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Research Article

FORMULATION AND EVALUATION OF MANGO POMACE FLAVORED SOYMILK YOGURT AS A NOVEL PLANT-BASED ALTERNATIVE TO DAIRY PRODUCTS

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ABSTRACT. In the present era, there is a growing demand for natural and healthier alternatives to dairy-based products. Soy milk stands out as an excellent substitute, offering enhanced nutritional value and catering to individuals with lactose intolerance. In this research, soy milk yogurt was crafted from nutrient-dense soymilk, with the addition of mango pomace (MP) to naturally enhance its flavor. Stevia, a natural zero-calorie sweetener, was also incorporated. Four distinct treatments were administered: T1 (control - 100% soymilk + 0% MP +s 1.5% stevia) and other treatments T2 (95% soymilk + 5% MP + 1.5% stevia), T3 (90% soymilk + 10% MP + 1.5% stevia), and T4 (85% soymilk + 15% MP + 1.5% stevia) to create soy milk yogurt samples. Each treatment underwent proximate analysis to determine crude fat, crude protein, crude fiber, mineral, and moisture content. Viscosity, pH, total flavonoid content (TFC), total phenolic content (TPC), and sensory characteristics were assessed through various tests. The results revealed that the soy milk yogurt, enriched with MP and stevia, exhibited a delightful taste and smooth texture, offering balanced sweetness with a low caloric profile. Furthermore, it displayed high TPC and TFC contents, making it a favorable choice for lactose-intolerant consumers seeking dairy-free and nutritious products.

Keywords: *Soymilk, plant-based yoghurt, dairy alternatives, mango pomace, stevia, low-caloric sweetener*

INTRODUCTION

The annual legume crop known as soybean (Glycine max L.), which is a member of the Fabaceae family, originated in China and is currently grown all over the world [1]. It has a high digestibility of roughly 92–100% and is packed with high-quality protein as well as nearly all of the important amino acids [2, 3]. It reduces the risk of cardiac failure, hyperlipidemia, and renal disorders, lowers plasma cholesterol, and has anti-atherosclerotic properties, among other health advantages [1]. Soybeans are eaten fermented, unfermented, and roasted, in sauce, tofu, butter, yogurt, cheese, and soy pickles, among other things soy flour is used for fortification in grained-based food products. One of the main nutrients in the diet that is necessary for an organism to survive is protein. The body uses and absorbs amino acids and proteins based on several factors, one of which is the source of the protein. [4].

Soymilk is made by processing soybeans and can be used in place of cow, buffalo, and goat milk. [5]. Because soymilk is inexpensive, very nutritious, and simple to use, it might be a better option than dairy milk. Consequently, there is a rise in the market for human-grade alternatives to milk. [6]. Yogurt has enjoyed widespread popularity as a dairy product for an extended period, and its appeal has significantly grown in recent decades. This surge in popularity is largely attributed to research highlighting the health benefits associated with yogurt consumption across various racial and ethnic groups worldwide. The increased understanding of these health benefits, coupled with product innovation and a diverse range of flavors, has contributed to the rising consumption of yogurt [7]. The main driver behind yogurt's popularity is its multitude of health benefits, supported by extensive research. Notably, yogurt has been linked to enhanced lactose tolerance, among other physiological and nutritional advantages. Fermented milk products, such as yogurt, not only offer nutritional benefits but also contribute to physiological well-being. These include fortifying the immune system, combating harmful bacteria, safeguarding against gastrointestinal disorders, preventing cancer, and reducing blood cholesterol levels. Yogurt containing probiotics is particularly regarded as superior to regular yogurt in terms of promoting various health outcomes [8, 9]. Plants like stevia are utilized to make leaf extracts that are used as a low-calorie sweetener in food products [7]. Plant-derived products, have shown antioxidant, and antimicrobial effects. These mechanisms may be linked to the bioactive compounds present in these products [10, 11].

