Smart Food Innovation: Creating Hemp Seed Laddus with Rice Flour using IoT Integration

Vadita Pal, Kusum Lata

Chandigarh University, Punjab, India

Corresponding author: Vadita Pal, Email: vadita01pal@gmail.com

This study focuses on the development of value-added rice flour laddus enriched with hemp seed, aiming to enhance their nutritional profile and sensory appeal. The research integrates the use of IoT technologies to optimize various stages of the product development process, including ingredient selection, formulation, and quality control. Employing IoT-enabled sensors and devices, real-time monitoring of ingredient quality and consistency was achieved, ensuring a precise balance of nutrients and taste. The laddus were evaluated for their nutritional content, including protein, fiber, minerals, and fat, and underwent sensory analysis to assess the texture, flavor, color, and overall acceptability. The integration of IoT in the development process not only facilitated data-driven adjustments to the recipe but also enabled efficient tracking of shelf-life and storage conditions. The findings demonstrate the potential of IoT in enhancing the production of functional foods, particularly in the context of addressing PEM in children. However clinical trials are limited by providing insight into the creation of nutritious and appealing food products that cater to health-conscious consumers.

Keywords: IoT, Healthcare monitoring system, Blockchain technology, Hemp seed.

2025. In Sandeep Kumar & Kavita Sharma (eds.), *Computational Intelligence and Machine Learning*, 35–44. Computing & Intelligent Systems, SCRS, India. DOI: https://doi.org/10.56155/978-81-975670-5-6-4

1 Introduction

The rise of the Internet of Things (IoT) moves beyond traditional approaches, enabling the connection of numerous, if not all, objects in our environment to a network. This technology links vehicles, household appliances, and various electronic devices, leading to a smarter and more interconnected lifestyle. IoT systems facilitate real-time identification, location tracking, and monitoring, and can automatically trigger relevant actions. Additionally, IoT plays a pivotal role in Industrial IoT (IIoT), which focuses on creating intelligent manufacturing processes and building smart factories with strong connections between customers and business partners [1]. In terms of food product quality and safety, these technologies enable comprehensive inspection throughout all stages of the product's life cycle, utilizing tools like electronic traceability systems, service-oriented architecture, and global identification methods. The authenticity and freshness of food products can be determined using specialized sensors with IR- Fourier transformation, which compare the acquired spectra to established standards. The results can be automatically shared not only with manufacturers but also with consumers through dedicated Internet of Things (IoT) applications as shown in Fig.1.[2].

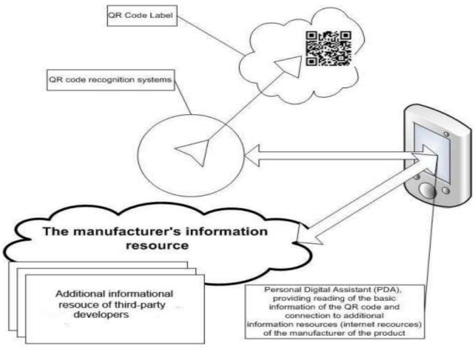

Figure1. structure of information exchange (Source [2]).

A traditional Indian sweet, rice flour laddus, presents a unique opportunity for innovation through the incorporation of nutrient-dense ingredients such as Hemp seed. Hemp seed (Cannabis sativa L.) is a yearly herbaceous plant that is a member of the cannabinaceae family and has played a significant role as a source of food, fiber, medicine, and psychoactive/ religious drugs. Throughout history, hemp cultivation faced limitations because it contains the psychoactive component tetrahydrocannabinol (THC). However, since 1990, numerous countries have granted authorization for licensed cultivation and processing of hemp cultivators with significantly decreased THC i.e. <0.3% [3]. Hemp is of two varieties one is the non-intoxicating variety with low levels (<0.3%) of tetrahydrocannabinol was used for nutritional purposes and marijuana high in tetrahydrocannabinol is used for recreational and medicinal purposes such as psychoactive effects, and relieving pain [4]. Hemp seed has a pleasurable nutty flavor and has essential fatty acids, minerals, vitamins, fibers, and essential amino acids found to be easily digestible proteins like edestin and albumin also contain high levels of total polyphenols, flavonoids, and flavonols, which are recognized for their beneficial impact on cardiovascular health and metabolism [5]. Hemp seed proteins are predominantly concentrated in the inner layer of the seed, with only a small amount of total proteins in the hull. Therefore, in processed hemp seed protein content is high because the outer layer hull is rich in fiber and low in protein, after the removal of the hull the content of protein and oil increased about 1.5 times in the hemp seed, and protein content is more when the oil content is removed, then the removal of fiber and oil give highest protein content up to 50% and lowest fat content [6]. Hemp seed protein is highly digestible and rich in essential amino acids, suitable even for young children according to FAO/WHO standards [7].

