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Process Optimization and Quality Characterization of Jackfruit Seed-Based Instant Milkshake Premixes

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Consumers are in search of foods that can be easily prepared and wholesome in supplementing adequate nutrients for a healthy life. The milkshake premixes were developed using jackfruit seed flour as the main ingredient to provide a nutritious food option to the population. Five different premixes were formulated with varying proportions of different ingredients and evaluated for their functional properties and sensorial attributes. Based on the results, three premixes (T_1, T_3 and T_5) were selected as the best and evaluated for their proximate composition and storage stability. The premix T_1 had more crude fibre (2.86%), protein (8.42 g/100g) and carbohydrate content (68.39 g/100g) than the other two premixes. The premix T_3 had a good level of calcium (597.73 mg/100g). All the premixes had negligible amounts of fat (T_1- 1.70%, T_3- 2.03% and T_5- 1.60%), which served

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as favourable attributes *viz.* prevention of rancidity and improved shelf life of the product. Microbial analysis of stored products was carried out to ascertain the shelf life of the products. There was no presence of fungal and coliform count detected during the 60-day of storage period. Hence the premixes can be stored up to a minimum of 60 days without any microbial contamination. Jackfruit seed flour incorporated food products have greater nutraceutical properties, which increases consumer acceptance. The instant milkshake premix development will provide more convenience in both domestic and commercial levels in packaging, handling, storage and preparation of milkshakes.

Keywords: Jackfruit seed; flour; premixes; milkshake; functional properties.

1. INTRODUCTION

The food industries confront various challenges in developing new products for a healthy and quality life in the current scenario. The limited availability of alimentative food products for purchasing could be muffled by value addition and processing of food products that follow the current trends in nutraceuticals and functional foods. In recent years there is more demand for milkshakes among consumers due to its ease of preparation and consumption. High-protein milkshakes, milk drinks, smoothies, fortified milk beverages, powders etc. are commonly available in the market. The biggest problem with milkshakes is their short shelf life, which is caused by microbial deterioration and quality decline. The shelf life of milkshake premixes in instant versions will be longer.

The jackfruit often referred to as *Artocarpus heterophyllus* Lam., belongings to the Moraceae family, is a tropical climacteric fruit that is native to India's Western Ghats and is widely available in Asia, Africa, and some parts of South America [1]. Jackfruit seeds are not effectively utilized and are unpopular among the population, even though they are enriched with nutrients. The toil faced during processing and storage of seeds can lead to colossal seed loss, which will add to the food wastage. Jackfruit seeds provide ample fount of protein, fiber, starch, antioxidants and flavonoids. The seeds are rich in minerals such as manganese, magnesium, potassium, calcium, iron and sulphur [2]. Other phytonutrients present in the seeds are lignans, saponins and isoflavones [3]. A type of glycoprotein lectin known as jacalin is abundantly found in jackfruit seed and imparts antibacterial, antifungal and anticarcinogenic benefits [4].

Consumers are in search of foods that can be easily prepared and wholesome in supplementing adequate nutrients for a healthy life. In the functional food market, milk-based beverages tend to be an opportunistic option to satisfy emerging consumer expectations. This has led to the formulation of novel milk-based beverages. Some of the commercial milk-based drinks include high-protein milkshakes, powders, milk drinks, smoothies, and fortified milk products. Although milkshakes are one of the most significant fluid milk products in western countries, limited research has been done on various aspects of the product. Hence, the current investigation was undertaken to develop milkshake premixes from jackfruit seeds which are generally discarded as waste and to evaluate their functional, nutritional, sensory and shelf-life attributes.

2. MATERIALS AND METHODS

2.1 Raw Materials

The jackfruit cultivar *varikka* was selected for the study. Whole jackfruits were procured from Instructional farm, College of Agriculture, Vellayani, Kerala Agricultural University. The other ingredients used in this study such as Milk powder, Peanut, Almond and Cashew nut etc., were procured from a local supermarket in Trivandrum.

2.1.1 Processing of jackfruit seed flour

The white arils (seed coat) were peeled off and the brown spermoderm were removed manually using stainless steel knife. The seeds were cleaned and washed under running water. Then it was gelatinized at a temperature of 65°C for 10 minutes. After gelatinization the seeds were sliced and Tray dried at 110 °C for 12 hours. The dried seeds were ground to powder form and sieved through a fine wire mesh (150 micron), packed in polyethylene pouches and used for the formulation of premixes.