This research focuses on the development and evaluation of a unique soybean milk-based yogurt, catering to the growing demand for plant-based milk substitutes. The rich, complex flavor of mango pomace gives the yogurt a distinctive flavor that differs from traditional yogurt flavors. This product is innovative because it uses soymilk and mango pomace, which work well as dairy substitutes and stevia, a natural sweetener, takes the place of artificial flavors. By analyzing the sensory qualities, nutritional makeup, and consumer acceptability of this unique food product, it adds to the conversation about cutting-edge, eco-friendly, and nutritionally sound food products.

MATERIALS AND METHODS

Procurement of Raw Material

All the ingredients needed to make yogurt, including soybeans, stevia, soymilk, and mango pomace, were bought from the Faisalabad local market.

Preparation of product

The soybeans were soaked overnight and manually dehusked afterward. Subsequently, the soybeans were ground and mixed with water in a 1:4 ratio of soybeans to water. The resulting mixture was sieved to extract the milk using muslin cloth. Soy milk was continuously stirred while boiling over low heat for ten to fifteen minutes. Mango pomace was then added to the mixture, followed by the incorporation of stevia. The entire mixture was subjected to low heat. After the addition of the starter mixture, the concoction was left at room temperature overnight. Four treatments were prepared: T1 (control) containing 100% soymilk, 0% MP, and 1.5% stevia; T2 (95% soymilk + 5% MP + 1.5% stevia); T3 (90% soymilk + 10% MP + 1.5% stevia); and T4 (85% soymilk + 15% MP + 1.5% stevia).

Physiochemical analysis of product

Moisture content

The method outlined in [12] was used to calculate the moisture content of soy yogurt. Five-gram samples of various flavors of soy yogurt were individually weighed into pre-weighed, cleaned, and dried china plates. The samples were then baked for twenty-four hours at 105°C in a hot air oven. Following their removal from the oven and cooling in desiccators, each sample was weighed once again.

Ash content

The technique described in [12] was used to measure the amount of ash in the flavored soy yogurt samples that were collected. First, the weights of the empty crucibles were recorded. After that, a 1 g sample of soy yogurt from each treatment was weighed in a porcelain crucible that had been previously weighed, set on the stove, and cooked in a muffle furnace for an entire night to 600 °C. The crucible is removed from the muffle furnace and allowed to cool in desiccators before being weighed again.

Crude fat

We assessed the crude fat content by applying the solvent extraction method outlined in [12]. After obtaining 2 g of moisture-free samples from every treatment, 50 mL of n-hexane was added to the flask that was attached to the Soxhlet apparatus. As the fat was extracted, three to four drops of hexane were added to the sample every second for two to three hours. After 6-7 siphons, the thimble was taken out and cooked in an oven for an hour to 105°C before being weighed.

Crude protein

The crude protein content of soy yogurt supplemented with mango pomace was measured using Kjeldahl's methodology, as detailed in [12]. Soy yogurt samples were introduced into a digestive tube, to which 25 ml of concentrated H_2SO_4 and 5g of digestion solution ($CuSO_4$, $FeSO_4$, and K_2SO_4) were added. The sample underwent digestion for three to four hours, or until it achieved translucency or a light green color. The digested material was then transferred to a 250 mL volumetric jar and filled with distilled water. In a distillation setup, 20 mL of the diluted sample was blended with 25 mL of a 40% NaOH solution, and the resulting mixture underwent distillation. The emitted ammonia was recovered in 4% boric acid with the assistance of methyl red indicator. Subsequently, the solution was titrated using 0.1 N hydrochloric acid. This entire process was conducted for both the flavored soy yogurt sample and a blank (sample-free) tube.

Crude fiber

According to [12] the crude fiber content of fat-free flavored soy yogurt was determined by dissolving it in 1.25% H2SO4 and subsequently 1.25% NaOH solution. A 1 g sample of flavored soy yogurt was placed in a glass crucible and connected to an extraction apparatus. A solution of boiling 1.25% H2SO4 was introduced. After thirty minutes of digestion, the acid was removed from the processed soy yogurt sample. Subsequently, the sample was washed with boiling distilled water. Next, 150 milliliters of 1.25% NaOH solution were added, and the soy yogurt sample underwent another thirty-minute digestion before the acid was eliminated once again. The sample was then rinsed with boiling distilled water. Following this, the crucible was detached from the extraction apparatus and left to dry overnight at 110°C in an oven. The soy yogurt sample was allowed to cool in a desiccator before being weighed (W1). Subsequently, the soy yogurt sample was ashed in a muffle furnace for two hours at 550°C, chilled in a desiccator, and weighed once more (W2). This entire process was employed to determine the quantity of extracted fiber relative to the original, unprocessed sample.

