any data can be added to the Blockchain in two ways. It can be through automatic machines, or a person should push the data into the block. As humans tend to make mistakes, automated machines are more reliable for data accuracy. IoT is not mandatory but would add precision to the data.

As the designed model is just a prototype, there is enormous scope for further developments, such as automation at every stage. The problem of errors while entering data is completely solved through automation.

REFERENCES:

1. Detailed case study at SANGAM DAIRY, VADLAMUDI, TENALI, GUNTUR, AP, 522213 on 12 October 2021.
2. Blockchain A-Z™: *Learn How to Build Your First Blockchain*[Online], Udemy course.
3. *Ethereum and Solidity: The Complete Developer's Guide*, Udemy course.
4. *Ethereum Stack Exchange*[Online], site design/logo © 2022 Stack Exchange Inc; user contributions licensed under cc by-sa. rev 2022.1.28.41306.
5. Fran Casino et al. / IFAC Papers Online 52-13 (2019), *Modelling food supply chain traceability based on blockchain technology*, 2728–2733
6. (2018), *Milk Products in India Not as Per FSSAI Standard*
7. Sanjeev Kumar Sharma, Vinay Sharma et al. (2020), *Applications of blockchain technology in the food industry*
8. Nikolay Ivanov, et al. (2021), *Rectifying Administrated ERC20 Tokens*
9. Copyright © 2022 Elsevier B.V. (2019),A systematic literature review of blockchain-based applications: Current status, classification and open issues
10. Copyright © 2021 GetSmarter | A 2U, Inc. brand(2022) *The Future of Blockchain Technology in 2022*
11. ShuvamShingh, Virendra Kamalvanshi, Sarthak Ghimire, Sudarshan Basyal et al. (2020), Food Information Requirements of the Indian Consumers, *Dairy Supply Chain System Based on Blockchain Technology*
12. IBM: *Benefits of blockchain*

Conceptual Design
of
Essential Oil Extraction Unit
for
Efficiency Improvement

By

Sahil Kumar

Akant Buddija

Aditya Sharma

Department of Mechanical Engineering

JMIT, Radaur

Faculty Guide

Er. Pankaj Sharma

Assistant Professor

Department of Mechanical Engineering

JMIT, Radaur

Abstract

Research has been conducted to study the performance of the proposed solution over the traditionally used apparatus for steam distillation of essential oils. Taking the problems associated with the extraction of essential oil the proposed solution was designed to overcome these problems which were loss of heat, non- uniformity of temperature, low yield of oils extracted and unstable thermal efficiency, etc. For increasing the efficiency or yield of essential oils the center of the study was to reduce the heat losses across the apparatus (composite cylinder). For that two cases were analyzed: Heat loss across the traditional apparatus and the proposed solution. Results showed that 90.86 percentage drop in heat loss occur by using the proposed solution which consists of four layers in the composite cylinder. That occurs due to the introduction of vacuum layer as second layer. These results were also verified by the simulation in Simulink (an add-on MATLAB product). For squeezing the plant charge placed in the composite cylinder perforated piston was installed in it. And it was reciprocated by the Scotch Yoke mechanism. The proposed solution was designed in solidworks (a CAD software). Temperature profiles were also plotted for these two cases which showed a sudden drop in temperature after second layer in the proposed solution, which would maintain uniformity of temperature inside the composite cylinder. All these analysis would confirm the better performance of the proposed solution.

Acknowledgements

The satisfaction and joy that accompany the successful completion of any task would be incomplete without mentioning the people who have made it possible, because success is the epitome of hard work.

With gratitude, we acknowledge all those whose guidance and encouragement have made our efforts successful. We wish to express our deep sense of gratitude to Er. Pankaj Sharma, Assistant Professor in Mechanical Engineering Department, JMIT Radaur, Haryana for his valuable time, suggestions and guidance throughout the success of our research work.

We express gratitude Dr. S.K. Garg, Director, JMIT Radaur, Haryana for his constant encouragement and support of our Endeavour's.

We thank every individual who has directly or indirectly influenced us to propel the research to its completion.

Table of Content

Table of Figures

Introduction

Essential oil is a concentrated hydrophobic liquid containing volatile chemical compounds from plants. Essential Oils are also known as volatile oils, ethereal oils or simply by the oil of the plant from which they are extracted such as Clove oil, Rose oil, Basil oil, etc. Essential Oils have the same characteristic aroma as the plant part they came from. The term "Essential" means they are nutritionally required by a living organism as the terms essential amino acids and essential fatty acids. Essential oils have a large range of applications: They have been widely used as food flavors and possess anti-oxidant and anti-microbial activities. It serves as natural additives in food and food products. They are known for their antiseptic (such that bactericidal, virucidal, and fungicidal), medicinal properties, and their fragrance. Essential oils are used in the preservation of foods and as an antimicrobial, analgesic, anti-inflammatory, and local anesthetic remedies. Essential oils are produced by different methods such as solvent extraction, supercritical fluid extraction, hydro distillation, and steam distillation, etc. Recently, ultrasound and microwave-assisted processes have been coming to use nowadays. The team has chosen steam distillation for the extraction of essential oil from the plant material. Some problems are associated with oil extraction from plant material which is described in figure 1.

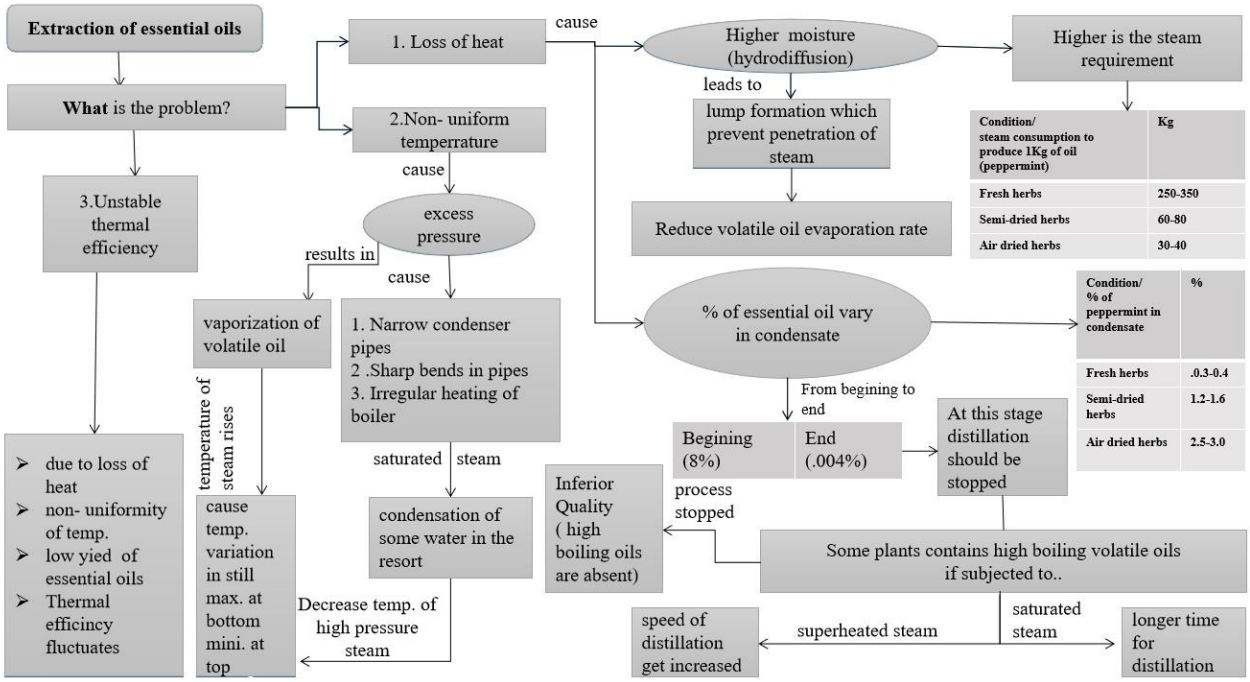


Figure.1 Flow Chart Showing Problems Associated With Steam Distillation

It is a special type of distillation process for temperature-sensitive materials like oils, resins, hydrocarbons, etc. which are insoluble in water and may decompose at their boiling point. The fundamental nature of steam distillation is that it enables a compound or a mixture of compounds to be distilled at a temperature substantially below that of the boiling point of the individual constituent. Essential oil contains components with the boiling points up to 200°C or higher temperatures. In the presence of steam or boiling water, however, these substances are volatilized at a temperature close to 100° C, at atmospheric pressure. Certain problems which arrive in the distillation of essential oil by steam distillation are loss of heat, non-uniform temperature and, unstable thermal efficiency. The cause of loss of heat is higher moisture in the plant charge which leads to lumps formation which prevents the penetration of steam and thus, reduces the volatile oil evaporation rate in the composite cylinder. Due to these losses percentage of essential oil vary in condensate from around 8% in the beginning to around 0.004% at the end of steam distillation in the case of peppermint oil. The causes of excess pressure are narrow cylindrical pipes, sharp bends in pipes, irregular heating of boiler, etc. which leads to temperature variation which is maximum at bottom and minimum at top. Unstable thermal efficiency is caused due to loss of heat, non-uniformity of temperature (as mentioned above), low yield of essential oils, etc.

Background

C. Boutekedjiret et al. [1] study was conducted to identify the components of rosemary oil by both hydro distillation and steam distillation consecutively and figured out that steam distillation gave better results compared to hydrodistillation. Avat Arman Taherpouret al. [2] research was carried out on hydro distillation and solid phase micro extraction methods and figured out that there were different components present in essential oils during both the processes. Bouchra Louaste et al. [3] they worked on Hydrodistillation and Microwave assisted Hydro-distillation and concluded that microwave heating leads to embrittlement or rupturing of plant cells rapidly than that of hydro distillation and hence, extraction can be done be done more effectively. Hanyue Chen et al. [4] they found that certain amount of sodium chloride promotes the yield of essential oil rosemary leaves but due to increased salinity after a certain amount the high salinity increases the oxidation stress of organic component, thereby inhibits the extraction. O.Chiavone-Filho et al. [5] experimented on the extraction of essential oil from Lippia sidoides cham using pressurized carbon dioxide and was compared with steam distillation and oleoresin obtained using ethanol the super critical fluid extraction yield was much better as compared to that of steam distillation and ethanol extraction. Chen Zhi-ling et al. [6] worked on extraction of plant volatile oils and and concluded that microwave process combined with steam distillation gives an advantage over any of these two processes carried out alone as the combined method provides better yield, is convenient and efficient. Chunchao Zhao et al. [7] extracted oil by two techniques that were solvent free microwave assisted distillation followed by homogenate extraction method and hydro distillation and it indicated that extraction by solvent free microwave assisted distillation was a more efficient isolation method and can be used for essential oils, flavonols and proanthocyanidins from the natural plants. Meryem Boukroufa [8] integrated green and solvent free extraction processes using ultrasound and microwave techniques in which microwave hydro diffusion and gravity (MHG) was compared with steam distillation and figured out that microwave hydro diffusion and gravity gave 24.2% yield for microwave power of 500W in only 3 minutes on the other hand conventional steam distillation gives 18.32% yield in 2 hours which proves that microwave hydro diffusion is faster and more effective than compared to conventional steam distillation. Fengli Chen et al. [9] researched on Microwave Assisted Simultaneous distillation and Dual Extraction (MSDDE) to extract volatile essential oils, non-volatile chlorogenic acid hyperoside and was concluded that this methods gave higher yields in

