DEVELOPMENT AND QUALITY EVALUATION OF COOKIES FROM LIMA BEAN AND EMMER WHEAT

ABSTRACT

The increasing interest in nutritious and functional foods has led to the investigation of alternative grains with enhanced health benefits. This research centres on developing highly nutritious cookies using lima bean (*Phaseolus lunatus*) and emmer wheat (*Triticum dicoccon Schrank*). These grains are cultivated for their outstanding nutritional qualities, such as high protein, essential minerals and bioactive compounds, making them ideal for creating health-promoting food products. The physical properties and chemical composition of lima bean and emmer wheat seeds were investigated. Five distinct trials with varying blends of lima bean and emmer wheat were carried out, with proportions of emmer wheat to lima bean being 50:50 (T_1), 60:40 (T_2), 70:30 (T_3), 80:20 (T_4) and 90:10 (T_5). The physical and sensory analysis of the all developed cookies was performed and sample T_3 was selected for physical and chemical analysis among all the samples after sensory analysis. Analytical methods were used to evaluate the nutrient composition, including protein, fiber and mineral content. Storage study of 60 days developed cookies also evaluated. It was found that the cookies gained moisture and lost fat, protein, fibre and energy over the storage period, with carbohydrate content showing minor fluctuations. The data obtained in the present investigation are sufficient to conclude that lima bean is an effective substitute for wheat flour in cookies preparation. The cookies prepared using lima bean were found to be acceptable in terms of quality characteristics. This substitution increased the protein content of the cookies. The cookies made with a 30% replacement of wheat flour with lima bean flour were the most acceptable.

Keywords: Cookies**,** Lima Bean, Emmer Wheat, Chemical Composition

Introduction

The Indian bakery sector plays a significant role in the nation's industrial landscape. Due to their affordable prices and excellent nutritional content, bakery products are consumed in large quantities. Customers are demanding healthier bakery items and the market is witnessing certain trends in the development of light, nutritious, organic products and natural.

Lima bean (*Phaseolus lunatus L.*) is a cultivated species belonging to the genus Phaseolus and the leguminosae family. It is one of the twelve principal grain legumes worldwide and is the second most economically significant species. Lima bean is extensively farmed in temperate and subtropical regions, thriving in various ecological situations including warm temperate zones and arid and semi-arid tropical regions common in Africa, the United States and Canada. The place of origin for the lima bean is in or near Guatemala and it is native to Central America (Choudhary, 2006). Planting season for lima beans is from April to June, with harvesting beginning roughly five months after planting. The lima bean is also known as the butter bean or double bean and has become extensively naturalized in tropical regions. Lima bean crops are primarily cultivated for their seeds, but sprouts and young pods are also edible. Mature green seeds are used as a vegetable for fresh market consumption, freezing, or canning (Okekunle *et al*., 2020). Lima beans are rich in minerals, dietary fibre, proteins, amino acids (AA) and B-complex vitamins (niacin, folate and B6). The seeds have an advantage over other legumes because of their substantial amount of protein without fat. However, there are differences in nutritional makeup among species, which are related to variations in growth phases and climate (Adebo, 2023).

Emmer wheat, also known as (*Triticum dicoccon Schrank, Triticum dicoccum Schubler or Triticum turgidum subsp. dicoccum Schubler*), is a historically significant cereal crop found in the Mediterranean region. Emmer wheat was the main wheat during the Neolithic and Early Bronze periods and one of the first Triticae to be domesticated by humans. Approximately 40% of the world's population primarily obtains their nutrition from wheat, making it a staple food grain crop grown in more than 40 nations and a major source of carbohydrates (Sendhil *et al*., 2020). Middle East (Palestine, Syria, Jordan, Iraq and Iran) is its area of origin, where the wild predecessor (*Triticum dicoccoides*) is cultivated. Compared to common wheat, emmer, spelt and einkorn have lower gluten and higher protein content (Konvalina *et al.,* 2008). The ratios of gliadins to glutenins increased from common wheat (< 3.8) to spelt, emmer and einkorn (up to 12.1), while common wheat had higher glutenin levels than einkorn, emmer and spelt (Serpent *et al*., 2008). **Include study objective here**

Materials and Methods

Materials

Cite study (s)

The material required was selected carefully and with reference to previous researches. The material such as lima beans (AKLB-2), emmer wheat (DDK - 1029), milk, jaggery powder, ghee, baking powder, custard powder and essence was easily available in the local market, Kolhapur, Maharashtra, India. Packaging material i.e. low-density polyethylene (55 micron thick) were used for storage study.

