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Development of Plant-Based Milk by Combining Sesame Seeds, Pumpkin Seeds, Mango-Flavored Sesame, and Dates Flavored Sesame

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ABSTRACT

Despite the increased demand for plant-based milk alternatives, there is a lack of sustainable and nutritious options that combine the nutritional benefits of sesame and pumpkin seeds. **Objectives:** To develop plant-based milk by combining sesame seeds and pumpkin seeds, assess the sensory and nutritional properties by using a hedonic scale and proximate analysis and do a cost analysis of this plant-based milk. **Methods:** A cross-sectional study took place at the lab of UVAS Lahore, Pakistan.Three samples were developed per 100ml (sesame and pumpkin seeds milk, mango flavored sesame and pumpkin seeds milk and dates flavored sesame and pumpkin seeds milk).Sensory evaluation was done using a hedonic scale. Proximate analysis was also performed to calculate dry matter, crude protein, fat and ash content of the three samples. **Results:** Date flavor was the most liked sample (40%) rating in appearance, 50% in odor, 50% in taste and 60% in texture. Proximate analysis of the first sample (sesame and pumpkin seeds milk) showed that it contained about 19.17% dry matter, 7.04% crude protein, 2.20% fat and 0.90% ash content. Proximate analysis of the second sample (mango flavor) showed about 13.00% dry matter, 3.60% crude protein, 4.00% fat and 0.46% ash content. Proximate analysis of the third sample (dates flavor) achieved 15.67% dry matter, 3.74% crude protein, 5.00% fat and 0.38% ash content. **Conclusions:** It was concluded that it is easier to make this plant-based dish using ingredients which are easily available from the local store.

INTRODUCTION

The consumers have developed a great interest in consuming those products that are made from vegetable raw materials. Among the population, there is a great increase in the number of allergic diseases. These allergies affect both children and adults equally. Cow's milk protein or lactose allergy is one of the most prevalent allergies which due to some enzymatic changes, the body is not able to absorb lactose. These alternatives were being developed because the cow's milk contains up to 80% casein in its protein composition, while the plant-based milk alternatives do not contain lactose and casein [1]. Sesame seed is unusual in its composition, containing significant levels of crude protein, moisture, crude fat, carbs, crude fiber, and mineral components. It is observed that sesame seeds contain 4.53% of moisture, 22.41% crude protein, 41.20% crude fat, 3.42% crude fiber and 4.27% ash content. Sesame seeds are known not only for their traditional use but also for their pharmaceutical, nutraceutical and industrial roles [2]. Sesame milk contains nutraceutical properties such as anti-oxidative, hypocholesterolemia, anti-carcinogenic, anti-tumor and antiviral activities [3]. Sesame milk can overcome the restrictions of soy milk use, such as flatulence, allergy to soy proteins, and off-flavors [4]. Cold plasma processing is a non-thermal technique which can be used to reduce the Ige-mediated allergies caused by sesame milk [5]. Pumpkin belongs to the Cucurbita species and family Cucurbitaceae. There are 3 species of pumpkin, i-e.

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cucurbita maxima, cucurbita pepo, and cucurbita moschata [6]. It is a diploid plant that usually contains 20 pairs of chromosomes. The use of pumpkin seeds is different, as in domestic purposes, uncooked, cooked or roasted depending on the area and personal choices of the people [7].Pumpkin seeds consist of many beneficial nutrients and nutraceuticals such as curcubitans, unsaturated fatty acids, amino acids, phyto-sterols and tocopherols.They also contain zinc, iron, calcium, potassium, copper, phosphorus, magnesium and manganese. The calories in pumpkin seeds vary, but they usually include 574 calories of energy per 100 grams, 49 grams of fat, 6.6 grams of fiber, and 30 grams of protein. Pumpkin seeds are a fantastic addition to a healthy diet due to their high protein content.Pumpkin seeds also possess cyto-protective effects(the ability to protect the cells from metabolic attacks). Along with pumpkin seeds also have antimicrobial and wound healing effects [8].Pumpkin seeds have antioxidant properties.Thus, they are considered a valuable ingredient to be added to food products. Lack of beneficial nutrients is a major concern in the world. To overcome this problem, food additives can be used, originating from plant sources, and pumpkin seeds are one of them. By adding pumpkin seed flour, the nutritional quality of the product can be enhanced or enriched [9]. By producing biscuits made with ingredients like pumpkin seed meal, konjac and maltitol, it is proven that biscuits can be made healthier, more nutritious and can be beneficial for cardiac, diabetic and obese patients [10]. Pumpkin seed oil(PSO)is extremely beneficial not only to diabetics, but also to hypertension and dyslipidemia [11]. Heat treatment is the most crucial step to enhance the stability, improve the physicochemical properties of food products such as pumpkin seeds [12]. Pumpkin seeds prevent stomach, lung, or colon cancers [13]. In Korea, pumpkin seeds are used for the treatment of depression [14]. The use of pumpkin seeds daily reduces the chance of Parkinson's and Alzheimer's diseases [15]. In previous studies, there was a lack of a plant-based milk which was made from combining two or more seeds.