short times compared to traditional methods and essential oil components were also not changed in this process. Fengli Chen et al. [10] worked on Microwave Assisted Distillation and Dual Extraction by one-pot process and figured out that it gives better yield than hydro distillation, microwave assisted distillation and other conventional processes and this method worked for a large range of plants. Aurore Filly et al. [11] used solvent free microwave assisted distillation process for the extraction of essential oil and results provide that it provides the same essential oil qualitatively and quantitatively in 30 minutes which takes hydro distillation 2 hours. Mohamed Amine Balti et al. [12] study was conducted to investigate the effects of ultrasonic pre treatment on the extraction of essential oil from dried leaves of lemongrass by hydro distillation and was compared with conventional hydro distillation without pre-treatment and concluded that maximum amount of essential oils was obtained under optimized conditions (≈3.093g/100g d.m.). Krishna P. Solanki et al. [13] worked on Microwave intensified extraction and concluded that extraction microwave radiation has very much effect on the process leading to energy efficiency, shortened carbon footprints, and lowered utility consumption along with yield, in this process operating cost is reduced so, we can use this technique at a higher scale and this technique was proved to be a green approach for sustainable development of extraction process. Kyriakos et al. [14] studied Microwave assisted extraction to optimize an efficient alternative and very effective technique for the extraction of phenolics from pomegranate peels and extraction yield was found to be increased in Microwave assisted method. This method shortened the treatment time by over 60 times as compared to conventional extraction methods. 1.7 times higher yield obtained in microwaves method in shorter process time of 4 minutes as compared to ultrasound assisted extraction of time 10minutes. E.M. Garcia-Castello et al. [15] researched on Ultrasound Assisted Extraction (USE) and it was compared with conventional solvent extraction, ultrasound assisted extraction allowing higher extraction yields with lower temperatures and extraction times. Meriem Bouras et al. [16] worked on optimization of microwave assisted extraction in which they found that the microwave assisted extraction has a potential to recover the antioxidant compounds. It was found that the moisture content of bark did not affect the final antioxidant yield since the water intake in sample occurred rapidly. Deep Jyoti Bhuyan et al. [17] researched on microwave assisted extraction and figured out that conventional soxhlet extraction usually requires long extraction times leading to thermal degradation of phyto constituents. The internal pressure of solid media was increased by microwave that leads to enhanced extraction

efficiency. Also deterioration of phenolic compound was reduced. Ahmed Zermane et al. [18] studied supercritical CO2 process using response surface methodology and conclude that extracts obtained by this process were of much better quality as compared to that of conventional processes. Irena Zizovic et al. [19] worked on supercritical CO2 extraction and figured out that there was no significant influence on the extraction rate with respect to particle size when Asteraceae family species, marigold and chamomile essential oils were extracted. E. Reverchon and F. Senatore [20] compared hydro-distillation and supercritical CO2 extraction in which qualitative aroma testing showed that the oil obtained by supercritical fluid extraction (SFE) using CO2 gave better resemblance with rosemary leaves than that hydro-distillation and also percentage composition of the two oils obtained varied widely.

The Specification and Design

The team presented a solution that might overcome the problem listed above. The name given to the proposed solution is “Enoilmos”. The base of the cylinder was made from stainless steel of thermal conductivity 50 W/mK and coefficient of thermal expansion $16*10^{-6}$ /℃. Such specifications lead to effective heat transfer for quick heating of water and also ensure corrosion-resistant behavior. The base plate is heated electrically.

The base was welded to the composite cylinder consisting of four layers. The innermost layer was made from ferritic stainless steel of thermal conductivity k_s and coefficient of thermal expansion α_s. This material has lower thermal conductivity than stainless steel which helps to reduce heat transfer across it thus maintaining uniformity of temperature across the inner surface of the cylinder. So, to reduce the heat losses (both conductive and convective) vacuum is created just after the inner layer which was considered as the second layer of thermal conductivity k_v. Now to maintain this vacuum a thin layer of ferritic stainless steel was provided. For insulation fourth layer of fiberglass having thermal conductivity k_f was used. Fiberglass was chosen because it is eco-friendly, economical and easily available. To make the system closed a lid was provided at the top of cylinder and was fastened by clamping. Use of threaded lid was avoided because that might increase the cost of lid due machining of threads. Moreover, the profile and life of threads might deteriorate by heat exposure. To avoid leakage of steam and volatile oil mixture a rubber seal was placed between cylinder top and lid. A hole has been provided at the center of the lid for reciprocating motion of the piston rod with proper leak proof.

A perforated plate of circular cross-section was placed halfway along the length of the cylinder on the extrude provided at the inner surface, so as to hold the plant charge and provide passage for the steam to pass through it. The piston rod was fixed to the top perforated piston to which three or four springs are fixed and other ends of the springs were free. A perforated piston was used to provide squeezing to the plant charge thus releasing more oil. Ideally, the temperature across the cylinder was made constant and hence change in internal energy of plant charge would become zero. Thus by the first law of thermodynamics, the work done by the perforated piston gets converted into heat which causes evaporation of more oil from the oil glands. Springs were used to disturb the squeezed plant charge which otherwise cause blockage to the floe of steam through the plant charge. At the top of the cylinder, a passage for the flow of steam and volatile mixture to the condenser has been provided.

The condenser was a counter flow shell and tube (helical shape) type heat exchanger. For the supply of cold water inlet and outlet ports were provided at the bottom and top of the condenser respectively. The tube of the condenser was chosen helical in shape which would provide a large heat transfer area in compactness.

Scotch Yoke mechanism was used to provide reciprocating motion to the perforated piston and same provides reciprocating pump motion. This pump motion was used to feed cold water to the condenser.

Florentine Vase was provided for final the separation of essential oil from the distillate.

Figure 2 shows the CAD model of the proposed solution.

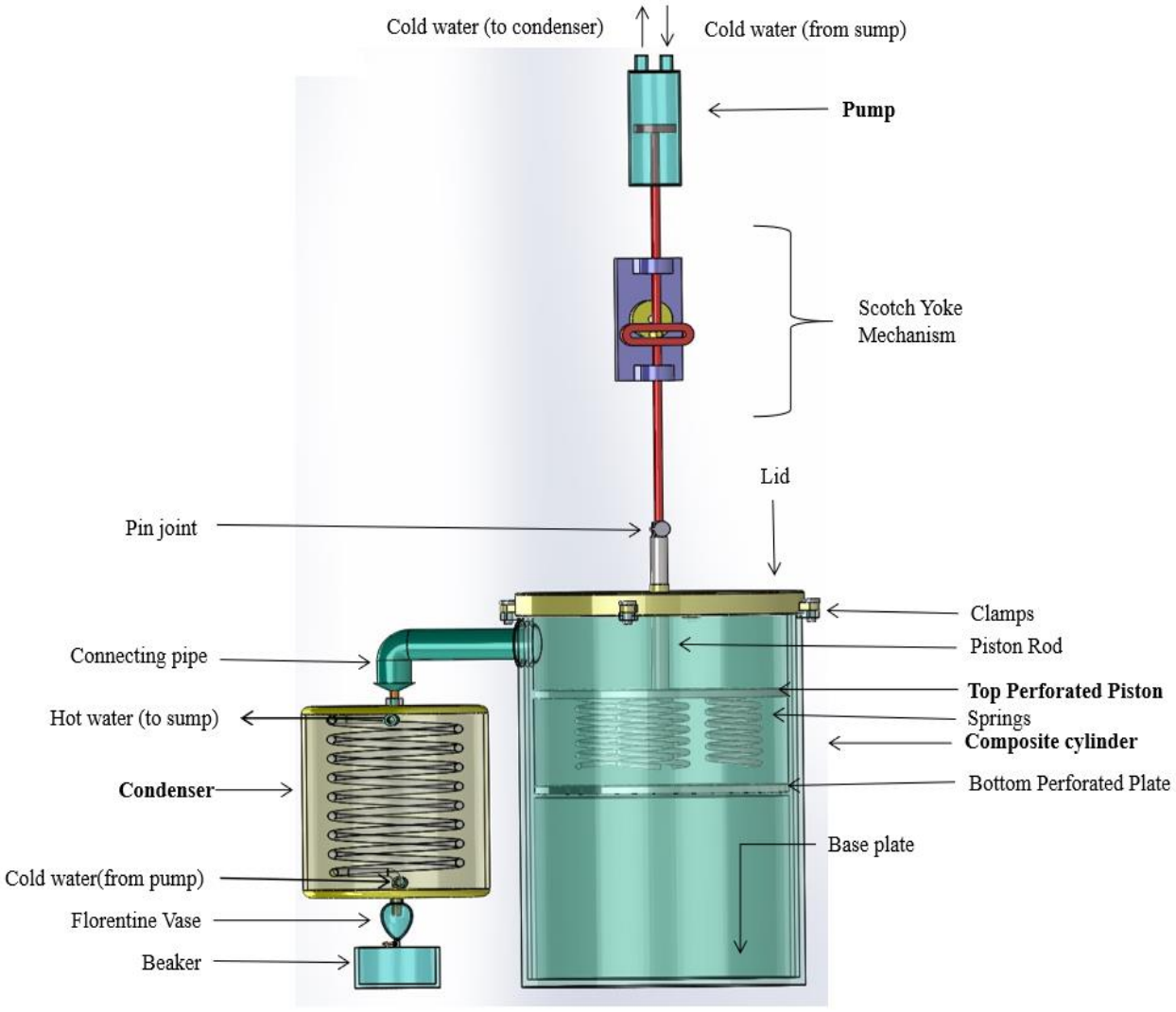


Figure.2 CAD Model of Proposed Solution

Implementation

To extract the essential oil from the oil glands in the plant charge steam is required. For that water was filled in the cylinder up to a quarter length. Heat was supplied to the water electrically from the base. Water was heated up to 200° C temperature. Hence superheated steam was generated which was made to pass through the plant charge (non-comminuted or partially comminuted) placed between the two perforated plates. Superheated steam releases oil from the oil glands by rupturing. The mixture of volatile oil and steam got collected at the top of the perforated piston. The Reciprocated motion of the perforated piston squeezes the plant charge thus releasing more oil. The upward motion of the piston disturbs the plant charge with the help of springs, which helps the steam to reach the unexposed plant charge. Some plant charge was carried by spring during this upward motion, which momentarily makes the piston un-perforated to some extent that exerts the pressure on the steam and volatile mixture at the top forcing it to move into the condenser. Coldwater was supplied by the pump at the bottom of the condenser. After condensation hot water was available at the top of the condenser which is supplied to the sump. After the mixture of volatile oil and steam was condensed the essential oil was collected from the Florentine Vase, as illustrated in figure.3. Due to lack of physical model and laboratory apparatus the team faced the problem to verify the proposed solution experimentally.