Table 1. Different methods for monitoring food quality and safety.

Method	Devices	Application	Sources
Smart food traceability	Smart sensors Blockchain	Monitor the location of the food, along with its ingredients and packaging, at any point throughout the supply chain, from producers to consumers.	[26]
Portable spectroscopy	IR spectroscopy NMR(Nuclear magnetic resonance)	Assess the food contaminants, moisture, and temperature of food products.	[27,28]
Array sensors	Electronic nose Electronic tongues	Examine foods by replicating human sensory perception systems, like taste and smell. It is used to assess the sensory properties of food products.	[29,30]
Smartphone-based analysis	Smartphones	Food analysis	[25]
Temperature indicator	MonitorMark OnVu Fresh-Check	They help to ensure the safety and quality of food products.	[31,25]
Freshness indicators	Ripesense To-GENKYO-TOKYO	Measure the microbial growth in the food product.	[25]
Biosensor indicators	Food Sentinel System Toxin Guard	Detects harmful bacteria in food products.	[25]

Hemp seed is globally acknowledged for its nutritional value, leading food manufacturers to create various types of products for retailing such as oil, protein flour, energy bars, granola, hemp nut butter, pasta, and even ice cream. Hemp protein is less allergic than other plant proteins, making it a viable substitute in various food products. Hemp seeds are rich in various vitamins and minerals such as Vitamin E, alpha-tocopherol, gamma-tocopherol, Thiamine, Riboflavin, phosphorus, Potassium, Magnesium, Calcium, Iron, Sodium, Manganese, Zinc, and copper[8]. Hemp seed also contains antinutritional factors such as phytic acid, condensed tannins, cyanogenic glycosides, and saponins, which decrease nutrient bioavailability and food intake and can be metabolized into toxic byproducts, which may lead to compromised gastrointestinal and metabolic function [9]. The development of laddus using hemp seed and rice flour aims to create a nutrient-rich laddus that is both palatable and capable of meeting the dietary needs of those suffering from PEM. While the potential is promising, the availability of clinical trials to support its efficacy is currently limited. Protein-energy malnutrition (PEM), which includes a deficiency of both protein and energy, is the most prevalent nutrient deficiency worldwide. Hunger and poverty are the main causes [10]. Malnutrition includes overnutrition, undernutrition, and micronutrient deficiencies[11]. In 2022, 45 million children were suffering from wasting, of which 13.7 million were experiencing severe wasting WHO/UNICEF, 2023. PEM accounts for 11% of the global health burden, especially in low to low-middle-income countries, malnutrition among school-age children is a significant public health issue. In 2005, it accounted for 16% of the global disease burden and 22.4% of India's burden. India has the highest rate of underweightchildren globally at 47%, which is the highest in some countries. Similar to sub-Saharan African countries, ensuring child survival and development is critical for future progress[12]. PEM includes kwashiorkor and marasmus. Kwashiorkor is worsened by anemia and diarrhea and occurs as a result of inadequate diet and infectious disease. Marasmus, caused by inadequate nutrient intake and poor hygiene, was originally called protein-calorie malnutrition and has a high mortality rate [13]. Kwashiorkor usually develops around 12 months of age when breastfeeding ends, but it can occur at any time during a child's development period, causing edema, dry, peeling skin, and hair discoloration. Marasmus usually develops between 6 months and 1 year in children who are no longer breastfed and suffer from chronic diarrhea[14]. According to the National Family Health Survey (NFHS-4), the stunting rate is 38.4% and the prevalence of underweight is 35.8%[15]. The integration of IoT will help assess the intervention of laddus for children with Protein-Energy Malnutrition (PEM). The IoT is an emerging technology that connects devices in real time transforming basic objects into smart ones. In healthcare, IoT plays a significant role by enabling continuous monitoring of patients' physiological data through sensors which then transmit this data to health-monitoring units. The data is often stored in the cloud for secure access and management [16]. An IoT-based system combines AI with advanced sensing technologies and semantic knowledge to improve a wide range of healthcare applications. This technology enables timely, high-quality telemedicine and healthcare services through remote assistance. IoT facilitates health monitoring, fitness programs, and the management of chronic disease by using connected devices like sensors and medical equipment. These devices optimize regular operations, support dynamic scheduling, and improve patient care [17] i.e. healthcare monitoring systems (HCMS) that utilize IoT and radio frequency identification (RFID) tags are employed to track and assess patient's health condition [18]. All these systems will be helpful in the future for the intervention of laddus in children with PEM.