2.1.2 Standardization of milkshake premixes

Different components are used to blend with the Jackfruit seed flour for the standardization of five different premixes, the components and their proportions are mentioned in the following Table 1.

2.2 Analytical Methods

2.2.1 Determination of functional properties of the milkshake premixes

Functional properties are the fundamental physicochemical characteristics that take into account the intricate interactions between the composition, structure, molecular conformation, and physico-chemical characteristics of dietary components, as well as the characteristics of the environment in which these are related to and assessed [5,6]. The rehydration ratio was determined by the method described by Ranganna [7]. The solubility index was determined according to the method of Anderson [8]. While Water absorption capacity and swelling power were determined by the methods of Sathe et al. [9] and [10]. The bulk density and Tapped density were determined by the method of Okaka and Potter [11].

2.3 Evaluation of Sensory Quality Attributes of Milkshake Premixes

The organoleptic evaluation of the samples was performed by 20 semi-trained panellists. To develop the sensory sample, 15g of different premixes were mixed in 200 ml of cold milk The sensory attributes of the premixes, such as their colour and appearance, taste, texture, flavour, and overall acceptability were scored using a 9-point hedonic scale. (1= dislike extremely and 9= like extremely). The difference in the scores was analyzed using Kruskal – Wallis test.

2.3.1 Selection of best premixes

Based on functional quality analysis and sensory evaluation results, the best premixes out of the five samples were chosen for quality analysis and shelf-life study.

2.4 Determination of Proximate Composition of Milkshake Premixes

Major nutrients like carbohydrate, crude fat, protein, crude fibre content of the selected jackfruit seed instant milkshake premixes were analysed using standard techniques. Carbohydrate and protein content were determined by the mod of Sadasivam and Manickam [12] and [8]. While the crude fat and crude fiber content of the premixes were analysed by using methods of AOAC [13] and [14].

2.4.1 Determination of the mineral composition of milkshake premixes

The Calcium content of the developed premixes was determined by titrimetric method after precipitation as calcium oxalate as outlined by Stanković et al. [15].

2.5 Determination of Storage Stability of Milkshake Premixes

Analysis of the microbial population in developed food products is important as it determines the quality and safety of food products. The storage qualities of the milkshake premixes were measured in terms of moisture intake, Total viable count (TVC), Total fungal count (TFC) and Total coliform count (TCC) at 0 days (initial) and after two months of storage. The growth of bacteria, fungi and coliforms was observed using Nutrient agar, Rose Bengal agar and Eosin methylene blue (EMB) respectively. The evaluation was done by serial dilution of samples followed by pour plating technique suggested by Johnson and Curl [16]. The serial dilution of the samples followed by pour plating was employed to estimate the population of viable micro-organisms in the developed premixes. The moisture content in the developed premixes was determined by using the method of AOAC [14].

Table 1. Standardization of milkshake premixes

Treatments	Ratio of ingredients
T_1	70 JSF+ 30 MP
T_2	50 JSF + 20 MP + 30 PP
T_3	50 JSF + 20 MP + 30 AP
T_4	50 JSF + 20 MP + 30 CP
T_5	50 JSF + 20 MP + 30 JB

(Key: JSF – jackfruit seed flour, MP- milk powder, PP- peanut powder, AP- almond powder, CP- cashew nut powder, JB- Osmo-tray dried ripe Jackfruit bulb)

2.6 Statistical Analysis

All data obtained from various analysis were pooled and subjected to Completely Randomized Design (One-way ANOVA) using KAU-GRAPES software. The sensory scores were analysed using Kruskal – Wallis test.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of the Milk-shake Premixes

The functional properties of the milkshake premixes are presented in Table 2.

Rehydration is used to express the ability of dried material to absorb water. Rehydrating dried powder is a difficult process affected by several variables, including chemical composition, drying methods, temperature, and immersion medium composition, all of which have a significant impact on the product's quality features [17]. The rehydration ratio of the premixes ranged from 0.63 – 0.82 %. Highest rehydration ratio was observed for T_1 (0.82%). The rehydration ratio obtained in this study is higher than 0.34-0.43% reported by Liji et al. [18] for jackfruit-based ready-to-cook instant mixes.