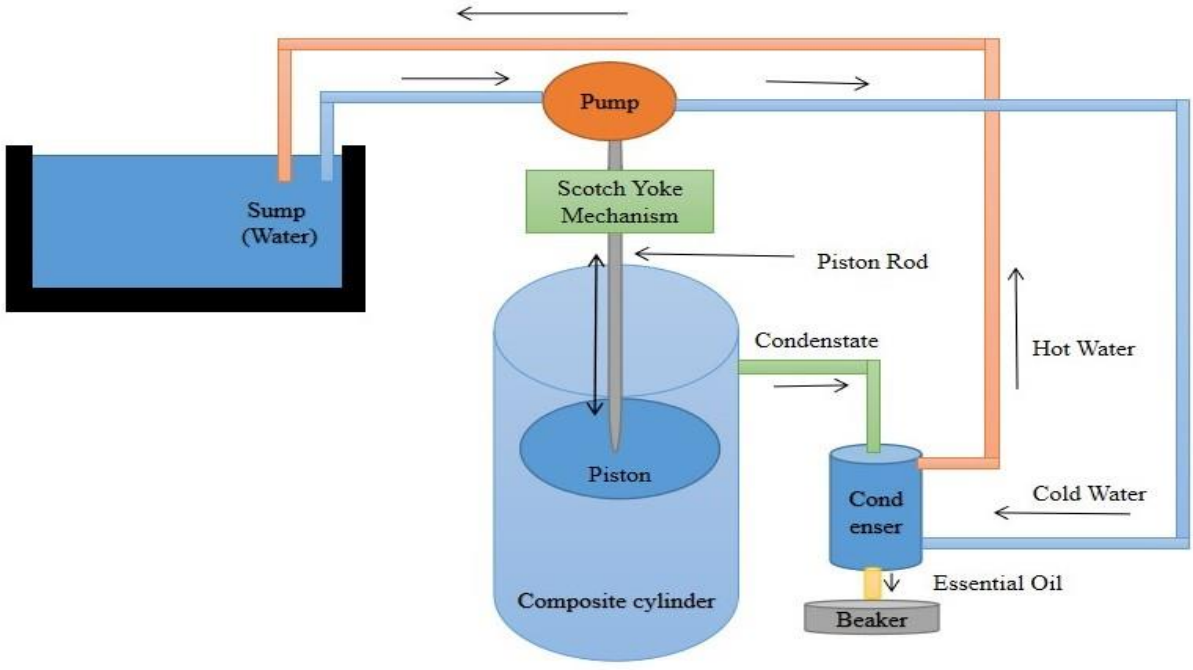


Figure.3 Implementation Model

Results and Evaluation

1. Analytical Approach

1.1 <u>Calculations of Heat Losses and Temperature</u>

For checking the performance of the proposed solution, consider two cases for the calculation of heat losses across the composite cylinder. For calculations system was assumed to be in a steady state and only one-dimensional conductive heat flow was considered.

<u>Case 1</u>: Traditional Apparatus-When composite cylinder consists of only two layers: Innermost layer was made of ferritic stainless steel and a second layer of fiberglass.

r_1=0.150m; r_2=0.155m; r_3^*=0.160m; l=0.5m; T_1=473K; T_2=293K; k_s=25 W/mK; k_f=0.04 W/mK

Therefore, heat losses across the traditional apparatus,

$$Q_1 = \frac{2\pi l(T_1 - T_2)}{\frac{\ln(r_2/r_1)}{k_s} + \frac{\ln(r_3*/r_2)}{k_f}}$$

$$Q_1 = \frac{2\pi * 0.5(473 - 293)}{\frac{\ln(0.155/o.150)}{25} + \frac{\ln(0.160/0.155)}{0.04}}$$

$$Q_1 = 711.28 \text{ W} \quad (1)$$

For steady state heat flow through each cell would be same.

Therefore, heat loss through innermost layer,

$$Q_1 = 711.28 \text{ W}$$

$$\frac{2\pi l(T_1 - T_3)}{\frac{\ln(r_2/r_1)}{k_s}} = 711.28\ W$$

$$\frac{2\pi * 0.5(473 - T_3)}{\frac{\ln(0.155/0.150)}{25}} = 711.28\ W$$

$$T_3 = 472.70 \text{ K} \quad (2)$$

Case 2: Proposed Solution by the team- When the composite cylinder consists of four layers as discussed in specification and design.

r_1=0.150m; r_2=0.155m; r_3=0.160m; r_4=0.162m; r_5=0.167; l=0.5m; T_1=473K; T_2=293K; k_s=25 W/mK; k_v=0.004 W/mK; k_f=0.04 W/mK

Therefore, heat losses in the proposed solution,

$$Q_2 = \frac{2\pi l(T_1 - T_2)}{\frac{\ln(r_2/r_1)}{k_s} + \frac{\ln(r_3/r_2)}{k_v} + \frac{\ln(r_4/r_3)}{k_s} + \frac{\ln(r_5/r_4)}{k_f}}$$

$$Q_2 = \frac{2\pi * 0.5(473 - 293)}{\frac{\ln(0.155/0.150)}{25} + \frac{\ln(0.160/0.155)}{0.004} + \frac{\ln(0.162/0.160)}{25} + \frac{\ln(0.167/0.162)}{0.04}}$$

$$Q_2 = 65 \text{ W} \quad (3)$$

From equations (1) and (3),

$$\text{Percentage drop in heat loss} = \frac{Q_1 - Q_2}{Q_1} \times 100$$

$$= \frac{711.28 - 65}{711.28} \times 100 = 90.86\ \%$$

Hence, from calculations it was evaluated that the proposed solution would reduce the heat losses by 90.86%.So, the performance of the proposed solution would be higher than the traditionally used apparatus.

For steady state heat flow through each layer would be same.

Therefore, heat loss through first layer = Q_2

$$\frac{2\pi l(T_1 - T_4)}{\frac{\ln(r_2/r_1)}{k_s}} = 65 \text{ W}$$

$$\frac{2\pi * 0.5(473 - T_4)}{\frac{\ln(0.155/0.150)}{25}} = 65 \text{ W}$$

$$T_4 = 472.97 \text{ K} \quad (4)$$

Similarly, heat loss through second layer= Q_2

$$\frac{2\pi l(T_4 - T_5)}{\frac{\ln(r_3/r_2)}{k_v}} = 65 \text{ W}$$

$$\frac{2\pi * 0.5(472.97 - T_5)}{\frac{\ln(0.160/0.155)}{0.004}} = 65 \text{ W}$$

$$T_5 = 308.75 \text{ K} \quad (5)$$

Similarly, heat loss through third layer = Q_2

$$\frac{2\pi l(T_5 - T_6)}{\frac{\ln(r_4/r_3)}{k_s}} = 65 \text{ W}$$

$$\frac{2\pi * 0.5(308.75 - T_6)}{\frac{\ln(0.162/0.160)}{25}} = 65 \text{ W}$$

$$T_6 = 308.74 \text{ K} \quad (6)$$

Moreover, from the first law of thermodynamics,

$$\delta Q = \delta W + dU \quad (7)$$

Where, $\delta Q, \delta W, dU$=Heat change, change in work, change in internal energy of the system (space enclosed by the composite cylinder)

The team tried to maintain constant temperature inside the composite cylinder. Also for constant temperature change in internal energy of the system become zero.

$$dU = 0 \quad (8)$$

Work had been done on the system by reciprocating motion of the piston.

$$\delta W = -ve \quad (9)$$

From equations (7), (8) and (9),

$$\delta Q = \delta W = -ve$$

Here, the negative sign shows that the heat was released by the system. Hence this heat can be utilized to evaporate more oil from oil glands. Which ultimately increases oil yield.

For the comparison of temperature profile across the layers of the traditional apparatus and proposed solution graph has been plotted from values of T_1, T_2 and equations (2), (4), (5), and (6) which were shown in figure.4 and figure.5.

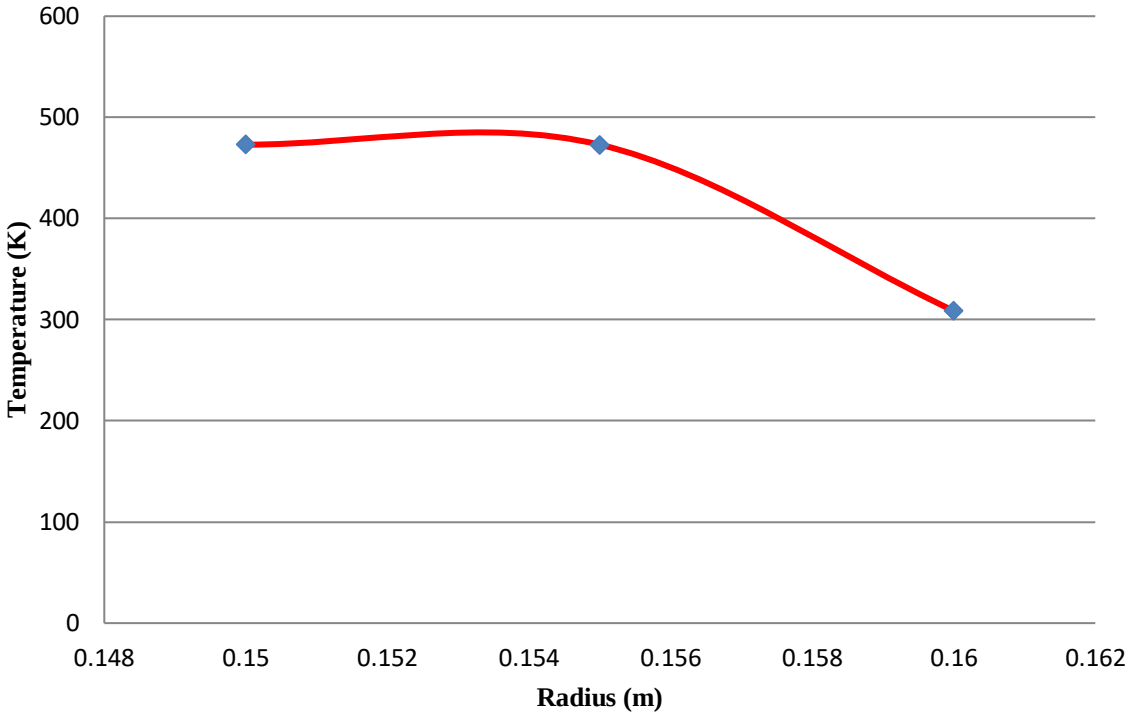


Figure.4 Temperature Profile of Traditional Apparatus

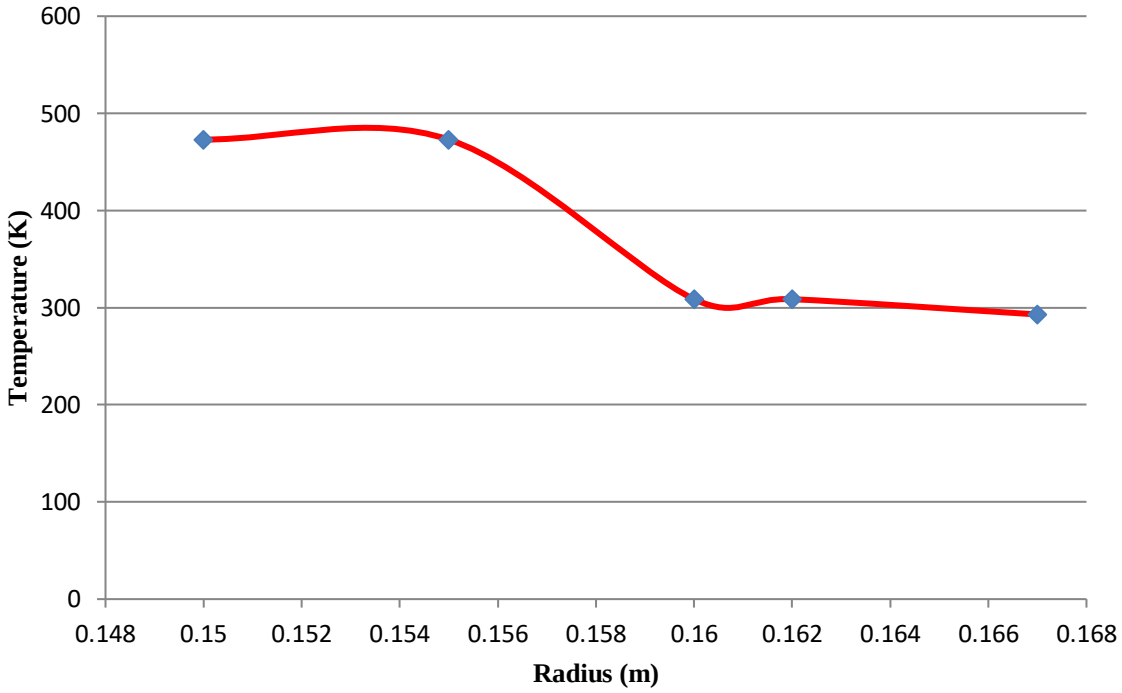


Figure.5 Temperature Profile of Proposed Solution

2. Software Simulation

Simulink, an add-on product to MATLAB, provides an interactive, graphical environment for modeling, simulating, and analyzing dynamic systems. Simulink provides a user friendly graphical user interface (GUI) for rapid building of simulation models as block diagrams. Due to these features, proposed solution was also built on the Simulink.