2 Material and Methodology

A selected variety of hemp seeds (dehulled), whose tetrahydrocannabinol (THC) level is less than 0.03% was roasted on a stove to optimize the reduction of trypsin inhibitor and phytic acid. The powder of roasted hemp seeds was then used to develop the product Ladoo. The optimized hemp seed-fortified food products were analyzed for their proximate composition by the AOAC method and subjected to sensory evaluation by the Hedonic scale.

2.1 Procurement of Material

Hemp Seed

Hemp seed variety dehulled & THC less than 0.03% was collected from the supplier of Moksha. The procured hemp seed was stored properly at room temperature (28 to 35° C) in an airtight container before the experiment was used. The hemp seeds were roasted for 10 minutes on a stove and ground in a domestic mixer for 2 min. The undersized ground powder of hemp seed was used in further experiment work.

Raw Materials

For the manufacturing of the product, rice flour (Brand 24 Mantra Organic), Jaggery, cardamom powder, and ghee (Brand Mother Dairy) were procured from the local market. The rice flour was roasted in a pan till a golden-brown color came and the jaggery was melted in a pan to be used in the product.

Quality sensing technologies, including commercial tags, are proving valuable for assessing food quality throughout the transportation and delivery supply chain. The quality of the ingredients can be determined by the data collection device used in this process including radio frequency identification, barcode scanners, QR code scanners, video cameras, infrared sensors, GPS, laser scanners, and other critical sensing equipment [19].

Blockchain technology enables users to access all transactions that can be viewed simultaneously and in real-time by all participants within a supply chain ecosystem and can track the movement of goods throughout the supply chain. They can also check the status of customs documents, access bills of lading, and obtain other relevant data. No single entity can modify, delete, or add any record without agreement from the other participants in the network. Blockchain technology also maintains transparency related to storage conditions, nutrient content, shelf life, and information accuracy related to products and blockchain technology holds significant potential for improving food safety. It helps to minimize the contamination incidents [19].

All these technologies will be helpful in the procurement of materials for further study.

2.2 Methods

Preparation of Hemp Seed Powder.
The Hemp seed powder was prepared by using hulled hemp seed (100g), and then the hemp seed was roasted using a roasted pan for 10 minutes until the lightly brown color came. Roasted hemp seed was allowed to cool at room temperature after cooling down the seed, hemp seed was ground in the grinder until a fine powder was obtained.

Preparation of Laddus
A standard recipe is shown in Table 1. where the amount and proportion of the ingredients and method consistently produce a high–quality product, involving carefully balanced ingredients tailored to the number of servings required. In this context, the formulation was prepared by blending rice, ground hemp seed powder, and melted jaggery and to enhance the flavor of the laddus a pinch of cardamom powder was added as shown in Table 2. All the ingredients were kept in the bowl and formed the round shape of a laddus.

Table 2. Ingredient proportion of laddus.

Sample	Rice flour	Hemp seed	Jaggery	Milk	Ghee	Cardamom Powder
Control	50g	-	30g	10g	10g	Pinch of powder
T1	40g	10g	30g	10g	10g	Pinch of powder
T2	30g	20g	30g	10g	10g	Pinch of powder
T3	20g	30g	30g	10g	10g	Pinch of powder
T4	10g	40g	30g	10g	10g	Pinch of powder

Organoleptic Evaluation value-added Product (Laddus)
Thirteen trained panel members from the Department of Nutrition and Dietetics, University Institute of Allied Health Sciences, Chandigarh University, Participated in evaluating the value-added products. These panel members were provided with a control and four different treatment samples, each with varying levels of incorporation of ground hemp seed. To assess the sensory attributes, a 9-point hedonic scale was provided to the panel, different codes were assigned to the samples, and the exact composition levels were not disclosed to ensure unbiased results from the panel members. The evaluations were based on a 9-point hedonic scale ranging from 9 for "like extremely" to 1 for "dislike extremely. They assessed sensory parameters including color, taste, texture, and overall acceptability [20].