Methods

Physical properties of raw material (Lima bean and Emmer wheat)

Physical properties of lima bean (AKLB-2) and emmer wheat (DDK - 1029) include length, thickness and diameter were evaluated using a vernier caliper of about 0.01mm precision. The average seed size was then calculated. The weight of 100 seeds randomly selected was determined by weighing (AOAC, 2000). The average seed weight was then calculated. A measuring cylinder was used to measure the seeds' respective densities. The volume increase was observed when 100 seeds of a specified weight were submerged in 200 ml of distilled water in the measuring cylinder. The following equation was used to compute the relative density,

$$\text{Relative density} = \frac{\text{The weight of seed (g)}}{\text{The volume of seed (ml)}} \quad \ldots (1)$$

Proximate analysis of raw materials (lima bean and emmer wheat)

The nutritional parameters of lima bean and emmer wheat such as moisture, protein, fat, fibre and ash were determined by using standard methods (AOAC, 2000). Carbohydrates for lima bean and emmer wheat was calculated by difference method equation as follows,

$$\text{Carbohydrates (\%)} = 100 - \% \text{ (Moisture + Fat + Protein + Ash + Crude fibre)} \quad \ldots (2)$$

The energy value of food is typically calculated based on the macronutrient content: carbohydrates, proteins and fats. The formula for calculating the energy value is:

$$\text{Energy (kcal)} = (\text{carbohydrate} \times 4) + (\text{protein} \times 4) + (\text{fats} \times 9) \quad \ldots (3)$$

Development of Cookies

This study conducted five trials using varying blends of lima bean and emmer wheat flour for cookie production, ranging from 50% to 10% lima bean flour. The objective was to evaluate how different proportions of lima bean affect the cookies' sensory and nutritional properties. Each formulation included ghee (40 g) for texture, jaggery (60 g) as a sweetener and milk (50 g) as a binding agent. The goal was to identify the optimal blend that offers the best balance of taste and nutritional benefits.

Powdered sugar and shortening were blended together. Ammonium bicarbonate, sodium bicarbonate and composite flour were combined as the dry ingredients. After thorough mixing, a uniform paste of sugar and shortening was created. The mixture was carefully kneaded by hand after the necessary amount of milk was added. Using a cutter, the dough was shaped into uniform pieces and rolled to a thickness of 3 to 5 mm to form round cookies. The cookies were then baked at 135°C for fifteen minutes. The above mentioned steps were followed in the process of developing new products.

Quality Evaluation of Prepared Cookies

Quality evaluation of all prepared cookies was carried out which include physical evaluation, sensory evaluation and proximate analysis. Physical evaluation include weight, diameter, thickness and spread ratio. Three pieces of cookies from each trial was randomly selected. The dimensions like width, thickness will be measured with digital vernier caliper (accuracy of 0.001 mm) and weight of sample cookies was measured using sensitive weighing balance. Mean of three determinations was recorded. Spread ratio of cookies is the ratio of average value of diameter to the average value of thickness. The cookies sample have been evaluated for different sensory attributes such as appearance, colour, flavour, taste and overall acceptability by using 9-point Hedonic scale with the help of panel. The mean of observations has been considered for evaluating the quality of prepared cookies.

How many panelists were used for the sensory study?

Storage Studies of Developed Cookies

One sample out of five trials was selected on the basis of physical and sensory analysis. The selected cookies were packed in LDPE packages (55 micron) and stored at room temperature. The nutritional and microbial evaluation of cookies was evaluated at an interval of 15 days for a period of 60 days. In storage the proximate and microbial analysis of the developed cookies was evaluated as per standard methods. In proximate analysis nutritional parameters of developed cookies such as moisture, protein, fat, fibre, ash, carbohydrate and energy value were determined. In the study of microbial quality Total Plate Count were examined for developed cookies.

Statistical analysis

The data collected was examined statistically to determine statistical significance at $P \leq 0.05$ of treatments. Completely Randomized Design (CRD) was used to test the significance of results (Kukade, 2017).