2.1 Simulation Model

A simulation model of the proposed apparatus based on mathematical formulation has been prepared using Matlab/Simulink virtual window. The Simulink model prepared in this work is able to simulate the behavior of heat loss across the proposed composite cylinder design for essential oil extraction unit as well as for the conventional cylinder arrangement for the same.

The behavior of temperature variation and corresponding heat loss across the system has been obtained and are analyzed for the purpose of comparative study of improvement again the heat loss in proposed model. The simulation result obtained for heat loss is shown in figure 6. The analysis shows a significant reduction in heat loss in the proposed model in comparison to conventional model and transformation of piston work into heat, and squeezing of plant charge by the piston would collectively increase the efficiency of the essential distillation unit. The simulation model is shown in figure 7.

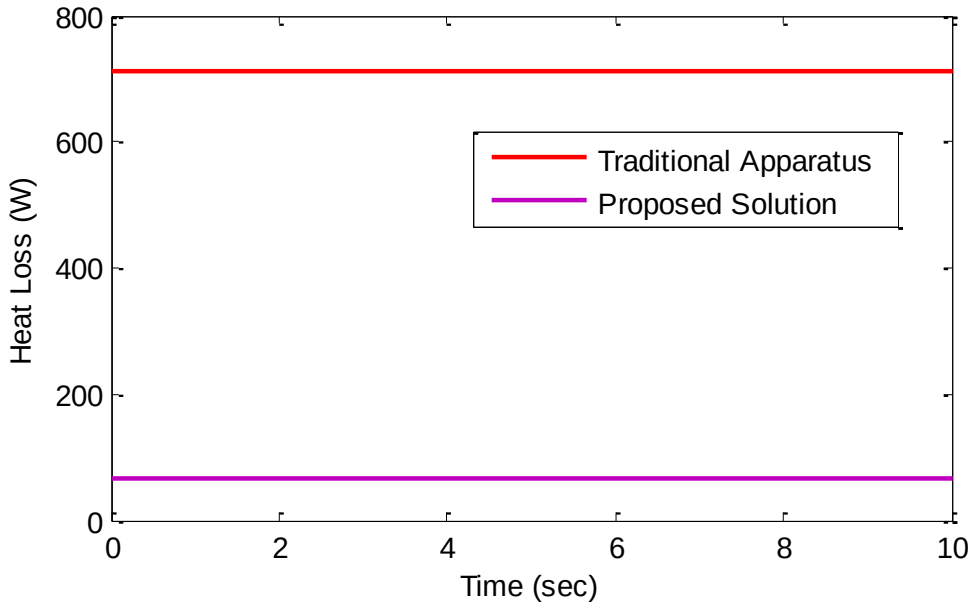


Figure.6 Comparison of Heat Loss by Simulation on Simulink

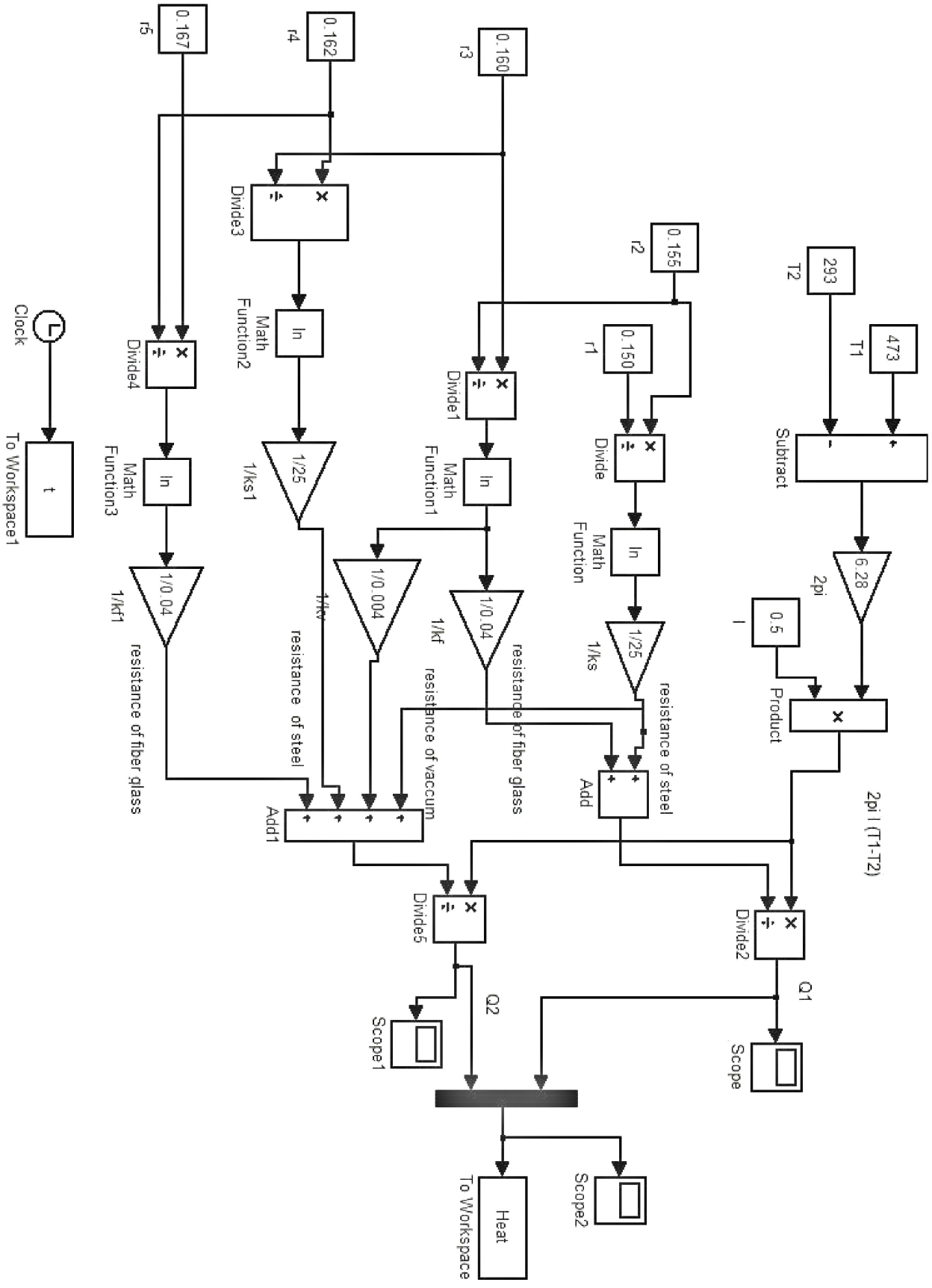


Figure.7 Simulink Model for Heat Loss

Future Work

To increase the efficiency of essential oil distillation the team has a lot of plans for future work like replacing fiberglass with aerogel, which is an insulating material of thermal conductivity (0.015 W/mK) much lower than fiberglass which reduces the heat losses more effectively. Moreover, it is lightweight and cheap; air conditioning arrangements will also be helpful to automatically cool the water for the condenser supply. In this arrangement, a tube is wound around the composite cylinder which carries the refrigerant this tube is also passed through the cold water storage (sump). If a refrigerant is maintained at a lower temperature than water (in the sump) then heat is released by the water which cools the water and heats the refrigerant. As temperature after the third layer of the composite cylinder (proposed solution) was nearly 35° C (as shown in the temperature profile) which will be lower than that of refrigerant (coming from the sump). So heat is released by refrigerant which adds heat into the composite cylinder. Hence, this arrangement will give two benefits one is to cool the water for the condenser supply (which prevents the addition of ice cubes in the water manually) and the second is to add extra heat into the composite cylinder. Which increases the evaporation rate of essential oil. This apparatus is shown in figure.8.

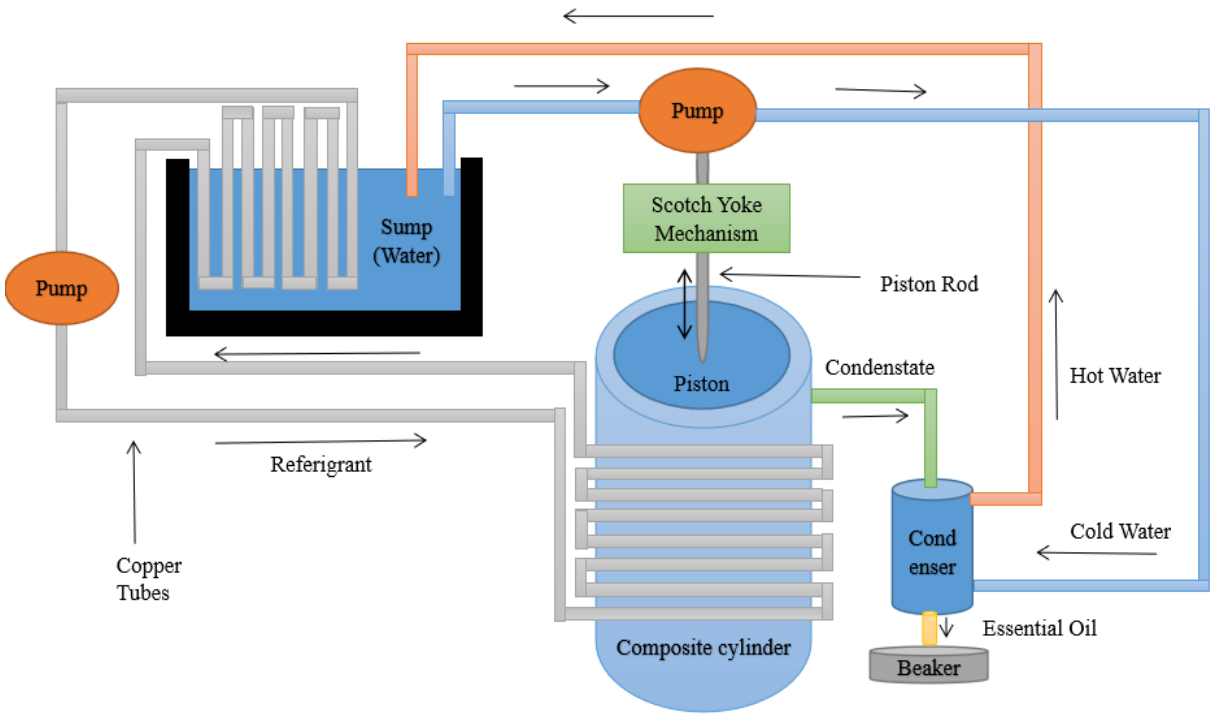


Figure.8 Model for Future Work

Conclusions

The analytical calculations and software-based simulation both confirms the better performance of the proposed solution. As in the case of traditional extraction apparatus (double layer), the heat loss obtained was 711.28 W whereas in the case of the proposed solution these heat losses were reduced to 65 W. This significant decrease in the heat loss gave a 90.86 percentage drop in heat loss. Hence, by saving this much amount of energy evaporation rate of essential oil increases.

