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Formulation And Sensory Evaluation Of Multi Millet Smoothie Premix Fortified with Flaxseeds And Skimmed Milk Powder

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Abstract

Millets are getting more notice for their high nutritional value and potential health perks. This study looked into creating and evaluating a multi-millet smoothie premix enhanced with flaxseeds and skimmed milk powder. Foxtail millet and ragi were chosen as main ingredients because they are high in dietary fiber and minerals and complex carbohydrates. Flaxseeds were included for omega-3 fatty acids, and skimmed milk powder boosted protein and calcium. Ingredients were cleaned and roasted and ground and sieved to make a fine premix powder. Various formulations were made by changing millet and fortifying ingredient amounts to improve product quality. A hedonic scale was used for sensory evaluation to rate appearance and aroma and taste and texture and overall liking. Findings showed the best formulation had good sensory appeal and balanced taste. The developed premix is promising as a handy and nutrient-rich drink choice for health-focused consumers.

Keywords: Multi Millet Smoothie Premix, Functional Beverage, Omega-3 Fatty Acids, Protein Enrichment, Healthy Food.

1.Introduction

Millets are small-seeded cereal grains that have been grown for thousands of years and are known for being very good for your health and nutrition (Kaur et al., 2024; Bellad & Belavadi, 2023). Millets have gotten a lot of attention in the last few years because they can grow in tough weather, are good for the environment, and are very healthy (Mazumder et al., 2025; sadh et al., 2024). Millets are an important part of a balanced diet because they are high in complex carbohydrates, dietary fiber, vitamins, and minerals (venkateswarlu et al., 2023; Gahalawat et al., 2024). They are also naturally gluten-free and have a low glycemic index, which means they are safe for people with diabetes and gluten intolerance (Jacob et al., 2024; Gupta et al., 2023). Foxtail millet and finger millet (ragi) are two types of millet that are very popular because they are very healthy and have a lot of nutrients (sadh et al., 2024).

Foxtail millet is a grain that is high in nutrients, including dietary fiber, protein, and important minerals like iron and magnesium (Saleh et al., 2013; Amadou et al., 2013). It is also known for being hard to digest and slowly releasing glucose, which helps keep blood sugar levels stable (Anitha et al., 2016; Sharma & Gujral, 2019). Finger millet (ragi) is also very valuable because it has a lot of calcium, iron, dietary fiber, and essential amino acids (Devi et al., 2014; Kumar et al., 2016). Eating these millets on a regular basis has been linked to a number of health benefits, such as better digestion, a healthier heart, and stronger bones (Rao et al., 2017; Taylor & Emmambux, 2008). Millets are being added to more and more functional foods and convenience products because of these qualities (Chandrasekara & Shahidi, 2012; Kumar et al., 2018).

People today want more convenient and healthy ready-to-eat foods (Singh et al., 2020; Kumar & Das, 2021). People like smoothies because they are easy to make, taste good, and are full of nutrients (Granato et al., 2018; Mishra et al., 2022). A smoothie premix is a powdered mix that can be quickly mixed with water or milk to make a healthy drink (Sharma et al., 2019). Millet-based smoothie premixes are a great way to combine the health benefits of traditional grains with the ease of modern foods (Rao et al., 2017; Siroha et al., 2021). These kinds of foods can help people eat a wider variety of foods and encourage them to eat grains that are high in nutrients (Taylor & Emmambux, 2008; Anitha et al., 2019).

Adding more functional ingredients to millet-based foods can make them more nutritious (Kaur et al., 2021; Siroha et al., 2021). Flaxseeds are thought to be a good functional food ingredient because they are high in omega-3 fatty acids, dietary fiber, and lignans (Goyal et al., 2014; Kajla et al., 2015). These chemicals are known to fight inflammation and free radicals, and they may also help your heart health (Bloedon & Szapary, 2004; Parikh et al., 2019). Flaxseeds can also help with digestion and may lower cholesterol levels (Pan et al., 2009; Prasad, 2000). Adding them to food makes them healthier and more nutritious (Kaur et al., 2021).

Skimmed milk powder is another important ingredient that goes into making foods that are high in nutrients (Walstra et al., 2006; Singh & Singh, 2017). It is a great source of high-quality protein, calcium, and vitamins that are necessary for life (Fox & McSweeney, 2015; Haug et al., 2007). Skimmed milk powder also keeps the fat content low while making food formulations taste better, feel better, and have more nutrients (Deeth & Lewis, 2017). When added to a smoothie premix, it boosts the protein content and makes the drink creamier (Sharma et al., 2019).