Total soluble solids

Refractive index can be used to estimate the concentration of % dissolved solids of a substance. The brix scale, often known as brix, measures the quantitative amount of sugar and other dissolved compounds in a solution. The total soluble solids were determined as the method described Cavalcanti et al [13].

Acidity

A few factors that determine yogurt's acidity are the number of bacteria and how long it is stored. Acidity is intimately correlated with these parameters. It is discovered that increasing these variables increases acidity. The method suggested by Karaca, [14] was used to measure the acidity.

Phytochemical analysis of product

Utilizing the Folin Ciocalteu method as described by Unuigbe et al., [15], the total phenolic content (TPC) and total flavonoid content (TFC) of flavored soy yogurt were established.

Determination of total phenolic content

250 µl of Folin-Ciocalteu reagent, 0.75 ml of 20% sodium carbonate solution, and 0.05 ml of flavored soy yogurt sample were used in each tube to compute TPC. Using distilled water, each sample's ultimate volume was calculated to be 5 milliliters. The absorbance of each sample was measured at 765 nm using an ultraviolet-visible light spectrophotometer after 120 minutes, whereas the control sample contained all reaction components except the model extract. Milligrams of gallic acid equivalents (GAE) per 100 g of dry weight (mg GAE/100g dry weight) are used to measure the total phenolic content as the method given in [12].

Determination of total flavonoid content

To prepare the flavored soy yogurt samples, 0.25 g was combined with 20 cc of methanol for two hours at room temperature. Subsequently, 5 mL of 6 M HCl was added to the extract solution, followed by refluxing at 90°C for two hours. After cooling the hydrolyzed sample to room temperature, it underwent filtration using filter paper. The total flavonoid content in the flavored soy yogurt extract was determined through a colorimetric aluminum chloride assay, with quercetin serving as the standard for measurement. For the assay, a 10 mL volumetric flask was filled with 4 mL of distilled water, 0.3 mL of 5% sodium nitrite, and 1 mL of soy yogurt extract. After five minutes, 0.3 mL of 10% aluminum chloride was added to the flask, and at the six-minute mark, 2 mL of 1 M sodium hydroxide was introduced. Distilled water was added to reach a total volume of 10 ml. Following thorough mixing, the absorbance at 430 nm was measured using a UV-VIS Spectrophotometer against a generated reagent blank. The quantity of total flavonoids is represented in milligrams of quercetin equivalents (mg QE/100g dry weight), or QE as the approach outlined in [12].

Antioxidant analysis

Using three milliliters of sample extract and one milliliter of DPPH to produce the solution, which was then left in the dark for thirty minutes, antioxidant analysis was carried out using the DPPH scavenging method. Next, measure the quantity of absorption at 517 nm using a spectrophotometer. Each test was conducted three times. The procedure outlined in [12] was also applied to the examination of ascorbic acid and BHT standard solutions.

Sensory Analysis

All of the samples were assessed on a 9-point hedonic scale as the method used by Aksoylu et al., [16]. To score a product's overall acceptability, 1 is for dislike extremely, 2 is for dislike very much, 3 is for dislike moderately, 4 is for dislike slightly, 5 is neutral, 6 is for like slightly, 7 is for like moderately, 8 is for like very much, and 9 is for like extremely.

Statistical analysis

All the treatments are repeated three times and values are expressed as mean ± standard deviation. The data was examined with a one-way ANOVA (one-way analysis of variance) using a completely randomized design (CRD) by using Statistics 8.1 Software as the method described in [17].