As observed in the temperature profile for traditional and proposed solution apparatus significant drop in temperature occurs by the introduction of a vacuum layer, which would maintain uniformity of temperature across the composite cylinder which was a problem faced by industries.

Moreover, the reciprocating motion of the perforated piston not only would add heat (by the first law of thermodynamics) to the plant charge but also squeezes the plant charge to release more oil, which would increase oil yield.

Reflections

The idea and motivation that leads to the design of the proposed solution in such a configuration have come from day-to-day lifestyle practices. The first and foremost idea to insulate the composite cylinder by introducing a vacuum layer has come from “Thermos” in which also vacuum layer was used for insulation. Observing the “Lemon Squeezer” which extracts the lemon juices so effectively that the proposed solution also utilizes the same principle for the reciprocating motion of the perforated piston. Different models and mechanisms were designed to perform these tasks. The mechanism to provide the reciprocating motion to the perforated piston was changed several times from hydraulic actuation to rack and sector gear arrangements to the final Scotch Yoke mechanism. These designs were changed keeping in mind the aspects of ease of manufacturing, maintenance and, cost, etc.

The same was true for the design of the lid in which two mechanisms were designed these were lid with internal threads and lid with clamps. Finally, a lid with clamps was chosen because of its ease of manufacturing, and better leak-proof properties.

Selecting materials for the composite cylinder was a big task because the selected material should be such that it is economical, eco-friendly, has good thermal conductivity and a low coefficient of thermal expansion, etc. Most of the parts were made from ferritic stainless steel because it has all those properties. Fiberglass is chosen because it is easily available, cheap, eco-friendly and, has very low thermal conductivity.

Table of Abbreviations

Symbol	Description
T_1	Inside temperature
T_2	Ambient temperature
T_3	Interface temperature of the first and second layer of traditional apparatus
T_4	Interface temperature of the first and second layer of the proposed solution
T_5	Interface temperature of the second and third layer of the proposed solution
T_6	Interface temperature of the third and fourth layer of the proposed solution
k_s	Thermal conductivity of ferritic stainless steel
k_v	Thermal conductivity of vacuum
k_f	Thermal conductivity of fiberglass
l	Length of the composite cylinder
r_1	Inner radius of the first layer of composite cylinder
r_2	Outer radius of the first layer and the inner radius of second layer
r^*_3	Outer radius of the second layer and the inner radius of third layer of traditional apparatus
r_3	Outer radius of the second layer and the inner radius of third layer of the proposed solution
r_4	Outer radius of the third layer and the inner radius of fourth layer
r_5	Outer radius of fourth layer
Q_1	Heat loss through traditional apparatus
Q_2	Heat loss through proposed solution
δQ	Heat change in the system
δW	Change in work-done
dU	Change in internal energy

References

[1] Boutekedjiret, C., Bentahar, F., Belabbes, F., Bessiere, J.M.B. (2003) 'Extraction of rosemary essential oil by steam distillation and hydrodistillation', *Flavour Fragr. J.*, Vol.18, pp.481–484.

[2] Taherpour, A.A., Khaef, S., Yari, A., et al. (2017) 'Chemical composition analysis of the essential oil of Mentha piperita L. from Kermanshah, Iran by hydrodistillation and HS/SPME methods', *Journal of Analytical Science and Technology,* Vol.8, pp.1-6.

[3] Louaste, B., Nechad, I., Elkamli, T., et al. (2019) 'Extraction of Essential Oils of Rosmarinus officinalis L. by Two Different Methods: Hydrodistillation and Microwave Assisted Hydrodistillation', *The Scientific World Journal*, vol. 2019, pp.1-6.

[4] Chen, H., Gu, Z., Yang, L., et al. (2021) 'Optimization extraction of rosemary essential oils using hydrodistillation with extraction kinetics analysis', *Food Sci Nutr.*, Vol.11, pp.6069–6077.

[5] Chiavone-Filho, O., Moreno, M.T., et al. (2002) 'Experimental results for the extraction of essential oil from Lippia sidoides cham. using pressurized carbon dioxide', *Braz. J. Chem. Eng.*, Vol. 19, pp. 229 – 241.

[6] Zhi-ling, C., Jian-ping, C., Hui-lin, C., et al. (2011) 'Research on the Extraction of Plant Volatile Oils', *Procedia Environmental Sciences*, Vol.8, pp. 426-432.

[7] Zhao, C., Yang, X., Tian, H., Yang, L. (2020) 'An improved method to obtain essential oil, flavonols and proanthocyanidins from fresh Cinnamomum japonicum Sieb. leaves using solvent-free microwave-assisted distillation followed by homogenate extraction', *Arabian Journal of Chemistry*, Vol.13, pp.2041-2052.

[8] Boukroufa, M., Boutekedjiret, C., et al. (2015) 'Bio-refinery of orange peels waste: A new concept based on integrated green and solvent free extraction processes using ultrasound and microwave techniques to obtain essential oil, polyphenols and pectin', *Ultrasonics Sonochemistry*, Vol.24, pp.72-79.

[9] Chen, F., Du, **X.,** Zu, Y., et al. (2015) 'A new approach for preparation of essential oil, followed by chlorogenic acid and hyperoside with microwave-assisted simultaneous distillation and dual extraction (MSDDE) from Vaccinium uliginosum leaves', *Industrial Crops and Products***,** Vol.77, pp.809-826.

[10] Chen, F., Du, X., Zu, Y., et al.(2016) 'Microwave-assisted method for distillation and dual extraction in obtaining essential oil, proanthocyanidins and polysaccharides by one-pot process from Cinnamomi Cortex', *Separation and Purification Technology,* Vol.164, pp.1-11.

[11] Filly, A., Fernandez, X., Minuti, M., et al.(2014) 'Solvent-free microwave extraction of essential oil from aromatic herbs: From laboratory to pilot and industrial scale', *Food Chemistry*, Vol.150, pp.193-198.

[12] Balti, M.A., Hadrich, B., et al. (2018) 'Lab-scale extraction of essential oils from Tunisian lemongrass (Cymbopogon flexuosus)', *Chemical Engineering and Processing - Process Intensification,* Vol.124, pp.164-173.

[13] Solanki, K.P., Desai, M.A., Parikh, J.K. (2019) 'Microwave intensified extraction: A holistic approach for extraction of citronella oil and phenolic compounds', *ChemicalEngineering and Processing - Process Intensification,* Vol.146, pp.1-38.

[14] Kaderides, K., Papaoikonomou, L., et al. (2019) 'Microwave-assisted extraction of phenolics from pomegranate peels: Optimization, kinetics, and comparison with ultrasounds extraction', *Chemical Engineering and Processing - Process Intensification,* Vol.137, pp.1-11.

[15] Garcia-Castello, E.M., Rodriguez-Lopez, A.D., et al. (2015) 'Optimization of conventional and ultrasound assisted extraction of flavonoids from grapefruit (Citrus paradisi L.) solid wastes', *LWT - Food Science and Technology*, Vol.64, pp.1114-1122.

[16] Bouras, M., Chadni, M., et al. (2015) 'Optimization of microwave-assisted extraction of polyphenols from Quercus bark', *Industrial Crops and Products,* Vol.77, pp.590-601.

[17] Bhuyan, D.J., Vuong, Q.V., Chalmers, A.C., et al. (2015) 'Microwave-assisted extraction of Eucalyptus robusta leaf for the optimal yield of total phenolic compounds', *Industrial Crops and Products***,** Vol.69, pp.290-299.

[18] Zermane, A., Larkeche, O., Meniai, A.H., et al.(2016) 'Optimization of Algerian rosemary essential oil extraction yield by supercritical CO_2 using response surface methodology', *Comptes Rendus Chimie,* Vol.19, pp.538-543.

[19] Zizovic, I., Stamenić, M., et al. (2007) 'Supercritical carbon dioxide extraction of essential oils from plants with secretory ducts: Mathematical modelling on the micro-scale', *The Journal of Supercritical Fluids,* Vol.39, pp338-346.

[20] Pereira, P., Cebola, M.J., et al. (2016) 'Supercritical fluid extraction vs conventional extraction of myrtle leaves and berries: Comparison of antioxidant activity and identification of bioactive compounds', *The Journal of Supercritical Fluids*, Vol.113, pp.1-9.

TECHNOLOGIES FOR EXTRACTION OF LEMONGRASS ESSENTIAL OIL TO IMPROVE YIELD

MADHUSHREE C[1], SUSHMA B[2], HARSHITHA K[2], KAVYANJALI N[2]

[1]Assistant Professor, Department of Civil Engineering, Vidyavardhaka College of Engineering
[2]Student, Department of Civil Engineering, Vidyavardhaka College of Engineering
1madhushree.c@vvce.ac.in
[2]sushmab7771@gmail.com
[2]Premakariyappa75@gmail.com
[2]kavyanjalidigan@gmail.com

ABSTRACT:A large number of herb materials contain Essential Oil with extensive bioactivities. Acknowledging the importance of plants and their medicinal value, extraction of Essential Oil had been done using the Steam Distillation method. In this project, Steam Distillation was used to extract oil from lemongrass. Research has confirmed centuries of practical use of essential oil and we know that the fragrant pharmacy contains compounds with an extremely broad range of biochemical effects. Essential oils are so termed as they are believed to represent the very essence of odor and flavor. There are a variety of methods for obtaining volatile oils from plants. The steam distillation method was found to be one of the promising techniques for the extraction of essential oil from plants reputable distiller will preserve the original qualities of the plant. The distillation was conducted in a Soxhlet extractor in which boiling and condensing were done. Analysis of essential oil was done using liquid-liquid separator equipment, which gives valuates Essential Oil quantitatively. It was found that for 1kg of Lemongrass, 2ml of oil was extracted using the steam distillation method which gave better yield results compared to other methods.

Keywords: Lemongrass, Steam Distillation, Soxhlet apparatus, Solvent, Yield.

I. INTRODUCTION

Essential oils are the oils that are used in different industries like pharmaceuticals, insecticides chemicals, cleaning industry, food industry, and perfume industries. The essential oil consumption is increasing day by day all over the world. Different methods of the extraction of essential oils are invented in developing countries. But still, the traditional method of extraction of oil has a huge significance all over the world. Water distillation, steam distillation, and cohobating are some of the traditional methods of extraction of essential oil. Steam distillation is the most suitable method to extract the essential oils.

Essential oils are the extracted compounds from different parts of plants like roots, stems, leaves, flowers fruits, and seeds. These oils are extracted through the process of steam distillation most of the time.it can also be done through mechanical or cold pressing methods. Plants have unique characteristics of aroma or ‘essence’ in it. It gives a pleasant aromatic flavor and odor to the oil.

1.1USES OF ESSENTIAL OIL

Essential oils are used in different biological aspects. Different parts of the plants will undergo the isolation of essential oils. Essential oils are generally derived from one or more plant parts, such as flowers (e.g. rose, jasmine, carnation, clove, mimosa, rosemary,

lavender), leaves (e.g. mint, Ocimum spp., lemongrass, jamrosa), leaves, and stems (e.g. geranium, patchouli, petitgrain, verbena, cinnamon), bark (e.g. cinnamon, cassia, canella), wood (e.g. cedar, sandal, pine), roots (e.g. angelica, sassafras, vetiver, Saussurea, valerian), seeds (e.g. fennel, coriander, caraway, dill, nutmeg), fruits (bergamot, orange, lemon, juniper), rhizomes (e.g. ginger, calamus, Curcuma, orris) and gums or oleoresin exudations (e.g. balsam of Peru, Myroxylon balsamum, storax, myrrh, benzoin).