Although plant-based milk alternatives are increasingly popular due to lactose intolerance, milk protein allergies, and shifting dietary preferences, most commercially available products rely on single-source ingredients such as soy, almond, or oat. Limited research has explored the development of hybrid seed-based milk formulations that combine multiple nutrient-dense seeds to enhance protein quality, micronutrient profile, and sensory acceptability. Moreover, comparative evaluation of sensory characteristics, proximate composition, and cost-effectiveness of such formulations remains insufficient in local contexts. Therefore, there is a need to develop and systematically evaluate a nutritionally enriched, economically feasible plant-based milk prepared from combined sesame and pumpkin seeds. This study aims to develop a plant-based milk by combining sesame seeds and pumpkin seeds, and also produces two more flavors using mango and dates. The sensory and nutritional properties were also evaluated by using the hedonic scale and proximate analysis. Along with that, a cost analysis of this plant-based milk was also performed.

METHODS

This was a cross-sectional study in which a product was developed and given to the expert panel, then compared for differences based on sensory evaluation. This study took place at the lab of the University of Veterinary and Animal Sciences(UVAS), Lahore, Pakistan. All the ingredients were bought from the local market.For the preparation of the product, a blender, mesh filter, measuring cups and bottles were used.A product was developed using two types of seeds.Along with that, two more flavors were produced using mango and dates.Four samples were produced. These samples were collected in 100 ml bottles. Quantities of ingrédients were sesame seeds (125g), pumpkin seeds (14g), mango (30g), and dates (72g).For the first sample (sesame and pumpkin seed milk), about 41.6 grams of sesame seeds, 4.6 grams of pumpkin seeds were taken. These seeds were roasted for 1 minute. Then blended with the help of a blender by adding 2.5 cups of water. After blending it, it was filtered out with the help of a mesh filter. Milk of thin consistency was obtained. For the preparation of the second sample using mango (Sindri), all the above steps were repeated. Mango pulp was extracted using a strainer. About 2.5 tablespoons of mango pulp were added to 1/2 cup of milk. Then the remaining pulp was strained using a mesh filter. For a thin consistency, water was added.For the preparation of the third sample, dates were used. All the steps of the first sample were repeated. After that, about 3 dates were added to 1/2 cup of milk. Then it was blended using a blender.It was strained. To achieve a thin consistency, a few drops of water were added. After the development of the samples, sensory evaluation (appearance, texture, smell, taste) was performed by the expert panel of 10 panelists. The hedonic scale was used for sensory evaluation. Hedonic scale used ratings from 1 to 9. 1 denotes extremely dislike, and 9 denotes extremely like. To calculate the dry matter, fat, protein, and ash content of the three samples, proximate analysis was conducted. For dry matter analysis, a dish was weighed before putting the sample on it (W1).All the samples were put into their respective dishes and weighed before drying (W2). After

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weighing the samples, it was dried in the oven at 102 degrees Celsius until the dry matter was obtained. Then the weight of the samples was recorded again, and dry matter was analyzed (W3). Dry matter = *W*2 – *W*3 ÷ *W*2 – *W*1 * 100. For fat analysis, the Gerber machine method was used.The Gerber machine uses centrifugal force to extract the fat content of the given sample. For this purpose, sulphuric acid of about 10 ml was taken and pipetted into the butyrometer. Along with that, a quantity of 10 ml of the sample was added to the sulphuric acid. Following this, about 1 ml of amyl alcohol was added to the mixture. It was shaken until the milk was completely absorbed by the acid. After this, the butyrometer was placed in a water bath for about five minutes at 65 degrees, and then it was centrifuged in a Gerber machine for five minutes. This step was repeated. The final reading of the fat content was recorded. SNF content (%) = Total solids (%) - Fat (%) (3). For the determination of ash content, a dish was weighed first (W1), then the sample was put into the dish after weighing it (W2), and the sample was heated in a furnace at about 500 degrees until a grey colour of ash appeared. The final readings were calculated for the ash content. % Ash = W3 - W1 ÷ W2 - W1 * 100. All the data were analyzed by using SPSS version 26.0 computer software. The data were expressed in the form of pie charts, and bar charts were made with the help of MS EXCEL.