RESULTS AND DISCUSSIONS

Proximate analysis

To depict the nutritional composition of the food, calculations were performed for moisture, ash, protein, fiber, and fat content. T0 exhibited the highest moisture content at 88.51%, followed by T1, while T4 had the lowest moisture content. The treatments showed a statistically significant ($p<0.05$) influence on the moisture content of the yogurt, as indicated by the data. (Farinde et al., [18] found in a related investigation that the yogurt made from soy milk through the inoculation of commercial starter cultures had a moisture level of 0.63%. T0 exhibited the highest protein value at 3.68%, while T3 recorded the lowest protein value at 3.60%, followed by T2 with 3.63%. This highlights the notable protein content present in soy milk. The crude protein pattern indicated a decline in protein concentration until T3 as the proportion of soy milk in the treatment decreased. However, the protein concentration at T0 remained significantly higher than at the other treatment levels. The results indicated that the treatments did not have a statistically significant effect ($p < 0.05$) on the crude protein content of flavored soy yogurt. According to research by Osundahunsi et al., [19], soy yogurt has a protein concentration of 3.75 grams per 100 grams. Farinde et al., [18] did a study that was similar to this one, reporting that the yogurt made with soy milk by the inoculation of commercial starter cultures has a protein level of 3.25%. In a comparison of soymilk yogurt, cow milk yogurt, and commercial yogurt, Farinde et al., [20] found that soymilk yogurt had the highest crude protein content (6.6%).

T0 had the highest crude fat concentration (1.6%), followed by T1 (1.4%), while T3 had the lowest crude fat content (1.2%). According to Osundahunsi et al., [19], soy yogurt has 4.58 grams of fat per 100 grams. In a related investigation, Farinde et al., [18] found that yogurt made with soy milk and commercial starter cultures had a fat level ranging from 1.21% to 3.60%. T3 showed the greatest fiber content value (0.46%), while T0 showed the lowest value (0.33%). In a related study, [18] found that the fiber content of yogurt made with soy milk using commercial starting culture inoculation was comparable. T0 had the lowest value of the ash content (0.81%), while T3 had the highest value (1.09%), followed by T2 (1.03%). According to research done by Osundahunsi et al., [19], soy yogurt has an ash concentration of 0.520/100 g. In a related investigation, Farinde et al., [18] found that the yogurt made from soy milk through the inoculation of commercial starter cultures had an ash concentration of 0.63%. It is evident from statistical data that different treatments have a highly significant effect on the total soluble solids of flavored soy yogurt. For the treatments, with the increasing concentration of mango pomace, the total soluble solids of the flavored soy yogurt were increased. T_0 showed minimum total soluble solids (8.81 °Brix) which gradually increased and finally, the maximum value was obtained at T_3 (14.60 °Brix).

The findings of the current study were as per the outcomes of Navicha et al., [21] those who prepared yogurt with the addition of pawpaw puree. He found that by increasing the concentration of puree, the total soluble solids in flavored yogurt were also increased from 11.83 °Brix to 13.5 °Brix because fruit contains high sugar content. The flavored soy yogurt in the treatments had more acidity as the concentration of mango pomace increased. T0 displayed the lowest acidity (0.73%), which increased for T1 (1.16%), T0 (1.23%), and T3 (1.28%), which yielded the highest result.

After analysis, the mean pH values of yogurt samples T0, T1, T2, T3, and control were found to be 4.91, 4.13, 4.00, and 3.65, respectively. Because mango pomace was added, the pH of each yogurt sample varied; however, the pH of the T0 yogurt, which was made with 100% soy milk and stevia addition, was higher than that of the other samples (4.91). Sample T3 had the lowest pH (3.65) and sample T0 had the highest pH (4.91). These findings suggest that adding mango pomace significantly lowers the pH of all yogurts. All of the mean values from the proximal analysis treatments are displayed in Table 1.