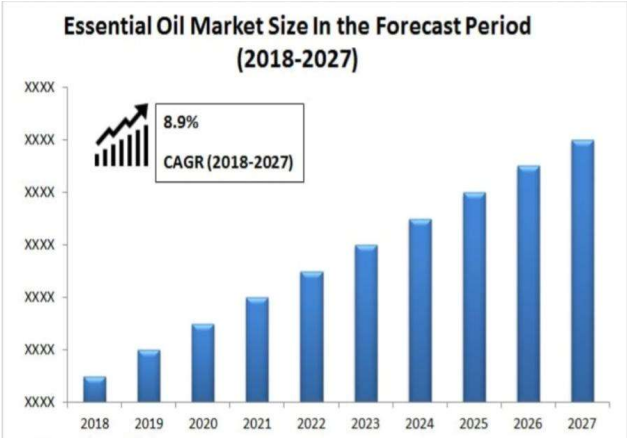
Essential oils are used in almost all the fields which we come across in daily life. Essential oils are mostly used in stress relief therapies i.e., aromatherapy, this will result in decreasing rate of depression, pain relievers, anxiety and it acts as antioxidant, antimicrobial, antifungal reactants. And it is also used in the field of cosmetics and perfume industries which are having an increasing market rate, in the food sector for cooking purposes, preservation, and manufacturing of food items. Essential oils are also used in folk herbal medicines in the improvement of mood swings, which results in the release of depression.

1.2 LEMONGRASS

Lemongrass oil is an essential oil extracted from the leaves and stalks of the lemongrass plant. It contains a citrus scent.India is the largest producer of lemongrass. Lemongrass production is 300-350tonnes per annum in India. It grows around 3000 hectares area in states of Kerala, Karnataka, Uttar Pradesh, and Assam. Most of the species of lemongrass are found in the southeast part of the world so it is also called East Indian lemongrass. Sri Lanka, Burma, and Thailand are subjected to west Indian lemongrass.

The global market of lemongrass is expected to be the rate to the value of $232 million throughout (2019-2025) at a CAGR of 8.4%. In India, oil produced 1800 tonnes per annum and held a monopoly both in production and world trade. The trend in prices of oil both in domestic and international markets during the 5 years i.e., 1998-2002 below the graph. In India, there are two markets for lemongrass oil which is in Mumbai and cochin. These agents of processing/ exporting companies visit the production area and check the quality of the crop and agree on a price with the producer. About 80% of the production is being traditionally exported to West Europe, the USA, and Japan.

A lemongrass yield of 100-150 kg/hectare is obtained under the irrigated condition of the land. The clean and fresh herb contains an average of 0.3% of oil. Thick stems are removed before the distillation, as these are entirely lacking in oil. Approximately India produces 500MT of oil per annum whereasthe oil demand is 800MT per annum. Lemongrass oil is majorly produced in Kerala, Tamilnadu, Assam, Madya Pradesh, West Bengal, Uttar Pradesh, and Maharashtra. Due to allergic reaction (tropical use) increased amylase, increased bilirubin, toxic alveolitis (inhaled use) productivity of lemongrass oil will decrease now and then.



Graph 1: Essential Oil Market Size

Fig.1: Lemongrass

For this reason, it is present in many medication products and daily care products. Lemongrass has antibacterial, antifungal, antioxidant, and anti-inflammatory properties. Hence it has huge benefits like medication for skin infections, pneumonia, blood infections, serious intestinal infections, fungal infections like ringworm.Lemongrass oil also treats many health problems like arthritis, cardiovascular diseases, liver cancer, etc. lemongrass oil prevents gastric ulcers and stomach pain, helps to cure diarrhea relieves, headache, migraine relieves, stress, and anxiety, reduce cholesterol, regulates blood sugar and lipids. and it also has huge importance in the food and cleaning industries.

Approximately 55 species of lemongrass can be seen in thriving tropical climates like India. Out of 55 species, two species namely Cymbopogon citrates (West Indian) and Cymbopogon flexuous (East Indian). Lemongrass is also known as Malabar and Cochin grass in India. Lemongrass oil is used in different sectors that are:

1. Pharmaceutical and ayurvedic industries
2. Tea industries
3. Meditative and retreat centers
4. Cleaning industry
5. Food and beverage industry
6. Fragrance industry

II. LITERATURE REVIEW

Madani Leila et. al (2021) has discussed in their paper that, supercritical fluid technology was used to extract oil from local Algerian Inula Viscose leaves. The extraction yields were in the range of 6.35–8.04 (w/w %). In this work, firstly the extraction of oil from aerial parts (airdried leaves) of the Inula Viscose plant of Algeria using supercritical carbon dioxide (SC-CO2) as solvent was carried out at temperatures and pressures in the range of 35–50^0Cand200–400 bars, respectively, the flow rate of 2 ml/min.In the second part of this work the experimental kinetic dataobtained were used for mathematical modellingtoinvestigate which of the three models applied fits the experimental dataof extraction kinetics best.

Ewa Majewska et.al (2019)havedescribed the chemical constituents of the essential oil which have constantly been detected and determined its biological activity are aldehydes, hydrocarbon terpenes, alcohols, ketones, and esters.This paper reviews recent information on extraction methods of lemongrass essential oil, its chemical composition depending on the origin of the plant, bioactivity of the oil constituents as well as the potential application as a food preservative.

k. Gopala Satheeskumar (2019) has preferred a Soxhlet extractor to extract the oil from the plant materials.And this review explains the various pre-extraction process and post-extractionprocesses of the Soxhlet extractor. In this review, it is concluded that the solvent selection, drying of the plant, size reduction, size separation of the plant materials is important for the extraction process and this review is useful to the proper usage of Soxhlet apparatus in phytochemical research.

Thien Hien Tran et. al (2018) in their paper they preferred Microwave-assisted hydrodistillation (MAHD) over traditional extraction methods to shorter extraction time, the inability of volatile components to be damaged, or decomposed to increase the efficiency and quality of extracted essential oils. In this research, they have investigated the parameters that affect the extraction of lemongrass oil process by microwave-assisted hydro-distillation (MAHD)method and compare with those of hydrodistillation (HD) method. They have identified Four parameters which were: raw material size, the raw material to water ratio, extraction time, and microwave power. And they have used Anhydrous sodium sulfate (Na_2SO_4) was used to remove water from the extracted oil.

Sara Moradi et.al (2018) in this research, Microwave-assisted Hydro-distillation (MAHD)is adopted to extract essential oils from the leaves of the cultivated plants of rosemary. The leaves were dried in the shade for two weeks and the results were compared with the conventional Hydro distillation in terms of extraction time, extraction efficiency, chemical composition, quality of the essential oils, and cost of the operation.

Lemongrass oil is a highly beneficial productive oil in India (myrcene, citral, citronellal, geranyl acetate, nerol, limonene) are some of the scientific benefits of lemongrass oil. It has a huge consumer rate across the world. The lemongrass oil production is more in India than exclusively in southeast and southwestregions of India. And most beneficial methods related to medication can be done with lemongrass oil. Since it has more benefits and availability in

India, essential oil extraction using lemongrass can be carried out to achieve an increase in the yield of oil.

III. SPECIFIC OBJECTIVES

- To determine the suitable methods for the extraction of essential oil.
- To evaluate the factors which are influencing improving the yield of essential oil.

IV. METHODOLOGY

Extraction of essential oils can be done by using the following methods

1. Water distillation
2. Water and steam distillation\
3. Direct steam distillation

1. **Water Distillation:** water distillation is mainly used to extract essential oils from dry or raw plants. Here it uses a diffusion mechanism to extract oil. The plants are soaked in the container which is filled with water to prevent overheating and charring of the plants, then heat is given to the water with plants till the steam comes out. The oil comes out and goes through the condensation of where water and oil are collected in a separate container. The temperature while extraction process is less than 100^0 C, in this method. Equipment used are open steam jacket/ closed steam jacket, closed steam coil/ open steam coil.

Fig.2: Water Distillation Unit

2. **Water and steam distillation:** here the equipment used isthe same as the water distillation method. The steam is generated by using a satellite boiler or within the still. It is economical as compared to the water distillation method. In this method, the plant material is spread over the boiling water by using a perforated grid. If the amount of water is not sufficient to complete the distillation process, then the water is added to the still by using a cohobating tube.

Fig.3: Water and Steam Distillation Unit

3. **Direct steam distillation:** in this method, the distillation of plant material takes place by using a satellite steam generator. In this process, the plant material is placed over the perforated grid on the steam inlet. The main advantage here is, the amount of steam can be controlled from the satellite steam generator. This is the most widely used method to produce essential oils.

Fig.4: Steam Distillation Unit

For the extraction of oil from the lemongrass we have used the steam distillation method. Because of the advantages that are amount of steam can be controlled, there is no thermal decomposition takes place in oil constituents. And also, this is the most widely accepted method for the extraction of essential oil. This method generates organic solvent-free products so that there is no need for subsequent separation steps. The steam distillation equipment is not so expensive.

4.1 APPARATUS

We have experimented using the Soxhlet apparatus which works on the principle of steam distillation. Soxhlet apparatus is designed as lab equipment for processing soil particles. Soxhlet extraction is required only when the solubility of the desired compound has a limit

and when the impurity of that compound is insoluble in the solvent. It is invented by Franz von Soxhlet in 1879. Soxhlet first experimentedwith the quantification of fat in the milk.

Fig.5: Soxhlet apparatus

4.2 Advantages

- **Efficiency:**Soxhlet extraction is more efficient compared to the traditional method mechanically advantageous on the sample and efficiency in separation.
- **Solvent:** in Soxhlet extraction usage of solvent dosage is less when compared to the process.
- **Simple arrangements:**the simple arrangement is needed and lightweight materials.
- **Cost affective:** for the experimentation purpose Soxhlet extraction cost is effective and once the equipment is set no other maintenance charges are required minimum amount of solvent is used for the complete process.

Soxhlet extractor mainly depends on distillation process it works on the principle of steam distillation and the extraction process works on a different process like

- Pre-extraction process
  It consists of preparation of plant process
  Selection of suitable plant material
  Drying of selected plant materials
  Selection of suitable solvent for the extraction process
- Post extraction process

It includes the complete process of extraction from solid to become essential oil.

4.3 Design of apparatus

- Design compounds
  1. Stirrer bar
  2. Still pot
  3. Distillation pot
  4. Soxhlet thimble
  5. Extraction solid
  6. Siphon arm inlet
  7. Siphon arm outlet
  8. Extraction solid

4.4 Assembly

- Prepared solid material for the extraction process is rolled or covered in a thick filter paper which is kept in the chamber of the extraction apparatus.
- The solvent selected for the extraction is placed in a distillation flask.
- The flask is kept inside the heating mantle.
- The Soxhlet extraction is placed on the flask.
- A reflex condenser connected to the extraction and the condenser is connected with two tube pipelines is to in letting of water and another one out letting of water.

4.5 Extraction process

Lemongrass leaves were collected from plants. The percentage of essential oil yield for the partially dried leaves was established to be higher than that of the day they were collected. Thus, once collected, the plant material was dried at room temperature for a maximum of four days, then kept in a sealed plastic bag at ambient temperature and protected from the light.

Lemongrass is cut into small pieces then it is filled in the filter paper and placed inside the thimble.For 10g of lemongrass sample,we took 170ml of distilled water, and also we took ethanolof 140ml for 10g of sample. The solventis poured from the top of the condenser, the solvent will enter the thimble and then passes to the round bottom flask. Flask is kept over the heating mantle. Temperature varies from 70^0c to 100^0c for ethanol and water respectively. For the extraction process, it takes around 30 minutes for one cycle and the extracted oil is collected in the bottom round flask according to the principle of steam distillation.