Results and Discussions

Physical Properties of Lima Bean (AKLB-2) and Emmer Wheat (DDK - 1029)

Lima bean seeds exhibit larger dimensions with an average length of 13.11 mm, width of 8.56 mm and thickness of 5.2 mm, compared to Emmer wheat, which has an average length of 10.63 mm, width of 4.2 mm and thickness of 2.3 mm. Additionally, Lima bean seeds are significantly heavier, with a 1000 seed weight of 200.22 g, while Emmer wheat seeds weigh 50.74 g. The bulk density of Lima bean seeds is also higher at 1.31 g/ml, in contrast to Emmer wheat's bulk density of 0.467 g/ml. Physical properties of lima bean and emmer wheat which was recorded at 9.26 % and 1.60 % moisture respectively.

Proximate Composition of Lima bean and Emmer Wheat Flour

Lima bean contains 9.26% moisture, which is significantly higher than the 1.60% found in Emmer wheat. The ash content, representing the mineral content, is 2.39% in Lima bean and 1.78% in emmer wheat. Protein content is notably higher in lima bean at 21.52%, compared to 17.72% in emmer wheat. This indicates that lima bean could be a better protein source. In terms of fat content, emmer wheat has a higher percentage (2.95%) compared to Lima bean (1.49%). Fibre content is another distinguishing factor, with lima bean containing 3.75% fibre, whereas emmer wheat has only 0.03%.

Physical Properties of Cookies

Table 1 presents the physical characteristics of developed cookies include Weight, Diameter, Thickness and Spread Ratio of the cookies. The mean values has been measured for each provided in Table 3.

Should be mean ± SD (including alphabet for detectable difference if any posthoc method was used for analysis

Table 1: Analyzed physical properties of cookies

Treatments	Weight	Diameter	Thickness	Spread Ratio
T1	10.2	54.2	5.2	10.42
T2	11	53.6	5.6	9.57
T3	10.8	52.2	5.1	10.24
T4	10.4	49.3	5.1	9.67

T5	11.05	56.3	5.5	10.24
Mean	10.69	53.12	5.3	10.028
SD	0.375	2.596	0.235	0.381
CV (%)	3.51	4.89	4.42	3.80

Table 3 shows the physical characteristics of cookies across five different treatments. The weight, diameter and thickness of the cookies across treatments ranges 10.2 - 11.05g, 49.3 - 56.3 mm and 5.1 - 5.6 mm respectively. The coefficients of variation for all measured parameters are relatively low, which indicates that there is consistency in the physical properties of the cookies across different treatments. There are slight differences between treatments in terms of weight, diameter, thickness and spread ratio, but overall, the cookies exhibit similar physical characteristics.

Sensory Evaluation of Cookies Incorporated with Lima Bean Flour and Emmer Wheat Flour

Following the sensorial evaluation using a 9-point hedonic scale for the organoleptic characteristics like colour and appearance, texture, taste, flavour and overall acceptability, various random trials with a wide range of incorporation levels have been conducted in order to study the effect of lima bean flour and emmer wheat on sensorial quality characteristics of cookies. Table 2 provides an overview of the impact of adding lima beans at different percentages (10%, 20%, 30%, 40% and 50%) on the sensory quality characteristics of cookies.

Table 2: Sensory analysis of all prepared samples

Should be mean ± SD (including alphabet for detectable difference if any posthoc method was used for analysis

Sample no./ treatments	Appearance	Colour	Texture	Flavour	Taste	Overall Acceptability
T_1	6.15	7.15	6.9	6.35	6.9	6.55
T_2	6.45	6.35	7.35	6.45	7.35	7.05
T_3	8.45	8.1	8.15	8.15	8	8.1
T_4	8	7.9	7.8	7.8	8.1	7.9

T_5	7.35	7.05	7.05	7.05	7.4	7.5
Mean	7.28	7.31	7.45	7.16	7.55	7.42
SD	0.982	0.705	0.521	0.800	0.497	0.631
CV (%)	13.49	9.64	6.99	11.18	6.59	8.50