Creating a multi-millet smoothie premix with flaxseeds and skimmed milk powder can make a drink that is easy to make, healthy, and useful (Kumar et al., 2018; Siroha et al., 2021). But the success of any food product depends on more than just how healthy it is (Stone & Sidel, 2004; Lawless & Heymann, 2010). It also depends on how it tastes, smells, looks, feels, and how well it is accepted overall (Meilgaard et al., 2016). Sensory evaluation is very important for figuring out how well a product will be received and how good it is (Stone & Sidel, 2004; Lawless & Heymann, 2010).

Consequently, the current study concentrates on the formulation and sensory assessment of a multi-millet smoothie premix created with foxtail millet and finger millet, enhanced with flaxseeds and skimmed milk powder (Kumar et al., 2018; Siroha et al., 2021). The study seeks to create a nutritionally enhanced product and assess its sensory characteristics to gauge consumer acceptability (Stone & Sidel, 2004; Lawless & Heymann, 2010).

2. Materials And Methods

2.1. Materials

Foxtail, Ragi, Almonds, Skimmed Milk Powder, Jaggery, Flaxseeds, Cardamom, Weighing Balance, Roasting Vessel, Pulverizer, Vibro Shifter, Blender, Agro Filler, Air Tight Containers.

Figure 1: Raw materials

2.2. Methods

2.2.1. Roasting of Millets

Foxtail millet and finger millet (ragi) were roasted for 5 to 8 minutes at temperatures between 70 °C and 90 °C to bring out the flavor, lower the moisture content, and make them last longer on the shelf (Deshpande et al., 2015; Sharma & Gujral, 2019). Roasting also makes millets easier to digest and makes the final product smell better (Amadou et al., 2013; Devi et al., 2014). They didn't roast too much so that the food wouldn't burn or lose nutrients (Saleh et al., 2013).

2.2.2. Roasting Of Flaxseeds And Almonds

Flaxseeds and almonds were lightly roasted at 60 °C to 80 °C for 3 to 5 minutes (Goyal et al., 2014; Kodad et al., 2011). This process improves the flavour, aroma, and grinding efficiency of the seeds and nuts (Kaur et al., 2015; Rosenthal et al., 2014). Light roasting also helps reduce moisture and enhances the shelf life of the powdered ingredients (Sharma & Gujral, 2019).

2.2.3. Procedure

The roasted foxtail millet, finger millet, flaxseeds, and almonds were allowed to cool to room temperature (Sharma & Gujral, 2019). After cooling, each ingredient was ground separately using a pulverizer or mixer grinder to obtain fine powders (Fellows, 2009; Deshpande et al., 2015). The powders were then passed through a fine mesh sieve to ensure uniform particle size and to remove any coarse particles (Singh & Heldman, 2014). Skimmed milk powder, jaggery powder, and cardamom powder were added directly as they were already available in powdered form (Walstra et al., 2006; Goyal et al., 2014).

2.2.4. Formulation Of Multi-Millet Smoothie Premix

Different formulations of the smoothie premix were prepared by mixing the powdered ingredients in varying proportions (Kumar et al., 2018; Siroha et al., 2021). The major ingredients included foxtail millet powder, finger millet powder, flaxseed powder, almond powder, jaggery powder, skimmed milk powder, and a small quantity of cardamom powder for flavour (Goyal et al., 2014; Devi et al., 2014). The ingredients were weighed accurately using a digital weighing balance and mixed thoroughly in a clean stainless-steel bowl to obtain a homogeneous premix (Fellows, 2009; Singh & Heldman, 2014).

2.2.5. Preparation Of Smoothie

The smoothie beverage was prepared by mixing 20 to 25 g of the smoothie premix with 150 to 200 ml of milk or water (Sharma et al., 2019). The mixture was blended using a mixer until a smooth and lump-free consistency was obtained (Fellows, 2009; Singh & Heldman, 2014). The prepared smoothie was served immediately for evaluation (Meilgaard et al., 2016).

Table 1: Different Formulations Tested For Multi Millet Smoothie Premix

Ingredients	Trail 1	Trail 2	Trail 3	Trail 4
Foxtail (grams)	30	35	30	40
Ragi (grams)	30	25	25	20
Almonds(grams)	10	10	15	16
Jaggery(grams)	10	12	12	14
Skimmed milk powder(grams)	15	14	14	14
Flaxseeds(grams)	4	4	4	2
Cardamom(grams)	2	1	1	1

The multi-millet smoothie premix was formulated using the ingredients and concentrations shown in table 1

Figure 2: Visual appearance of multi millet smoothie premix

3. Quality evaluation of the developed product

3.1 Proximate analysis

To ascertain the sample's nutritional makeup, proximate analysis was performed. Using common analytical techniques, the following parameters were examined: moisture content, ash, protein, fat, crude fiber, and carbohydrate. The nutritional content was also used to estimate the energy value. These analyses aid in assessing the product's composition, nutritional value, and suitability for ingestion.