Fig.6: Prepared Sample

Fig.7: Extraction Process

4.6 Liquid separation process

Two immiscible liquids, oil, and water can be separated by using a separating funnel. The mixture of oil and water is from two separate layers since they are insoluble in one another. Oil forms the upper layer while water structures are lower.

Fig.8: Separation of Oil fromEthanol

Fig.9: Separation of Oil from Distilled Water

V. RESULTS AND DISCUSSIONS

The yield of essential oil is the ratio of the amount of essential oil obtained to several raw materials (in gms). According to the formula for 1kg of lemongrass, we got 2ml of oil. We have used two solvents as mentioned above distilled water and ethanol, by using distilled water as a solvent yield got more than the oil obtained from the ethanol as a solvent. The result is a decrease of about 25% by using ethanol as a solvent. Lemongrass should be dried at room temperature,if it is dried under the sunrays oil content in the lemongrass might decrease the yield. Temperature variation will not affect the yield condition as per our experiment.Usage of distilled water as a solvent may lead to the contamination of soil due to the presence of microbial action and it also affects the storage of extracted oil. Usage of ethanol as a solvent for the extraction process will not give a better yield but it gives attractive color to the oil after the extraction.After extraction of oil, it is very difficult to separate it from the solvent because it gives a small amount of oil for a large amount of sample, and also it requires more amount of solvent.

Product name	Quantity	Price
Lemongrass	1kg	160/-
Distilled water	1000ml	50/-
Ethanol	500ml	300/-

Table.1: Cost Analysis for The Project

VI. SCOPE OF WORK

For any work of research, there are some constraints. In this project,three problems are identified and to be worked on in the future is,

- Apparatus

- EthanolSolvent
- Extraction material
- Temperature

- Since the Soxhlet apparatus is limited to laboratory experimentation in the extraction process we cannot expect measurable results, theextracted oil will be usually in a small amount for a large amount of material as we already mentioned in the results part so that it is tough to separate the oil from the solvent.
- As we have experimented in one trial from the solution ethanol to increase the efficiency it will give good results and also good color during the extraction but the solution is costly compared to the distilled water. since essential oil is also used in food items it may be harmful to the health.
- For some of the trials we have changed the temperature and checked for any variations in cycles during the extraction process as a result no changes are seen. We can also say that temperature will not work or not give any change to improve efficiency.
- We can also change the extraction material for future work we are hoping to extract essential oil fromthe geranium plant as it is found in large amounts in the eastern part of the Mediterranean region.

VII. REFERENCES

[1]. Ewa Majewska et.al, Lemongrass (Cymbopogon citratus) Essential Oil: Extraction, Composition, Bioactivity and Uses for Food Preservation ļ a Review, Pol. J. Food Nutr. Sci., 2019, Vol. 69, No. 4, pp. 327ļ341 DOI: 10.31883/plans/113152.

[2]. OkpoSamsonO et.al, GC-FID and FT-IR Characterization of Lemongrass Oil Extracted WithSoxhlet Extraction Apparatus Using Ethanol as Solvent, IOSR Journal of Engineering (IOSRJEN) ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 10, Issue 5, May 2020, ||Series - II|| PP 33-38.

[3]. Neeraj Singh et.al, Microwave-assisted extraction of lemongrass essential oil: Study of the influence of extraction method and process parameters on the extraction process, Journal of Chemical and Pharmaceutical Research, 2014, 6(11):385-389 ISSN: 0975-7384 CODEN(USA): JCPRC5.

[4]. M.P.C. Van Leeuwen et.al, Essential oils compared to cholrhexidine with respect to plaque and parameters of gingival inflammation: A systematic review, volume number 2

[5]. Sara Moradi et.al, Microwave-Assisted Hydro-Distillation of Essential Oil from Rosemary: Comparison with Traditional Distillation. Vol. 10, No. 1, January-March 2018.

[6]. Madani Leila et. al, Experimental and mathematical modeling data of green process of essential oil extraction: Supercritical CO2 extraction. Materials Today: Proceedings 49 (2022) 1023–1029.

[7]. k.gopalasatheeskumar et.al, the significant role of the soxhlet extraction process in phytochemical research, vol 7, suppl 1, 2ISSNissn: 2320-3315.

[8]. Ali, A., Pheng, T.W., Mustafa, M.A. (2015). Application of lemongrass oil in vapor phase for the effective control of anthracnose of ĴSekakiij. 1456-1464.

[9]. Weiss E A, Essential Oil Crops(CAB International, USA)1997, 15-37.jeyarathnam, n., Nour, A.H., Kantasamy, R., and Akimdoyo, J.O., 20017, Microwave assisted hydro distillation, Review of Mehanism and heating properties,aust.j.Basic appl.sci.,11(3),22-29.
[10]. Mathialagan' R., 2012, Extraction and Characterization of essential oil from ginger and lemmon grass by microwave-assisted Hydrodistillation, Undergraduate Thesis, Faculty of chemical and natural resource engineering, universiti malayasia pashing.
[11]. Wei, l., Zhang, Y., B., 2013, Comparison of microwave-assisted hydrodistillation with them traditional hydrodistillation method in the extraction of essential oils from dwarfed cinnamomum camphora var. Linaolifera Fujjita leaves aand twigs, adv, J, Food sai. Technol., 5(11),1436-1442.
[12]. Gopalasatheeskumar K, Parthiban S, Manimaran T, Boopathi T. Phytochemical Screening on Various Extracts (Benzene, Ethanolic, and Aqueous) of Stem Parts of ZanthoxylumRhetsa (Roxb.) Dc. International Journal of Universal Pharmacy and BioSciences. 2017; 6(2):79-91.
[13]. Alhassan et, al, Extraction and Formulation of perfume from Locally Available Lemmon grass Leaves, ChemSearch Journal 9(2): 40-44, December,2018
[14]. Okpo SamsonO, SC-FID and FT-IR Characterization of Lemongrass oil Extraction with Soxhlet Extraction Apparatus Using Ethanol S solvent. IOSR Journal of Engineering (IOSRJEN)
[14]. Samson Onoriode Okpo,Modelling of Soxhlet Extraction of lemongrass oil, ISSN:2394-5370

Honey Authentication Using Machine Learning

Dr.Gururaj H L
Department of Computer Science and Engineering
Vidyavardhaka college of Engineering
Mysuru(Karnataka), India
gururaj1711@vvce.ac.in

Sumukh M G
Department of Information Science and Engineering
Vidyavardhaka college of Engineering
Mysuru(Karnataka), India
sumukhmg45@gmail.com

Jyothsna M S
Department of Computer Science and Engineering
Vidyavardhaka college of Engineering
Mysuru(Karnataka), India
jyothsna13santhosh@gmail.com

Abstract

Honey has been collected and used by humankind as both food and medicine for thousands of years. However, in the modern economy, honey has become subject to mislabelling and adulteration making it the third most faked food product in the world. The international scale of fraudulent honey has had both economic and environmental ramifications. In this paper, we propose a novel method of identifying fraudulent honey using a machine learning model.

1. Introduction

Honey is a sweet, viscous food substance made by honey bees and some other bees.[9] Honey bees are a significant economic resource as commercial producers of bee products, such as honey, beeswax, pollen, venom, and royal jelly.[11] The composition of honey, a complex natural product, challenges analytical methods attempting to determine its authenticity particularly in the face of sophisticated adulteration. Fifteen millilitres (1 US tablespoon) of honey provides around 190 kilojoules (46 kilocalories) of food energy. It has attractive chemical properties for baking and a distinctive flavour when used as a sweetener.[7]Honeybees (Apis mellifera) are considered not only a vital benefit to agriculture through pollination of many food crops, but their primary product, honey, is regarded as the most important product of beekeeping from a quantitative and an economic point of view. Honey is obtained from swarms of wild bees or domesticated beehives. On average, one hive will produce about 29 kg (65 lbs) of honey per year. Forest beehives are sometimes located by following nectar.

[12]a high number of Myrtaceae morphotypes may be a feasible criterion for authenticating the origin of Australian honey since most Australian honey is produced by honey bees mainly working indigenous floral resources. Honey and objects soaked in honey have been preserved for centuries. [15]Pollen analysis is widely used to verify the geographic origin of honey but has never been employed in Australia. [4]To protect domestic producers, the US imposed import duties of up to 221 per cent on Chinese honey in 2001, after declaring that it was being dumped on the US market at below-market value. Posing as a senior buyer for a co-operating honey firm, an undercover agent found that Chinese honey was arriving in the US disguised as other sweetening products, and being shipped via third countries. Calling it "the tip of the iceberg", Daniel Ragsdale, the deputy director of US immigration and customs enforcement, said: "The honey industry has been under assault due to anti-dumping circumvention".[14]To export manuka honey from New Zealand, it must be tested independently and pass the Manuka Honey Science Definition test as specified by the Ministry of Primary Industries (MPI). Bees mix glucose oxidase with expelled nectar that they have previously consumed, creating two by-

products - gluconic acid and hydrogen peroxide, which are partly responsible for the honey's acidity and prevent the growth. of bacteria.

To safely extract honey from the hive, beekeepers often appease the bees by using a vacuum cleaner. The smoke activates the foraging instinct (an attempt to save the hive's resources from possible fires), making them less aggressive and masking the pheromones that bees use to communicate. The hive is removed from the hive and honey can be obtained from the hive by crushing or using a honey extractor. The honey is then usually filtered to remove beeswax and other debris. Before the invention of the detachable frame, bee colonies were often sacrificed for the harvest. Collectors will take all available honey and replace the entire colony the following spring. Since the invention of the removable frame, breeding principles have led most beekeepers to ensure that their bee colonies have enough reserves to survive the winter, by leaving honey in the hive, or by providing honey to bees. substitutes such as sugar water or granulated sugar (usually in the form of "candy"). The amount of food needed to survive the winter depends on the variety of bees and the length and severity of the local winter. Many animals are attracted to wild or domestic honey sources.

Honey is sometimes adulterated by adding sugars, syrups or other compounds to change flavour or viscosity, reduce cost, or increase the fructose content to prevent crystallization. The enjoyment of honey has been practised since ancient times , when honey was sometimes mixed with syrup from trees such as maple, birch or sago and sold to customers as raw honey. Sometimes crystallized honey is mixed with flour or other fillers, masking adulteration from buyers until the honey liquefies. In modern times, the most common contaminant has become apparent, with almost no taste of corn syrup; Adulterated mixtures can be very difficult to distinguish from pure honey.

According to the United Nations Codex Alimentarius, any product labelled as "honey" or "pure honey" must be an all-natural product, although labelling laws vary between the nations. In the United States, according to the National Honey Board (NHB; overseen by the United States Department of Agriculture), “honey is specified as a pure product that does not permit the addition of any

substances. any other. … this includes, but is not limited to, water or other sweeteners."

Isotope ratio mass spectrometry can be used to detect the addition of corn syrup and sugar by the isotope symbol for carbon. The addition of sugar from corn or sugarcane (C4 plants, not unlike those used by bees, but also sugar beets, mainly C3 plants) distorts the isotope ratios of the sugars present in the sugars. honey, but did not affect the isotope ratio of proteins. In raw honey, the carbon isotope ratio of sugar and protein must match. Additional levels as low as 7% can be detected.

2. Literature Survey

[1]Honey is the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants which bees collect and transform by combining with specific substances of their own deposit, dehydrate, store and leave in the honeycomb to ripen and mature. [6] This study documents the stingless bees (Meliponinae) recent displacement in the Yucatan (Quintana Roo, Mexico) and the effects of human-induced ecosystem disturbance on bee diversity. Given an image obtained from a microscope, the pollen identification network segments and identifies the botanical origin, density and distribution of the extracted pollen grains. The outputs from the pollen identification network are then passed (alongside any other test results both physical and chemical) into the authentication network which outputs a decision as to whether or not the honey is genuine.