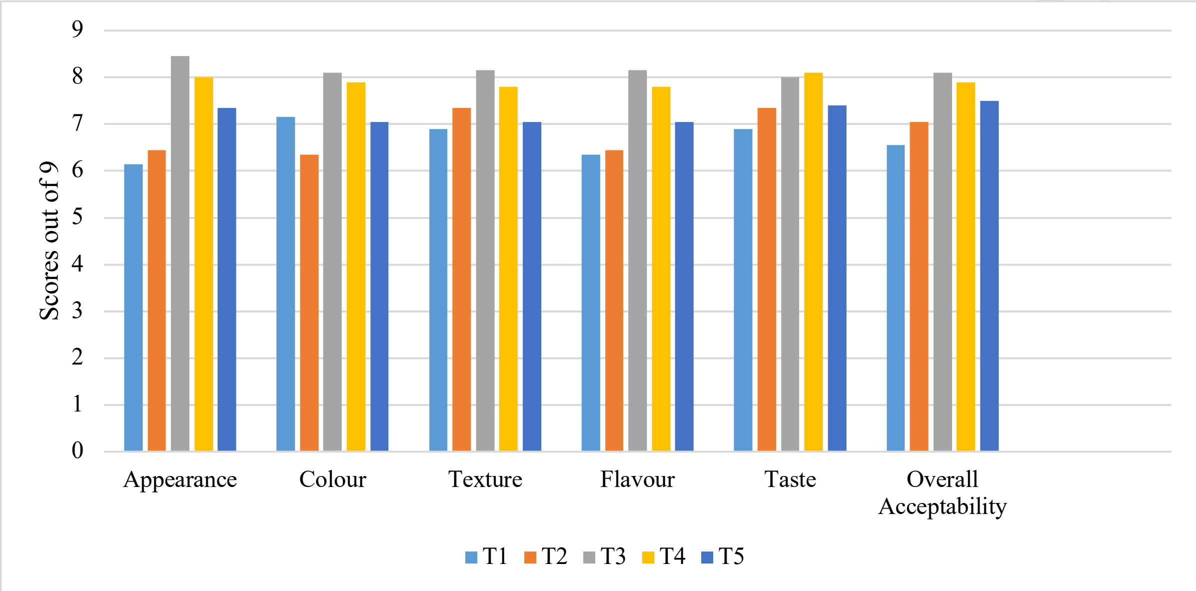

Fig. 1: Graphical representation of sensory evaluation of cookies

Based on the sensory evaluations we can clearly see that Sample T_3 stands out as the best treatment overall. It consistently received high scores across all attributes, including Appearance (8.45), Colour (8.1), Texture (8.15), Flavour (8.15), Taste (8) and Overall Acceptability (8.1), resulting in the highest mean score of 8.2. Sample T_4 closely follows with slightly lower scores in Flavour (7.9) but otherwise similarly high scores in other attributes, achieving a mean score of 8.17. Compared to the other samples, T_3's consistently superior evaluations across all sensory attributes make it the most favorable treatment.

Proximate Analysis Developed of Cookies

The present investigation was carried out to study the quality characteristics of cookies. Cookies were subjected to proximate analysis and the data pertaining to proximate composition of cookies are summarized in Table 4.

Table 3: Proximate analysis of prepared cookies

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)	Energy (Kcal/100g)
T_1	3.61	1.89	14.61	15.68	1.02	63.19	452.32
T_2	3.58	1.93	13.82	15.69	1.06	63.92	452.17
T_3	3.57	1.92	12.42	15.63	1.1	65.36	451.79
T_4	3.56	1.88	12.31	15.66	1.15	65.44	451.94
T_5	3.51	1.95	12.06	15.71	1.17	65.60	452.03
Mean	3.57	1.9	13.31	15.67	1.10	64.70	452.05
SD	0.04	0.03	1.05	0.03	0.06	1.08	0.20
CV (%)	0.01	0.02	0.08	0.00	0.06	0.02	0.0005

Table 4. presents the proximate analysis of five treatments (T_1 to T_5), highlighting the variations in moisture, ash, protein, fat, fiber, carbohydrate and energy content. Moisture content remains consistent across the treatments ranging from 3.51% to 3.61%, with an average of 3.57%. Ash content, indicative of the mineral composition, fluctuates slightly between 1.88% and 1.95%, averaging 1.91%. Protein content decreases from T_1 (17.61%) to T_5 (14.62%), with an average value of 15.91%. Fat content is relatively stable, varying from 15.63% to 15.71%, with a mean of 15.67%. Fiber content increases marginally across the treatments, from 1.02% in T_1 to 1.17% in T_5, averaging 1.10%. Carbohydrate content shows a gradual increase from 63.19% to 65.60%, with an average of 64.70%. The energy content remains quite consistent, ranging from 451.79 to 452.32 Kcal/100g with a mean of 452.05 Kcal/100g.

Sample T_3 was selected for proximate, physical and chemical analysis among all the samples after sensory analysis.