To enhance the product's quality and safety, we can use the Internet of Things (IoT) based monitoring and spoilage detector. with the progress in information technology, sensor devices, and electronic noses have emerged as essential tools for monitoring and detecting food quality. Sensors are at the forefront of an interdisciplinary field integrating embedded computing, networking, wireless communication technologies, and distributed processing, facilitating low-cost information transmission, processing, display, and control. electronic noses, which utilize sensor arrays, are particularly effective in assessing food quality, offering quick and sensitive odor detection in complex samples. Once data is acquired, deep learning-based algorithms are vital for precise data processing and fusion. these algorithms, such as k-nearest neighbors (KNN), principal component analysis (PCA), fuzzy c-means, artificial neural networks (ANN), partial least squares (PLS), and convolutional neural networks (CNN), are used for both qualitative and quantitative analysis, allowing for the prediction of quality parameters i.e. texture, color, sensory, shelf-life, and freshness grading. Texture can be analyzed by using a texture analyzer i.e. Model TA-XT PLUS, Texture Analyzer, Stable Micro System. The test speed range was 0.01-40mm/s, with a test distance accuracy of 0.001 mm and test force accuracy of 0.1g. The TPA assesses parameters such as hardness, chewiness, springiness, cohesiveness, and gumminess. Each sample was measured at five different points and the average of these measurements was used for the final determination. Color analysis can be conducted by using a colorimeter i.e. Konica Minolta CR-400 [21].

Nutritional Analysis of the Laddus

The developed product control, and T3, were tested for different chemical and nutritional constituents such as proximate and mineral analyses by AOAC,2005 method [22].

3 Result & Discussion

The T3 sample obtained the highest mean ratings of 7.61 to 7.84 for all sensory attributes and overall acceptability of 7.73, which indicates that it was highly appreciated, according to the mean scores as shown in Table 3.

Table 3. Sensory evaluation of laddus.

Sample	Color	Taste	Texture	Flavor	Appearance	Overall acceptability
Control	7.23±0.95b	8.15±0.89b	7.3±0.85bc	7.84±0.85b	7.30±1.11b	7.56±0.78b
T1	7.23±1.36b	7±1.35b	6.53±1.33b	6.92±1.32b	7.07±1.32b	6.95±0.78b
T2	7.3±1.37b	7.38±1.5b	7.3±1.75bc	6.92±1.65b	7.15±1.46b	7.21±1.5b
T3	7.76±0.98b	7.61±1.12b	7.69±1.1c	7.84±1.06b	7.76±1.09b	7.73±0.99b
T4	5.15±0.89a	5.3±1.1a	4.92±0.64a	5±1.08a	4.61±0.5a	5±0.65a
F-value	11.113	10.297	11.034	12.654	15.673	14.267
P-value	0.01	0.05	0.01	0.01	0.01	0.05

P≤ 0.05 is significant, Control, T1, T2, T3, and T4 are significant, C- Control laddus containing no hemp seed, T1- Treatment containing 10% hemp seed, T2- Treatment containing 20% hemp seed, T3- Treatment containing 30% hemp seed,T4-Treatment containing 40% hemp seed.

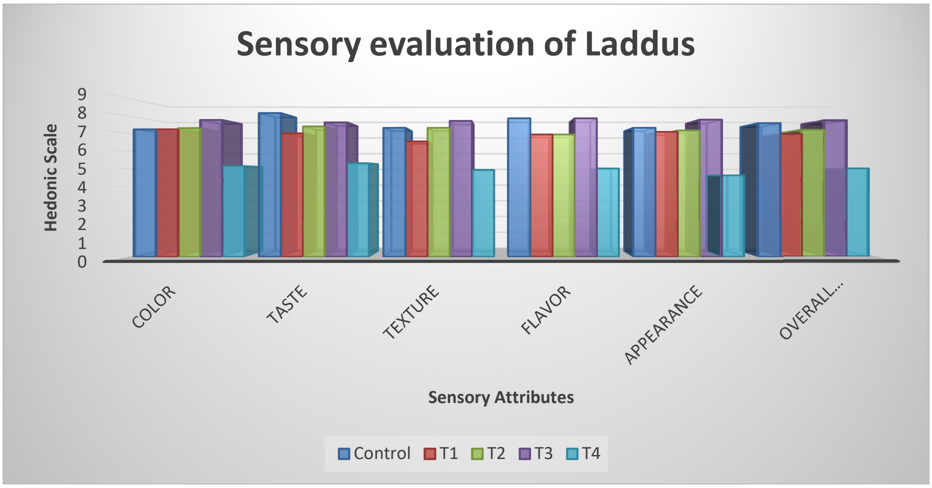

Figure 2. Sensory Evaluation of Laddus.