RESULTS

In the sensory evaluation of Sample A, out of all sensory characteristics, the appearance of sesame and pumpkin milk was liked by the majority (60%) (Figure 1).

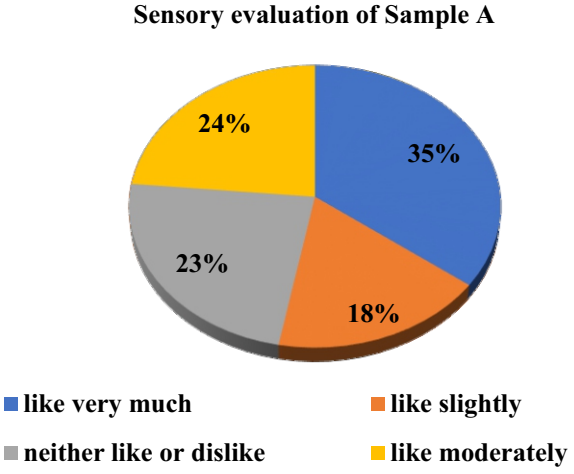

Figure 1: Sensory Evaluation of Sample D

For mango flavored sesame milk (Sample B), all the sensory attributes got an average rating of 30% from the panelists (Figure 2).

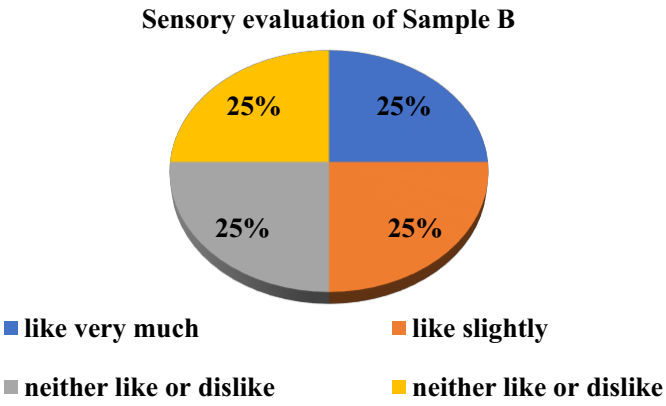

Figure 2: Sensory Evaluation of Sample B

For the dates flavour of the sesame and pumpkin seeds milk (Sample C), texture was the sensory quality that was liked by 60% of the panelists.But out of three samples, Sample C was the most liked one (Figure 3).

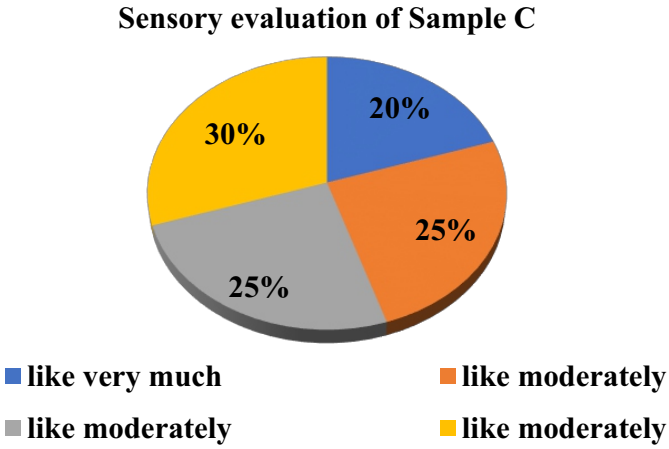

Figure 3: Sensory Evaluation of Sample C

Proximate analysis of the sesame and pumpkin seeds milk (Sample A) showed that it contained about 19.17% dry matter, 7.04% crude protein, 2.20% fat and 0.90% ash content. Proximate analysis of the mango flavour (Sample B) showed about 13.00% dry matter, 3.60% crude protein, 4.00% fat and 0.46% ash content. Proximate analysis of the date's flavor (Sample C) achieved 15.67% dry matter, 3.74% crude protein, 5.00% fat and 0.38% ash content. According to proximate analysis of the three samples, Sample A (sesame and pumpkin seeds milk) contains the highest amount of dry matter, crude protein, ash content and the lowest amount of fat as compared to Sample B and C (Figure 4).