Table.1 *Results of proximate analysis of flavored soy yogurt*

Variable	Treatments	Mean value
Moisture Content	T_0	88.51±0.04[a]
	T_1	84.80±0.06[b]
	T_2	81.72±0.04[c]
	T_3	78.81±0.06[d]
Protein content	T_0	3.68±0.04[a]
	T_1	3.66±0.05[a]
	T_2	3.63±0.04[a]
	T_3	3.60±0.03[a]
Fat Content	T_0	1.6±0.34[a]
	T_1	1.4±0.18[a]
	T_2	1.2±0.34[a]
	T_3	1.1±0.44[a]
Fiber Content	T_0	0.33±0.02[b]
	T_1	0.40±0.04[ab]
	T_2	0.43±0.03[ab]
	T_3	0.46±0.02[a]
Ash Content	T_0	0.81±0.01[d]
	T_1	0.93±0.02[c]
	T_2	1.01±0.01[b]
	T_3	1.09±0.02[a]
Total soluble solids	T_0	8.81±0.28[d]
	T_1	10.92±0.18[c]
	T_2	12.19±0.18[b]
	T_3	14.60±0.34[a]
Acidity	T_0	0.73±0.01[c]
	T_1	1.15±0.03[b]
	T_2	1.23±0.03[ab]
	T_3	1.28±0.01[a]
pH	T_0	4.91±0.04[a]
	T_1	4.13±0.03[b]
	T_2	4.00±0.03[c]
	T_3	3.65±0.04[d]

(T_0= 100% soymilk + 0% mango pomace + 1.5 stevia, T_1 = 85% soymilk + 15% mango pomace +1.5% stevia, T_2 = 80% soymilk + 20% mango pomace + 1.5%, T_3= 75% soymilk + 25% mango pomace + 1.5%, values indicated by the same letter in the same column of variable do not differ significantly from each other)

Phytochemical and antioxidant analysis

The findings clearly show that the TPC content of the soy yogurt was significantly impacted by the mango pomace. T3 had the highest result (20.69µg GAE/g), whereas T2 had the lowest (18.45µg GAE/g). T0 had the lowest recorded value (10.44µg GAE/g). In a similar vein, adding red fruit to soy yogurt improved its TPC content considerably [22]. The data clearly show that the TFC content of the soy yogurt was significantly impacted by the mango pomace. T3 had the greatest value (1.70µg QE/g), followed by T2 (1.65µg QE/g), while T0 (100% soy milk) had the lowest value (1.58µg QE/g). The same results were obtained when the soy yogurt was enriched with red fruit [22].

While the proportion of mango pomace in the soy yogurt grew, the percentage of DPPH in the T0 increased progressively to 48.42%. Because of the increased ratio of mango pomace (25%), the T3 had the largest DPPH (72.20%). The findings of this study are similar to those of [22, 22] work investigation of the phenolic chemicals found in soy yogurt. All of the mean values from the phytochemical and antioxidant analyses are displayed in Table 2.

Table 2. *Results of phytochemical and antioxidant analysis of flavored soy yogurt*

Variables	Treatments	Results
Total phenolic content	**T_0**	10.44 ± 0.04^{d}
	T_1	15.53 ± 0.02^{c}
	T_2	18.45 ± 0.04^{b}
	T_3	20.69 ± 0.03^{a}
Total flavonoid content	**T_0**	1.58 ± 0.02^{c}
	T_1	1.63 ± 0.03^{bc}
	T_2	1.65 ± 0.03^{ab}
	T_3	1.70 ± 0.03^{a}
Effect of DPPH	**T_0**	48.42 ± 0.03^{d}
	T_1	68.01 ± 0.05^{c}
	T_2	70.33 ± 0.05^{b}
	T_3	72.20 ± 0.04^{a}

(T_0= 100% soymilk + 0% mango pomace + 1.5 stevia, T_1 = 85% soymilk + 15% mango pomace +1.5% stevia, T_2 = 80% soymilk + 20% mango pomace + 1.5%, T_3= 75% soymilk + 25% mango pomace + 1.5%, values indicated by the same letter in the same column of variable do not differ significantly from each other)

Sensory analysis

Participants in verbal formats were fully informed about the nature of the study, and their consent was obtained before their involvement. The consumers preferred the color of the T3 the most, followed by the T2 (8.60) and T1 (8.58). Because there was no mango pomace in the T0, its hue was the lowest. The flavor, which combines the food's taste and aroma, is a crucial factor in the production of successful products. The soy yogurt's flavor was found to be considerably influenced by the mango pomace, according to the flavor study. There was a significant correlation between the flavored and unflavored yogurt textures according to the analysis of variance. When it came to texture, the T2 scored the highest. The minimum texture score was observed in the T0 samples. The overall acceptability resulted by the combination of all parameters showed a significant effect on the acceptability among all treatments showed in the Table.3. The consumers mostly liked the T2 and T3 samples and this might be due to the high levels of mango pomace.