Figure 2. also showed the higher acceptability of the T3. The control sample came in second with a mean acceptability of 7.56. When comparing the T3 sample to the control sample, a significant difference ($p \leq 0.05$) was found in the sensory measures, including flavor, taste, and overall acceptability. On the other hand, the T3 sample outperformed the other treatment samples in terms of color, appearance, texture, flavor, and taste, scoring 7.76, 7.76, 7.69, 7.84, and 7.61, respectively, with an overall acceptability score of 7.73. The control sample was crunchy and a little bit dry whereas the T3 sample was soft and palatable, here the inclusion of hemp seed enhanced the sample's texture, color, and appearance, and also had hemp seeds taste and color of the sample green and had well-balanced taste than other samples such as T1, T2, T4. T1 and T2 samples came in third and fourth, respectively. The T4 sample was neither liked nor disliked, The T4 sample with a ratio of 10:40(rice: hemp) had a bitter taste and its texture was too oily. Furthermore, a significant difference ($p<0.05$) in appearance, texture, flavor, taste, and overall acceptability for T3 (7.76, 7.76, 7.69, 7.84, 7.61, and 7.73 respectively) and T2 (7.3, 7.38, 7.3, 6.92, 7.15, 7.21), T1 (7.23, 7.6 5.3, 6.92, 7.07, 6.95), T4 (5.15, 5.3, 4.92, 5.46, 1.5) and also there was no significant difference of texture were observed between the control sample and T2 sample. The past studies of hemp products' sensory characteristics of rigatoni pasta results indicated that substituting 20% wheat flour with hemp seed meal (HSM_20) resulted in the lowest score for all sensory attributes such as taste, texture, color, flavor, appearance, and overall acceptability compared to other samples. These findings help to understand that a high level of hemp seed meal enrichment is not favorable from a sensory perspective simultaneously the pasta sample with15% seed meal substitution (HSM_15) was the most acceptable by the panelists [22].

Table 4. Proximate analysis of the laddus.

Sample	Moisture	Ash	Carbohydrates	Protein	Fat	Fiber
Control	7.08±1.10	1.02±0.05	35.5±2.55	2.80±0.95	0.20±0.03	0.17±0.03
T1	9.08±0.99	1.65±0.77	37.8±1.99	3.40±0.75	2.51±0.58	1.97±0.45
T2	10.02±0.99	1.86±0.55	39.5±1.66	4.80±0.67	4.60±0.87	3.92±0.96
T3	15.04±0.96	2.55±0.63	41.9±1.66	7.2±0.56	6.9±1.23	5.89±0.96
T4	20.05±1.66	3.4±0.67	42.8±1.57	9.6±1.77	9.4±1.77	7.85±1.23

C- Control laddus containing no hemp seed, T1- Treatment containing 10% hemp seeds, T2- Treatment containing 20% hemp seed,T3-Treatment containing 30% hemp seed, Treatment containing 40% hemp seed.