Effect of Storage Period on Developed Cookies

Effect of proximate analysis on developed cookies

The table 3 presents the results of a storage study conducted to evaluate the proximate composition of developed cookies over a period of 60 days. The parameters measured include moisture, ash, protein, fat, fiber, carbohydrate content and energy value. The study aimed to assess how these nutritional components change over time when the cookies are stored, with data recorded at intervals of 1, 15, 30, 45 and 60 days.

Table 4: Storage study of proximate composition on developed cookies

Storage period (Days)	Parameters						
Storage period (Days)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (kcal/ 100g)
1	3.57	1.92	12.42	15.63	1.1	65.36	451.79
15	3.81	1.9	12.38	15.59	1.03	65.29	451
30	4.27	1.85	12.22	15.29	0.68	66.69	449.25
45	4.31	1.76	12.18	13.01	0.6	67.08	438.13
60	5.26	1.7	12.15	12.38	0.6	68.91	431.66
Mean	4.24	1.83	12.27	14.38	0.80	66.67	444.37
SE	0.37	0.05	0.07	0.90	0.14	0.86	5.20
CD	0.77	0.11	0.14	1.85	0.29	1.76	10.65

From Table 3 it was found that there was increase in moisture content with increase in storage period. The initial moisture content of cookies was 3.57% at the initial day upon completion of storage duration (60 days), the final moisture content was increased up to 5.26%. Higher moisture uptake in polythene pouches might be due to their permeability to moisture and air. There was decrease in ash content with increase in storage period. The initial ash content of cookies was 1.92% at the initial day upon completion of storage duration (60 days), the final ash content was increased up to 1.7%. The ash content in foodstuff does not necessarily account for exactly the same composition as the mineral matter present in the original food, as there may be some losses due to volatilization or interactions between the constituents. There was slight decrease in protein content with increase in storage period. The initial protein content of cookies was 12.42% at the initial day upon completion of storage duration (60 days), the final protein content was increased up to 12.15%. Microbial activity during storage can contribute to the breakdown of proteins. Storage can lead to various chemical changes in cookies, including the Maillard reaction, which involves proteins and sugars reacting together. This is one of the reasons behind decreasing protein content. There was slight decrease in fat content with increase in storage period. The initial fat content of cookies was 15.63% at the initial day upon completion of storage duration (60 days), the final fat content was increased up to 12.38%. The results in the present study showed a significant decrease in the fat content of prepared cookies during storage. This decrease in fat content in cookies may be attributed to the development of rancidity. The fat deterioration during storage may be due to the activity of the lipase enzyme, which splits the fat into free fatty acids and glycogen in the presence of catalysts such as moisture, light and heat. There was decrease in fibre content with increase in storage period. The initial fibre content of cookies was 1.1% at the initial day upon completion of storage duration (60 days), the final fibre content was increased up to 0.6%. Fibres can undergo chemical changes over time. Factors such as heat, light and oxygen exposure can cause fibres to degrade. For example, soluble fibres might break down more quickly than insoluble fibres. There was increase in carbohydrate content with increase in storage period. The initial carbohydrate content of cookies was 65.36% at the initial day upon completion of storage duration (60 days), the final carbohydrate content was increased up to 68.91%.

Microbial Analysis of Cookies

Microbial analysis in which total plate count of developed cookies (T_3) was carried out at the interval of 15 days up to 60 days by using serial dilution method. The microbial analysis of cookies (T3) showed that at day 0, no microbial colonies were detected. By day 15, it was 9×10^2 cfu/g. At day 30, the count increased further to 22×10^2 cfu/g. By day 45, the total plate count reached 72×10^2 cfu/g, and by day 60, it significantly increased to 80×10^3 cfu/g. These findings showed that developed cookies was acceptable and their contamination level was still within acceptable limit. These results are similar with the results obtained by (Banusha & Vasantharuba 2014, chopra *et al*., 2014).

CONCLUSION

From the data obtained in the present investigation are sufficient to conclude that lima bean is an effective substitute for wheat flour in cookies preparation. The cookies prepared using lima bean were found to be acceptable in terms of quality characteristics. This substitution increased the protein content of the cookies. The cookies made with a 30% replacement of wheat flour with lima bean flour were the most acceptable. Therefore, it is concluded that the developed processing technology for making lima bean-incorporated cookies is techno-economically feasible. Cookies with this formulation should be produced and marketed on a large scale to provide nutritious and healthy food products to consumers.

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