The primary variables influencing the solubility of flour and food components are pressure, concentration, temperature, and the polarity of a solvent. Food ingredients' solubility is favourable and useful for separating combinations [19]. In the present investigation solubility index of premixes were ranged from 4.56 – 5.13%. There was no significant difference observed between the five premixes for solubility. The solubility index of jackfruit seed flour is reported as 1.80% by Akter and Haque [20] and 2.31% by Islam et al. [21]. Compared to the reported values, the premixes have shown a higher solubility index.

Variation in the water absorption capacity of different foods/flours can be due to different concentrations of protein, their conformational characteristics, and their degree of interaction with water [22]. In the present investigation water absorption capacity of the premixes ranged from 154 – 165 ml/100g. The water absorption capacity of Jackfruit seed flour was reported as 112.00 ml/100g by [20] and 72 ml/100g by Islam et al. [21]. The premixes had higher WAC than the reported values. Due to the higher WAC of premixes only a lesser amount will be required for each serving.

The swelling capacity of foods and flours is increased by high starch content, particularly when the starch contains more branching amylopectin [23]. Swelling power of the premixes ranged between 2.05-2.43g/g. The swelling power of JSF was reported as 3.62 g/g by Akter et al. [20] and 12.46% by [24]. The reported values are higher than the obtained values.

Foods with different amounts of starch in them may have varying bulk densities. The probability of an increase in bulk density rises with the starch concentration. Bulk density can be enhanced by making the particles smaller, more compatible, properly tapped, and packaged in the right way [25]. The value obtained from the present study ranged from 0.61 – 0.96 g/cm^3. The highest bulk density was noticed for the premix T_5 (0.96). The findings abide with the study done by Ocloo et al. [26] who reported the bulk density of JSF as 0.80g/cm^3. Low bulk density (0.47 g/ cm3) was reported by

Table 2. Functional Properties of the milkshake premixes

Samples	RR (%)	SI (%)	WAC (ml/100g)	SP (g/g)	BD (g/cm^3)	TD (g/cm^3)
T_1	0.82^a	5.10	154.66^b	2.29^a	0.81^b	1.30
T_2	0.70^b	4.56	162.66^a	2.43^a	0.61^c	1.36
T_3	0.63^c	5.00	164.00a	2.30^a	0.66^c	1.20
T_4	0.70^b	4.86	163.66^a	2.35^a	0.67^c	1.20
T_5	0.78^a	5.13	165.00^a	2.05^b	0.96^a	1.30
±SE(m)	0.021	0.289	1.826	0.068	0.033	0.053
CV (%)	4.988	10.135	1.952	5.119	7.759	7.176

Values are means of triplicates. Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05). T1-70% Jackfruit Seed Flour + 30% Milk Powder, T2-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Peanut powder, T3-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Almond powder, T4-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Cashewnut powder, T5-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Osmo-tray dried ripe Jackfruit bulb. RR = Rehydration ratio, SI= Solubility index, WAC= Water absorption capacity, SP= Swelling power, BD = Bulk density, TD= Tapped density

Dilrukshi et al. [27] in freeze-dried instant green smoothie powder.

Tapped density is the ratio of the mass of the powder to the volume occupied by the powder after it has been tapped for a definite period. In the present study tapped density of premixes ranged between 1.20 – 1.36 g/cm^3. For tapped density, there was no significant difference between the premixes. Tapped density of spray-dried jackfruit seed powder was reported as 0.86 g/cm^3 by Jyothi et al. [28]. According to Dilrukshi [27] the tapped density of freeze-dried instant green smoothie powder was 0.50 g/cm^3. The values of the tapped density of the premixes were found to be higher than the reported values.

3.2 Evaluation of Sensory Quality Attributes of Milkshake Premixes

The sensory quality attributes of milkshake premixes are depicted in the following Table 3. Sensory evaluation is an essential component of a research product or product development. The use of human senses (sight, smell, taste, touch and hearing) for the goal of evaluating consumer products is subject to the scientific discipline of sensory assessment, which applies the concepts of experimental design and statistical analysis.

3.2.1 Colour and appearance

The initial evaluation of the food is its colour and appearance. The key component of a product that determines how well a product is received by consumers is its colour, which has a significant impact on consumer interest [29]. The mean value for colour and appearance ranged from 6.8- 8.5. There was a significant difference between the treatments. Highest scores were observed for the premixes T_1 (8.5), T_3 (8.2) and T_5 (8.2) and they were found to be on par.