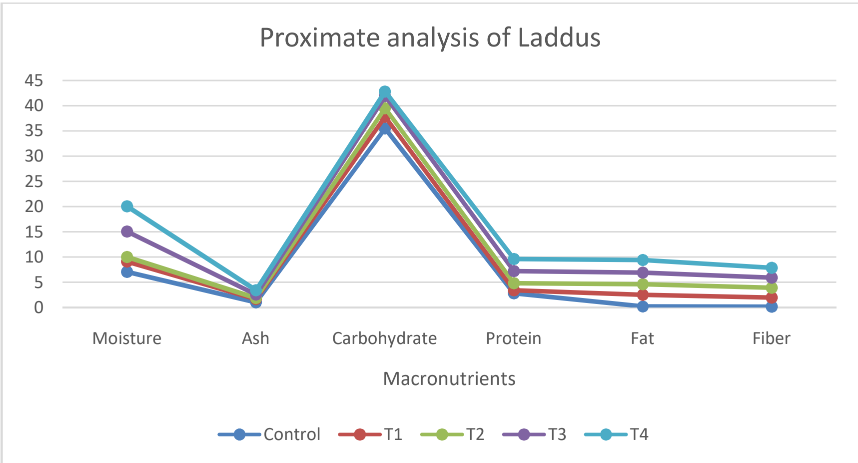

Figure 3. Proximate analysis of Laddus

The T4 sample, which consists of 40g hemp seed and rice, received the highest mean ratings ranging from 3.4 to 42.8 for all proximate parameters, as shown in Table 3. Similarly, the mean rating of T4 for mineral analysis was high, ranging from 3.20 to 94.33, as shown in Table 4. The sample proportions were as follows: Control (50g rice flour), T1 (10g hemp seed + 40g rice), T2 (20g hemp seed + rice), T3 (30g hemp seed + rice), and T4 (40g hemp seed + 10g rice). On comparing the mean ratings of proximate parameters for all the samples, including control (0.17-35.5), T1 (1.65-37.8), T2 (1.86-39.5), T3 (2.55-41.9), and T4 (3.4-42.8) as shown in Fig.3, comparing the mean ratings of minerals parameters for all samples as shown in Fig.4. including control (0.5-27.9), T1 (O.98-30.9), T2 (1.70-55.9), T3 (2.4-83.7), T4 (3.2-94.33), here, Mg is high in control than the T4, it was found that the T4 sample was the most acceptable based on nutritional composition, as shown in Table 4 & Table 5. However, according to the sensory evaluation, T3 was found to be more palatable than T4 because it had a bitter taste after tasting it, that's why T3 was a more acceptable option for consumers.

Table 5. Mineral analysis of laddus.

Sample	Iron	Calcium	Magnesium	Potassium
Control	0.50±1.10	2.73±0.99	3.50±0.88	27.9±1.13
T1	1.10±0.44	10.55±0.67	0.98±0.45	30.9±0.98
T2	2.20±0.76	20.7±1.76	1.70±0.33	55.9±1.77
T3	3.30±0.99	31.05±1.26	2.4±0.77	83.7±1.96
T4	4.40±0.97	41.4±1.69	3.2±0.96	94.33±1.84

C-Control laddus containing no hemp seed,T1-Treatment containing 10% hemp seed,T2-Treatment containing 20% hemp seed,T3-Treatment containing 30% hemp seed,T4-Treatment containing 40% hemp seed.

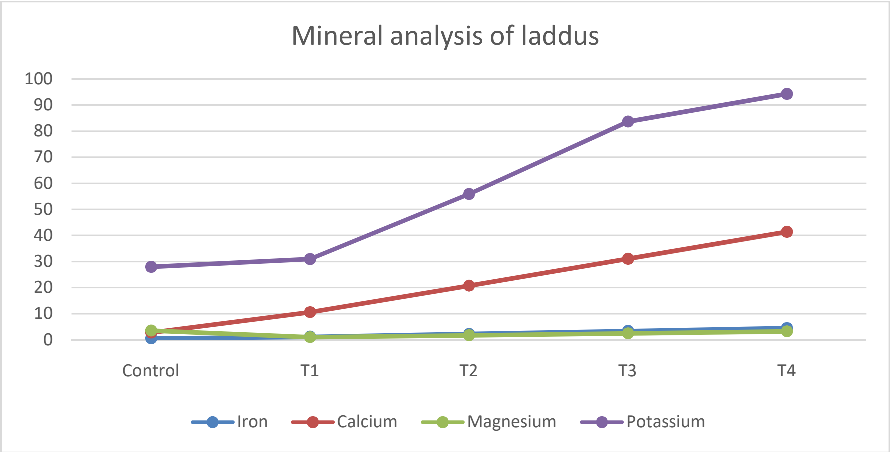

Figure 4. Mineral analysis of Laddus

The control sample provided energy of 160cal, T1 (110cal), T2 (185cal), T3 (258cal), and T4 (355cal) respectively. Furthermore, it was noted in past studies that cookies made with 20% roasted hemp flour contained 19.56% fat, which represents an increase likely attributed to the higher fat content in hemp flour. Utilizing hemp flour in cookies significantly raises the energy values of the cookies [24]. The shelf life of the laddus is 15 days when stored at a temperature of 25°C ± 5°C, they remain fresh and safe to eat for up to 15 days within the temperature range of 20°C to 30°C. Beyond this period or outside this temperature range, the quality and safety of the laddus may deteriorate.