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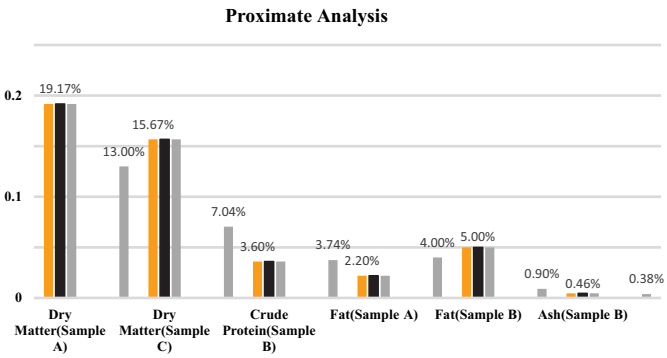

Figure 4: Proximate Analysis of the A, B and C Samples

Cost analysis of the sesame and pumpkin seeds (Sample A) showed that it costs Rs 58.6 per 100ml. Cost analysis of the mango flavor (Sample B) showed that it costs Rs 64.6 per 100ml. Cost analysis of the dates flavor (Sample C) showed that it costs Rs116.2 per 100ml. After assessing the cost analysis of the three samples, it was found that Sample A was the cheapest one, with the price of 58.6 rupees per 100 ml (Table 1).

Table 1: Cost Analysis of Sample A, Sample B and Sample C

Sesame and Pumpkin Seed Milk per 100 ml			
Ingredients	**Quantity Used (g)**	**Price in Rupees**	**Price in Rupees per Quantity Used**
Sesame Seeds	41.6	300 per 250 g	40
Pumpkin Seeds	4.6	1000 per 250 g	18.6
Total	46.2	1300 g	58.6
Mango Flavored Sesame And Pumpkin Seed Milk per 100 Ml			
Sesame Seeds	41.6	300 per 250 g	40
Pumpkin Seeds	4.6	1000 per 250 g	18.6
Mango	30	500 per 500 g	6
Total	76.2	1800 g	64.6
Dates Flavored Sesame and Pumpkin Seed Milk per 100 ml			
Sesame Seeds	41.6	300 per 250 g	40
Pumpkin Seeds	4.6	1000 per 250 g	18.6
Dates	72	800 per 500 g	57.6
Total	118.2	2100 g	116.2

In terms of calories, Sample A contains about 258.8 kilocalories (Table 2).

Table 2: Calorie Content in Sesame and Pumpkin Seed Milk (100ml)

Variables	Quantity
Carbohydrate	11.9g
Protein	8.2g
Fat	21.6g
Total Calories	258.8 kcal

Sample B contains about 276.8 kilocalories (Table 3).

Table 3: Calorie Content in Mango Flavored Sesame and Pumpkin Seed Milk (100ml)

Variables	Quantity
Carbohydrate	16.4 g
Protein	8.2 g
Fat	21.7 g
Total Calories	276.8 kcal

Sample C contains 461.8 kilocalories. Hence, sample C contains the highest number of calories compared to the other two samples (Table 4).

Table 4: Calorie Content in Dates Flavored Sesame and Pumpkin Seed Milk (100ml)

Variables	Quantity
Carbohydrate	65.9 g
Protein	10 g
Fat	21.8 g
Total Calories	461.8 kcal

DISCUSSION

In this research, an experimental study was conducted. A plant-based milk was produced from the combination of sesame seeds and pumpkin seeds. The purpose of this research was to develop a product which is an effective alternative or substitute for cow's milk. In this study, three samples were produced. The first sample was made of sesame and pumpkin seed milk.The second sample was mango flavored sesame and pumpkin seeds. And third sample was dates flavored with sesame and pumpkin seeds.These samples were produced to do a comparison among them in terms of sensory evaluation, proximate analysis and cost analysis. A study was done by Posokina *et al.*, which compared sesame milk with cow's Milk. This alternative was being developed because the cow's milk contains up to 80% casein in its protein composition, while sesame milk does not contain lactose or casein. Sesame contains more than 20 % protein, 50 % fat, a significant amount of dietary fiber (13.3 %) as well as a high content of minerals such as calcium, phosphorus, iron and zinc and vitamins such as A, E and folic acid.The results proved that the sesame milk is not inferior to the cow's milk and even surpasses it in some cases.In conclusion, the functional drink from sesame seeds contributes to the improvement of the body systems, and its main advantage is that it does not contain milk sugar.Thus, it can be recommended to those with lactose intolerance [1].Comparing this study with the current research, it was found that the past study only compared sesame milk with cow's milk.No plant-based product was developed using sesame and pumpkin seeds [16, 17].Also, the current research developed two more flavors to enhance the palatability of the milk. In past studies, no other flavors were developed. After producing these samples, sensory evaluation was done using hedonic scale. Sesame and pumpkin seeds milk got an appearance rating of 60%. But it only scored 30% in taste due to its strong flavor [18, 19]. Mango flavored sesame and pumpkin seeds milk got an average of 30% in terms of appearance, odor, taste and texture [20].That was because it was