Honeybees (Apis mellifera) are considered not only a vital benefit to agriculture through pollination of many food crops, but their primary product, honey, is regarded as the most important product of beekeeping from a quantitative and an economic point of view. The slides were covered with coverslips and put into a camera-mounted Solomark compound bright-field microscope for analysis at 320x zoom. The microscope was able to be controlled both manually as well as with stepper motors. Approximately 2500 pollen were imaged overall.

Have trained a three-class YOLOv2 network to detect and segment pollen. Used the standard YOLO loss function. Trained a feed-forward neural network with a single hidden layer. The network inputs were pollen counts and overall pollen

density (average number of pollen given an arbitrary area). The network was tasked with differentiating five samples of eucalyptus melliodora honey from five samples of manuka honey.

Drawbacks are that only 10 samples of honey is used. The proposed system is unable to identify contamination with heavy metals, pesticides or antibiotics. the system would be unable to authenticate ultra-filtered honey samples where pollen is not present though this is sometimes an indicator of adulteration.

[2]Honey is one of humankind's oldest food products. It contains a number of nutritionally important substances that support good health and recovery. Although, the consumer is often faced with worthless substitutes but sometimes also with a dangerous cocktail of chemicals such as antibiotics, colourings and hydroxymethyl furfural (HMF).

Direct Adulteration of Honey - Traditional analyses of chemical composition and physical properties of honey are commonly used to detect direct adulteration. analytical methods are relatively time-consuming and require tedious preparation of the samples as well as complex analytical equipments.

Botanical Origin of Honey – The quality of honey and its specific character are determined by the specific flora and vegetation in the area from which the honey originates and the diversity of the ecosystem in which the bees are kept, specifically in non-industrial areas. The botanical origin of the honey therefore significantly affects its organoleptic properties.Pollen Analysis - Pollen analysis is one of the oldest and most laborious methods, requiring highly skilled andwell-trained laboratory personnel.

[3]Honey consumption has increased during the past decade due to consumers' preference for natural and pure products with no additives or preservative addition. Whenever price differences exist, there is a potential for a dishonest trader to attempt to make money by passing off a cheaper product as a more expensive one or by adding low-commodity components such as sweeteners.

The most widely used is high-performance liquid chromatography (HPLC) (2), but this methodology does not detect low levels of adulteration, nor is it adequate for the more sophisticated falsifications.

3.Methodology

Through our research, we inferred that honey has various physicochemical parameters. These are the conditions that influence the quality of honey. This includes parameters like Moisture content, pH, electrical conductivity, C4 Sugar, optical density, ash content, sucrose, free acidity, specific gravity etc.[8]Significant advances have been made towards building accurate automatic segmentation systems for a variety of biomedical applications using machine learning.

FSSAI has declared the standard quantity of the parameters in honey which are summarised

in the table below. Any sample of honey must satisfy all these parameters to be labelled as honey of good quality.

Sl.no	Parameters	Quantity
1.	Moisture Content, in terms of percent by mass, Max	20
2.	pH, Min	3.4
3.	Electrical Conductivity, Max	0.8mS/cm
4.	C4 Sugar, in terms of per cent by mass, Max	7.0
5.	Pollen Count or Plant element /grams, Min	5000
6.	Total Ash, in terms of percent by mass, Max	0.50
7.	Sucrose, in terms of percent by mass, Max	5.0

8.	Free Acidity(Formic Acid), percent by mass, Max	0.20
9.	Specific Gravity at 27°C, Min	1.35

The standard values of other parameters as per FSSAI is as shown below.

Sl.no	Parameters	Quantity
1.	Fructose to Glucose Ratio(F/G Ratio)	0.95-1.50
2.	HMF(Hydroxymethylfurfural), mg/Kg, Max	80
3.	Diastase Activity, Schade units per gram, Min	3
4.	Optical Density at 25°C	0.14
5.	Proline mg/Kg, Min	180
6.	Foreign Oligosaccharides (Max. Percent Peak)	0.7

The proposed system has a machine learning approach to solve this problem. Firstly, various samples must be collected from different places so that we have different types of honey. Useful information like the values of various parameters must be obtained from these samples of honey. The various parameters may include any of those as mentioned above. This information is converted into a suitable format file which can be imported during the process of coding.

This file will be used as the dataset for the machine learning model. Hence all the faults in the dataset must be handled. After analysing the method of honey authentication through pollen, certain drawbacks were observed. Ultrafiltered honey has less pollen count. Thereby categorising honey as impure. This technique revolves around other suitable characteristics. One of the various methods to find out the values of these parameters are as listed below.

1. pH: This will influence the formation of other components such as the production of HMF (hydroxymethylfurfural). The pH of honey ranges between 3.5 and 5.5 depending on its botanical source, the pH of nectar, soil or plant association, and the concentration of different acids and minerals such as calcium, sodium, potassium and other ash constituents. The acidic pH of honey can be measured by titration against sodium hydroxide equivalents.

2. Moisture Content: This influences the viscosity of honey samples, crystallisation, maturity, flavours etc. If this moisture content is high, it leads to crystallisation and promotes the development of osmophilic microorganisms responsible for fermentation. This can be tested with the help of a refractometer.

3. Total Ash: Ash content expresses the richness of honey in mineral content. Testing can be done based on the weight loss that occurs when the product is incinerated to a maximum of 550 degrees Celsius.

4. Electrical Conductivity: The ability of ions in the honey solution to conduct electrons will aid in determining the electrical conductivity of that sample. Using this parameter, the botanical origin of that particular sample can be determined.

5. HMF (hydroxymethylfurfural): This can be used to determine whether to invert sugar or HMF. If Fisher's test is positive indicates that honey is over-mature. If this test is positive and HMF content is more than 80 milligram/kilogram, then the fructose-glucose ratio should be 1.0 or more. If honey is heated for a long time, it is prone to test positive in this test. HMF content can also be determined using this technique.

The data set is checked for null and duplicate values and is cleaned. The data set has the values for each parameter for various samples of honey. The parameters we have considered are Moisture Content, pH, Electrical conductivity, Total Ash, Sucrose, Free acidity and Specific Gravity.

The dataset must be divided into training and testing datasets. Once the dataset is loaded into the python IDE, the machine learning implementation begins. Various algorithms like a decision tree will be implemented to predict the quality of honey in the test dataset. Apart from the deep learning technique CNN and RNN can be used to build the model better. The model will be tested a certain number of times until a specific accuracy is achieved.

The final system will contain a user interface and backend where honey adulteration is done. The user interface will be user friendly and easy to handle. The system consists of a hardware device where the input in the form of honey samples will be taken from the concerned. This input can be processed in two ways. The values for the various parameters have to be calculated externally and these values are fed into the model and further computation is done. An alternative process is to make the system capable of determining these values internally. To achieve the latter, the procedures to carry out these experiments must also be fed into the model.

After taking these values or samples as input, the model will begin to determine the honey quality. The output will be displayed to the user after these computations. The end value will contain the honey status(good quality/poor quality) and if required the values of the various parameters. The output will be in such a manner that is easy to be interpreted by the user.

4. Limitations

1. Cannot detect purity if ultra-filtered
2. Performance cannot be audited or guaranteed at the ‘long tail’
3. Each narrow application needs to be specially trained
4. Another major challenge is the ability to accurately interpret results generated by the algorithms. You must also carefully choose the algorithms for your purpose.

5.Result

The final result of the system after the entire process is the required output which says if the honey is pure. The output will be displayed on the screen from which the user can interpret the required result. The output will be a set of values of the parameters and the quality of the honey sample.

6. Conclusion

We have proposed a new change in the old method of ensuring honey that can be obtained honey that has been refined and misplaced by mass production and low operating costs and high costs. Machine learning allows the user to feed a computer algorithm a large amount of data and make the computer analyse and make data-driven recommendations and decisions based on input data only with the help of this machine learning we have developed a algorithm to find the purity of the honey and stop some illegal marketing of fake honey. By this authenticator technique, we have enhanced our knowledge of the future.

7.References:

[1] Gkantiragas, Alexis & He, Peter & Glowacki, Gerard. (2018). Honey Authentication with Machine Learning Augmented Microscopy. 10.13140/RG.2.2.35406.82242.
[2]Zábrodská, Blanka & Vorlová, Lenka. (2015). Adulteration of honey and available methods for detection – a review. Acta Veterinaria Brno. 83. S85-S102. 10.2754/avb201483S10S85.
[3] Cabañero, Ana & Recio, Jose & Rupérez, Mercedes. (2007). Liquid Chromatography Coupled to Isotope Ratio Mass Spectrometry: A New Perspective on Honey Adulteration Detection. Journal of agricultural and food chemistry. 54. 9719-27. 10.1021/jf062067x.
[4]Jon Swaine. 'Honeygate' uncovered in US sting, Feb 2013. URL https : // www.telegraph.co.uk/news/worldnews/northamerica/usa/9886508/ Honeygate-uncovered-in-US-sting.html.
[5]Shivana Inalsingh. The business of honey: Rebuilding the apiculture industry of Trinidad & tobago. American College of Healthcare Science, 2014.
[6]Christine E. Cairns, Rogel Villanueva-Gutierrez, Suzanne Koptur, and David B. Bray. Bee populations, forest disturbance, and africanization in mexico. Biotropica, 37(4):686–692, 2005. doi: 10.1111/j.1744-7429.2005.00087.x
[7] Jeffrey C. Moore, John Spink, and Markus Lipp. Development and application

of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010. Journal of Food Science, 77(4), 2012. doi: 10.1111/j.1750-3841.2012.02657.x.
[8]Konstantinos Kamnitsas, Christian Baumgartner, Christian Ledig, Virginia Newcombe, Joanna Simpson, Andrew Kane, David Menon, Aditya Nori, Antonio Criminisi, Daniel Rueckert, and et al. Unsupervised domain adaptation in brain lesion segmentation with adversarial networks.
[9] Soares, S., Amaral, J.S., Oliveira, M.B.P. and Mafra, I. (2017), A Comprehensive Review on the Main Honey Authentication Issues: Production and Origin. Comprehensive Reviews in Food Science and Food Safety, 16: 1072-1100. https://doi.org/10.1111/1541-4337.12278
[10]Criteria for Identifying Manuka Honey. New Zealand Ministry for Primary Industries, 2017.
[11]Walker, M.J., Cowen, S., Gray, K. *et al.* Honey authenticity: the opacity of analytical reports - part 1 defining the problem. *npj Sci Food* 6, 11 (2022). https://doi.org/10.1038/s41538-022-00126-6
[12]Sniderman JMK, Matley KA, Haberle SG, Cantrill DJ. Pollen analysis of Australian honey. PLoS One. 2018 May 16;13(5):e0197545. doi: 10.1371/journal.pone.0197545. PMID: 29768495; PMCID: PMC5955576.
[13]Aristeidis S. Tsagkaris, Georgios A. Koulis , Georgios P. Danezis , Ioannis Martakos , Marilena Dasenaki, Constantinos A. Georgiou and Nikolaos S. Thomaidis Honey authenticity: analytical techniques, state of the art and challengesDOI: 10.1039/D1RA00069A
[14]Criteria for Identifying Manuka Honey. New Zealand Ministry for Primary Industries, 2017
[15]J. M. Kale Sniderman, Kia A. Matley, Simon G. Haberle, and David J. Cantrill. Pollen analysis of Australian honey. Plus One, 13(5), 2018. doi: 10.1371/journal.pone.0197545