4 Conclusion

The integration of the Internet of Things into various sectors has revolutionized traditional approaches, creating a highly interconnected environment where everyday objects, from household appliances to industrial machinery, are connected to a network. This connectivity enables real-time tracking, identification, and monitoring, with the ability to automatically trigger relevant actions, significantly enhancing the efficiency of processes. In the realm of industrial IoT, this technology fosters intelligent manufacturing, creating smart factories that maintain strong connections between customers and business partners. In the food industry, IoT facilitates comprehensive inspection of products throughout their life cycle, employing tools like electronic traceability systems and specialized sensors. These sensors, including those with IR-Fourier transformation capabilities, allow for the precise determination of food authenticity and freshness, ensuring that these details are accurately shared with both manufacturers and consumers through dedicated IoT applications. This technological advancement also presents new opportunities for food innovation, such as the development of nutrient-rich food products like rice flour laddus with hemp seeds. Hemp seeds, known for their high nutritional value, offer essential fatty acids, vitamins, minerals, and easily digestible proteins, making them an excellent addition to functional foods aimed at addressing Protein-Energy Malnutrition (PEM). The application of IoT in the production and monitoring of such foods not only increases the efficiency and safety of the process but also gives valuable insights into the development of nutritious and appealing products. This approach could play a criticalrole in addressing global malnutrition challenges, particularly in regions with high rates of PEM, by ensuring that food products are both nutritionally adequate and appealing to consumers. Ultimately, the use of IoT in this context underscores its potential to transform food production, making it more responsive to the needs of health-conscious consumers and vulnerable populations.

References

[1] Wang, Q., Zhu, X., Ni, Y., Gu, L., & Zhu, H. (2020). Blockchain for the IoT and industrial IoT: A review. Internet of Things, 10, 100081.

[2] Ben-Daya, M., Hassini, E., Bahroun, Z., & Banimfreg, B. H. (2020). The role of internet of things in food supply chain quality management: A review. Quality management journal, 28(1), 17-40.

[3] Wang, Q., & Xiong, Y. L. (2019). Processing, nutrition, and functionality of hempseed protein: A review. Comprehensive Reviews in Food Science and Food Safety, 18(4), 936-952.

[4] Salehi, A., Puchalski, K., Shokoohinia, Y., Zolfaghari, B., &Asgary, S. (2022). Differentiating cannabis products: Drugs, food, and supplements. Frontiers in pharmacology, 13, 906038.

[5] Menezes, R., Rodriguez-Mateos, A., Kaltsatou, A., González-Sarrías, A., Greyling, A., Giannaki, C., ... & Pinto, P. (2017). Impact of flavonols on cardiometabolic biomarkers: A meta-analysis of randomized controlled human trials to explore the role of inter-individual variability. Nutrients, 9(2), 117

[6] Mattila, P., Mäkinen, S., Eurola, M., Jalava, T., Pihlava, J. M., Hellström, J., &Pihlanto, A. (2018). Nutritional value of commercial protein-rich plant products. Plant foods for human nutrition, 73(2), 108-115.

[7] Xu, Y., Li, J., Zhao, J., Wang, W., Griffin, J., Li, Y., ... & Wang, D. (2021). Hempseed as a nutritious and healthy human food or animal feed source: a review. International Journal of Food Science & Technology, 56(2), 530-543.

[8] Chauhan, A. (2021). Nutrition and health benefits of hemp-seed protein (Cannabis sativa L.). Pharma Innov. J, 10, 16-19.

[9] Farinon, B., Molinari, R., Costantini, L., & Merendino, N. (2020). The seed of industrial hemp (Cannabis sativa L.): Nutritional quality and potential functionality for human health and nutrition. Nutrients, 12(7), 1935

[10] Grover, K., Arora, S., & Choudhary, M. (2020). Development of quality protein product using biofortified maize to combat malnutrition among young children. Cereal Chemistry, 97(5), 1037-1044.

[11] Dukhi, N. (2020).Global prevalence of malnutrition: evidence from literature. Malnutrition, 1, 1-16.