3.2.2 Taste

One of the key elements influencing whether or not someone finds food acceptable is taste. The taste of a food plays a significant part since, with the aid of the taste indicator, consumers would feel able to determine if the food is good or not. The taste of a food is also determined by the primary ingredients used [30]. The mean value for taste ranged from 6.4 – 8.5. There was a significant difference between the scores. The treatments T_1 (8.5), T_3 (8.4) and T_5 (8.4) were statistically found to be on par.

3.2.3 Texture

Food acceptance and behaviour regarding food intake are both thought to be fundamentally influenced by food texture. Textural properties also influence the post-ingestive satiation value of food. All these effects combined; texture affects the acceptability of a given food product [31]. The mean value for the attribute texture ranged from 6.4 – 8.3. There was a significant difference between the premixes for the attribute texture.

3.2.4 Flavour

Flavor has a major role in determining the acceptability of foods and beverages. It is a dynamic sense that changes in intensity over time. The highest score was obtained for the premixes T_1 (8.5), T_3 (8.3) and T_5 (8.2) and they were statistically found to be on par.

Table 3. Sensory quality attributes of milkshake premixes

Samples	Colour and Appearance	Taste	Texture	Flavour	Overall Acceptability
T_1	8.5^a	8.5^a	8.3^a	8.5^a	8.4^a
T_2	6.8^b	6.4^b	6.5^b	6.4^b	6.5^b
T_3	8.2^a	8.4^a	8.3^a	8.3^a	8.3^a
T_4	6.9^b	6.5^b	6.4^b	6.3^b	6.5^b
T_5	8.2^a	8.4^a	8.2^a	8.2^a	8.2^a
χ^2	45.529	52.136	53.581	52.897	51.33
*P*_value	0	0	0	0	0

Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05).
T1-70% Jackfruit Seed Flour + 30% Milk Powder, T2-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Peanut powder, T3-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Almond powder, T4-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Cashewnut powder, T5-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Osmo-tray dried ripe Jackfruit bulb

3.2.5 Overall acceptability

The overall acceptability of a food is a significant component that is determined by the product's sensory qualities as well as the attitude of the customer towards the food. It is thought that there are many different aspects to the process by which a person accepts or rejects food. Food's sensory qualities, including taste, texture, flavour, and appearance, have distinct and significant effects on the overall acceptability of food [32]. The highest score was obtained for the premixes T_1 (8.4), T_3 (8.3) and T_5 (8.2) and they were statistically found to be on par.

3.2.6 Selection of best premixes

Based on the results of functional quality analysis and sensory assessment, the best premix was chosen. According on the findings of the sensory evaluation, there a significant difference between the five premixes for the parameters like colour and appearance, taste, texture, flavor and overall acceptability. Hence, by comparing the result of functional quality analysis and sensory evaluation three premixes T_1, T_3 and T_5 were chosen as the best and it was selected for further quality analysis and shelf-life study.

3.3 Proximate Composition of Milkshake Premixes

The proximate composition of the milkshake premixes is presented in Table 4. Carbohydrate values ranged from 55.68 - 68.39g/100g. The premix T_1 had the highest (68.39 g) amount of carbohydrate due to its higher Jack fruit seed flour content compared to the other two premixes. The results obtained were in agreement with those reported (66.70g/ 100g) of carbohydrates in Jackfruit seed flour [33].

Concerning fat content, premix T_3 (2.03%) exhibited the highest fat content; the rise in fat content may be attributed to the almond flour content. Less fat allows for the prevention of rancidity issues and longer shelf life of the product. The results were in agreement with the study of Palamthodi et al. [34] who reported the fat content in JSF as 1.86%.

Protein content of the developed premixes was ranged from 6.02 – 8.42 g/100g. The premix T_1 had highest amount of protein (8.42 g). The decrease in protein content in the other two premixes may be attributed to the low amount of jackfruit seed flour. The results are comparable to the values obtained by Mukprasirt et al. [35], who reported the protein content in JSF as 6.34 – 8.57%.

In the present study fiber content of the premixes ranged from 1.71 – 2.86%. The premix T_1 had highest amount of crude fiber (2.86%). These findings abide with the study done by Maskey et al. [36] reported the crude fiber content of JSF as 2.50%.