Table3. *Results of sensory analysis of flavored soy yoghurt*

Variables	Treatments	Results
Color	T_0	6.65±0.03[c]
	T_1	8.58±0.02[b]
	T_2	8.60±0.01[ab]
	T_3	8.73±0.02[a]
Flavor	T_0	6.20±0.03[c]
	T_1	7.70±0.04[b]
	T_2	7.95±0.36[b]
	T_3	8.50±0.02[a]
Texture	T_0	7.65±0.02[a]
	T_1	7.52±0.05[b]
	T_2	7.56±0.03[b]
	T_3	7.20±0.03[c]
Overall acceptability	T_0	6.01±0.04[d]
	T_1	7.50±0.10[c]
	T_2	8.20±0.04[a]
	T_3	7.82±0.03[b]

(T_0= 100% soymilk + 0% mango pomace + 1.5 stevia, T_1 = 85% soymilk + 15% mango pomace +1.5% stevia, T_2 = 80% soymilk + 20% mango pomace + 1.5%, T_3= 75% soymilk + 25% mango pomace + 1.5%, values indicated by the same letter in the same column of variable do not differ significantly from each other)

CONCLUSION

The study revealed that T0 exhibited the highest pH, while T3 showed the lowest pH value. The acidity of these yogurts increased as the pH of mango-flavored soy yogurt decreased, correlating with the rising concentration of mango pomace. T3 demonstrated the highest acidity, whereas T0 achieved the lowest value. The incorporation of mango pomace led to a reduction in moisture, fat, and protein contents. T0 showed the highest protein content, with the lowest value observed at T3. Similarly, T0 had the maximum fat and moisture content, with the minimum values at T3. The ash, TSS, and fiber content of mango-flavored soy yogurt increased with the addition of mango pomace, reaching maximum values at T3 and minimum values at T0. The antioxidant capacity of the yogurt also increased with mango pomace, reflected in higher total phenolic and total flavonoid contents. The DPPH value ranged from 46.44 to 70.21, with T0 having the lowest and T3 the highest DPPH value. The addition of mango pomace enriched the yogurt with minerals, where T0 exhibited the lowest calcium, magnesium, potassium, and sodium values (191.33, 160.00, 375.00, and 150.00, respectively). Conversely, T3 had the highest values for calcium, magnesium, potassium, and sodium (509.00, 224.67, 481.00, and 204.00, respectively). Sensory analysis of the mango-flavored soy yogurt indicated that yogurt with 25% mango pomace presented the most attractive color, flavor, and overall acceptability. Yogurt with 20% mango pomace received the highest scores for texture.

Ethical Approval. The sensory evaluation in this research involving 20 panelists adheres to ethical standards, placing a priority on the rights, privacy, and well-being of human participants. The study protocol underwent thorough review and received approval from the Institutional Biosafety and Bioethics Committee under the reference number (D#1300/ORIC) at the University of Agriculture, Faisalabad, Pakistan. The approval aligns with national and institutional guidelines, ensuring compliance with the standards of Health and Human Protection Services.

Competing interests. The authors have no conflict of interest to declare.

Authors Contributions. Kinza Fatima: Conceptualization, conducted research, and draft writing. Ahsan Ali and Samran Khalid: Original draft writing, review and editing. Syed Ali Hassan: Review, and editing. Aqsa Irfan: Data curation and draft review, Mahnoor Zafar: Review and editing, Aman Ali and Abuzar: Draft writing and editing, Supervision, review, and editing. Madiha Rafique and Fatima Liaqat: Draft review and editing. Ahmad Din: Supervision, review and editing, Masood Sadiq Butt: Supervision, review, and editing.

Availability of data and materials. The data used to support the findings of this study are available from the corresponding author upon request.

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