[12] Singh, B. P., & Sharma, M. (2021). Nutritional Status of School Going Children in India: A Review. Health Sciences, 10(10), 130-8.
[13] Sengupta, R., Ghorai, N., Basu, S. K., Zandi, P., &Cetzal-Ix, W. (2019). A Review on the Nutritional Challenges of School Children From thePerspective Developing Countries. The Role of Functional Food Security in Global Health, 109-143.
[14] Nightingale, F. K., Sarathi, S., Hemavathy, V., Monisha, J. A., & Pandian, B. (2023). Protein Energy Malnutrition–an Overview. Cardiometry, (26), 585-588.
[15] Neelima, A., & Sudarsana, K. (2022). Malnutrition and its consequences: A review.
[16] Selvaraj, S., & Sundaravaradhan, S. (2020). Challenges and opportunities in IoT healthcare systems: a systematic review. SN Applied Sciences, 2(1), 139.
[17] Bhuiyan, M. N., Rahman, M. M., Billah, M. M., & Saha, D. (2021). Internet of things (IoT): A review of its enabling technologies in healthcare applications, standards protocols, security, and market opportunities. IEEE Internet of Things Journal, 8(13), 10474-10498.
[18] S. F. Khan, "Health care monitoring system in Internet of Things (IoT) by using RFID," in Proc. 6th Int. Conf. Ind. Technol. Manag. (ICITM),2017, pp. 198–204.
[19] Kodan, R., Parmar, P., & Pathania, S. (2020). Internet of things for food sector: Status quo and projected potential. Food Reviews International, 36(6), 584-600.
[20] Ranganna, S. (1986). Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Education.
[21] Feng, H., Zhang, M., Liu, P., Liu, Y., & Zhang, X. (2020). Evaluation of IoT-enabled monitoring and electronic nose spoilage detection for salmon freshness during cold storage. Foods, 9(11), 1579.
[22] AOAC (2005). Official methods of analysis of AOAC International. USA: AOAC International.
[23] Axentii, M., Stroe, S. G., &Codină, G. G. (2023). Development and Quality Evaluation of Rigatoni Pasta Enriched with Hemp Seed Meal. Foods, 12(9), 1774.
[24] Ertaş, N., & Aslan, M. (2020). Antioxidant and physicochemical properties of cookies containing raw and roasted hemp flour. Acta Scientiarum Polonorum Technologia Alimentaria, 19(2), 177-184.
[25] Yu, Z., Jung, D., Park, S., Hu, Y., Huang, K., Rasco, B. A., ... & Chen, J. (2022). Smart traceability for food safety. Critical Reviews in Food Science and Nutrition, 62(4), 905-916.
[26] Scholten, H., Verdouw, C. N., Beulens, A., & Van der Vorst, J. G. A. J. (2016). Defining and analyzing traceability systems in food supply chains. In Advances in food traceability techniques and technologies (pp. 9-33). Woodhead Publishing.
[27] Correia, R. M., Tosato, F., Domingos, E., Rodrigues, R. R., Aquino, L. F. M., Filgueiras, P. R., ... & Romão, W. (2018). Portable near infrared spectroscopy applied to quality control of Brazilian coffee. Talanta, 176, 59-68.
[28] Xu, Z., Morris, R. H., Bencsik, M., & Newton, M. I. (2014). Detection of virgin olive oil adulteration using low field unilateral NMR. Sensors, 14(2), 2028-2035.
[29] Gonzalez-Fernandez, I., Iglesias-Otero, M. A., Esteki, M., Moldes, O. A., Mejuto, J. C., & Simal-Gandara, J. (2019). A critical review on the use of artificial neural networks in olive oil production, characterization and authentication. Critical reviews in food science and nutrition, 59(12), 1913-1926.
[30] Cruz, M. G., Ferreira, N. S., Gomes, M. T. S., Botelho, M. J., Costa, S. T., Vale, C., & Rudnitskaya, A. (2018). Determination of paralytic shellfish toxins using potentiometric electronic tongue. Sensors and Actuators B: Chemical, 263, 550-556.
[31] Zhang, C., Yin, A. X., Jiang, R., Rong, J., Dong, L., Zhao, T., ... & Yan, C. H. (2013). Time–Temperature indicator for perishable products based on kinetically programmable Ag overgrowth on Au nanorods. ACS nano, 7(5), 4561-4568.