Calcium content of the developed premixes ranged from 554.40 – 597.73 mg/100g. The premix T_3 had highest amount of calcium (597.73mg/100g). Low calcium content (96.75mg/100g) of Jackfruit seed flour was reported by Sultana et al. [37]. The reported values were found to be lower than the results. The inclusion of milk powder may have contributed to the premixes' highest calcium level.

Table 4. Proximate composition of milkshake premixes

Premixes	Carbohydrate (g/100g)	Crude Fat (%)	Protein (g/100g)	Crude Fiber (%)	Calcium (mg/100g)
T_1	68.39^a	1.70^b	8.42^a	2.86^a	554.40^b
T_3	55.68^c	2.03^a	6.02^b	1.71^c	597.73^a
T_5	62.23^b	1.60^b	6.27^b	2.23^b	554.80^b
±SE(m)	0.781	0.054	0.176	0.043	0.713
CV (%)	2.178	5.238	4.403	3.288	0.217

Values are means of triplicates. Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05);T1-70% Jackfruit Seed Flour + 30% Milk Powder, T3-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Almond powder, T5-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Osmo-tray dried ripe Jackfruit bulb

Table 5. Storage stability of milkshake premixes

Treatments	Storage period	Moisture (%)	TVC (CFU/gram of sample)	TFC (CFU/gram of sample)	TCC (CFU/gram of sample)
T_1	Initial count	5.38^{i}	2.2×10^2	ND	ND
	30 days	5.45^{f}	4.0×10^2	ND	ND
	60 days	5.58^{c}	8.0×10^2	ND	ND
T_3	Initial count	5.41^{h}	2.4×10^2	ND	ND
	30 days	5.48^{e}	5.1×10^2	ND	ND
	60 days	5.61^{b}	8.9×10^2	ND	ND
T_5	Initial count	5.44^{g}	2.5×10^2	ND	ND
	30 days	5.53^{d}	5.0×10^2	ND	ND
	60 days	5.64^{a}	9.0×10^2	ND	ND
±SE(m)		0.004	0.033	_	_
CV (%)		0.131	1.1	_	_

Values are means of triplicates. Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05). TVC- Total viable count, TFC- Total fungal count, TCC- Total coliform count, ND – Not Detected. T1-70% Jackfruit Seed Flour + 30% Milk Powder, T3-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Almond powder, T5-50% Jackfruit Seed Flour + 20% Milk Powder + 30% Osmo-tray dried ripe Jackfruit bulb

3.4 Storage Stability of Milkshake Premixes

The microbial analysis of milkshake premixes is presented in the Table 5. To establish the shelf-life quality, the premixes moisture content and microbial profile was examined. The rate of contamination with bacterial colonies, fungal colonies and coliform colonies were analyzed to ascertain the microbial profile.

Moisture content is one of the most important parameters which determine the shelf-life quality of food product. Initially the moisture content of the developed premixes ranged from 5.38 – 5.44 per cent. By the end of two months, it was noted that the moisture content of premixes increased constantly but were within the standard range, the value was between 5.58 – 5.64 per cent. These findings abide with the study done by Liji et al. [18] who reported the moisture content of jackfruit based RTC instant mixes as 5.38 – 6.18 per cent.

The study analyzed the distribution and number of microorganisms present in the formulated milkshake premixes during a storage period of two months (60 days). The outcome showed that the Total viable count (TVC) in the premixes was significantly influenced by the storage period, with the count increasing from day 30 to day 60. However, the counts were within the permissible limits There was no detection of fungal and coliform colonies in the developed premixes during the storage period. According to Morshed et al. [38] Jackfruit seed flour was microbe-free over the first 96 days of storage.

4. CONCLUSION

The study concludes that the developed jackfruit seed based instant milkshake premixes are rich in nutrients and easy to prepare. The premixes are inexpensive and good source of nutrients compared to commercially available premixes. Hence the jackfruit seed based instant milkshake premix can be considered as a novel food product. The premixes can be stored up to two months (60 days) without any microbial spoilage. The opportunity to develop novel, healthy and ready to eat food stuff is increased along with the consumer consciousness about the sustainable living. Currently consumers are aware about the connective link between food, health and nature, which help them to implement a coherent food strategy. Development of value-added products using fruit by products has attained much scientific attention due to the global attempt to combat hunger.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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