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tasteless.It was not liked by the panelist. However, dates flavored sesame and pumpkin seeds milk got the highest ratings in terms of appearance (40%), odor (50%), taste (50%) and texture (60%) without a single dislike.Hence, it was proved that dates flavored sesame and pumpkin seeds milk is the most accepted one. Proximate analysis of the three samples was done.Sample A showed that it contained about 19.17% dry matter, 7.04% crude protein, 2.20% fat and 0.90% ash content. Sample B showed about 13.00% dry matter, 3.60% crude protein, 4.00% fat and 0.46% ash content. Sample C achieved 15.67% dry matter, 3.74% crude protein, 5.00% fat and 0.38% ash content. These results showed that sesame and pumpkin seeds milk (Sample A) has the highest value of dry matter, crude protein and ash as compared to Samples B and C. Thus, Sample A is the most nutritious one. A study was done by El-Bialy *et al.*, to provide a nutritious and palatable replacement milk for lactose and casein sensitivity. Sésame Milk has higher amounts of potassium, copper, zinc, manganese and selenium.Sesame milk can overcome the restrictions of soymilk use, such as flatulence, allergy to soy proteins, and off flavours. In the chemical composition, sésame Milk contains 13.38% protein, 26.52% fat, 1.19% ash, 58.91% carbohydrate, and 87.97% moisture [4].Compared to current research, it was found that sesame and pumpkin seed milk contained about 19.17% dry matter, 7.04% crude protein, 2.20% fat and 0.90% ash content. All these values are less because the product is made from two seeds.The carbohydrate content and moisture content were calculated, which are about 58.91% and 87.97% in the above study. Whereas in this research, the carbohydrate content and moisture content were not calculated. According to this study, the sesame milk had good sensor judging value in terms of taste, flavor, colour, texture, etc. But in the current research, the sensory values were not as acceptable as the dates flavored sesame and pumpkin seeds milk. Cost analysis of all samples was done to determine which sample cost the least.It was evident that the sesame and pumpkin seeds milk cost only Rs. 58.6, making it the cheapest sample out of all three. As compared to past studies, cost analysis of the plant-based milk was not performed.

This study is limited by its small sensory panel size and short-term laboratory-based evaluation, which may not fully represent broader consumer preferences. Shelf-life stability, microbiological safety, storage conditions, and large-scale production feasibility were not assessed. Additionally, micronutrient profiling and digestibility analysis were beyond the scope of this research. Future studies should focus on extended shelf-life testing, fortification strategies, large-scale consumer acceptability trials, and optimization of formulation to improve taste and nutritional balance, thereby enhancing commercial viability and functional food potential.

CONCLUSION

It was concluded that with an increasing trend of producing plant-based products, there is a high demand for dairy alternatives.Several plant-based milks have been produced, but there was a lack of a hybrid product. This research project developed a hybrid plant-based milk by combining sesame and pumpkin seeds. This study provided insight on how to make a plant-based milk, how much it costs and what the sensory attributes are acceptable and which attributes need more work to be better. This study successfully met all three objectives (development of plant-based milk, sensory and nutritional analysis, and cost analysis). However, there were some limitations to it; for example, shelf life was not taken into consideration. Future researches need to further work on it.

Authors' Contribution

Conceptualization: TA
Methodology: AK, TA
Formal analysis: SND, AK, MS
Writing and Drafting: SA, CB
Review and Editing: SA, CB, SND, AK, MS, TA

All authors approved the final manuscript and take responsibility for the integrity of the work.

Conflicts of Interest

All the authors declare no conflict of interest.

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