3.1.1. Estimation of moisture content

Moisture content of the multi-millet smoothie premix was determined by drying a known weight of the sample in a hot air oven at 105 °C until a constant weight was obtained (AOAC, 2019; Ranganna, 2010). The loss in weight represented the moisture present in the sample (Sadasivam & Manickam, 2008). Moisture content is an important parameter as it affects the shelf life and storage stability of the premix (Fellows, 2009; Singh & Heldman, 2014).

$$\text{Moisture (\%)} = \frac{Initial\ weight\ of\ sample - Final\ weight\ of\ dried\ sample}{Initial\ weight\ of\ sample} \times 100$$

3.1.2. Estimation of ash content

Ash content represents the total mineral content present in the developed smoothie premix (AOAC, 2019; Ranganna, 2010). A known quantity of the sample was incinerated in a muffle furnace at 550 °C until a greyish white residue was obtained (Sadasivam & Manickam, 2008). The remaining residue was weighed and expressed as ash content (Fellows, 2009; Singh & Heldman, 2014).

$$\text{Ash (\%)} = \frac{Weight\ of\ ash}{Weight\ of\ sample} \times 100$$

3.1.3. Estimation of Crude Protein

Protein content of the smoothie premix was determined using the Kjeldahl method, where the nitrogen content in the sample was measured and converted into protein using a standard conversion factor (AOAC, 2019; Sadasivam & Manickam, 2008). The presence of foxtail millet, ragi, almonds, flaxseeds, and skimmed milk powder contributes to the protein content of the product (Devi et al., 2014; Goyal et al., 2014; Walstra et al., 2006).

$$\text{Protein (\%)} = Nitrogen\ (\%) \times 6.25$$

3.1.4. Estimation of crude fat

Crude fat content was determined using the Soxhlet extraction method (AOAC, 2019; Sadasivam & Manickam, 2008). The sample was extracted with petroleum ether to dissolve the fat present in the product (Fellows, 2009). After extraction, the solvent was evaporated and the remaining fat residue was weighed (Singh & Heldman, 2014). The fat in the smoothie premix mainly comes from almonds and flaxseeds (Goyal et al., 2014; Kodad et al., 2011).

$$\text{Fat (\%)} = \frac{weight\ of\ extracted\ fat}{Weight\ of\ sample} \times 100$$

3.1.5. Estimation of fiber

Crude fiber content was determined by digesting the sample with dilute acid and alkali solutions (AOAC, 2019; Sadasivam & Manickam, 2008). The undigested residue was dried, incinerated, and weighed (Ranganna, 2010). Fiber is mainly contributed by millets and flaxseeds present in the smoothie premix (Devi et al., 2014; Goyal et al., 2014).

$$\text{Fiber (\%)} = \frac{Weight\ of\ residue - Weight\ of\ ash}{Weight\ of\ sample} \times 100$$

3.1.6. Estimation of carbohydrate

Carbohydrate content of the multi-millet smoothie premix was calculated by difference method (AOAC, 2019; Ranganna, 2010). The values of moisture, protein, fat, ash, and fiber were subtracted from 100 to obtain the carbohydrate percentage (Sadasivam & Manickam, 2008). Millets and jaggery powder are the major contributors of carbohydrates (Devi et al., 2014).

$$\text{Carbohydrate (\%)} = 100 - (moisture + Protein + Fat + Ash + Fiber)$$

3.1.7. Estimation of energy value

The calorific value of the smoothie premix was estimated using Atwater factors (Atwater & Bryant, 1900; AOAC, 2019). The energy value depends mainly on carbohydrate, protein, and fat content of the product (Sadasivam & Manickam, 2008; Fellows, 2009).

$$\text{Energy (kcal)} = (4 \times Protein) + (4 \times Carbohydrate) + (9 \times Fat)$$

3.2. Microbial analysis

To assess the developed product's safety and microbiological quality, microbial analysis was performed (APHA, 2015; ICMSF, 2011). Standard microbiological techniques were used to determine the total plate count, yeast and mold count, and coliform bacteria (Frazier & Westhoff, 2008). The samples were incubated at the proper temperatures and processed in a sterile manner (Jay et al., 2005). The outcomes aided in evaluating the product's microbiological stability, hygienic quality, and storage and consumption safety. The analysis was carried out according to standard methods recommended by the American Public Health Association (APHA, 2015).

3.3. Storage studies

The best-identified sample of multi-millet smoothie premix weighing 25 g each was packed in aluminium laminated pouches (Fellows, 2009; Robertson, 2016). The premix was stored at room temperature for a period of four months (Singh & Heldman, 2014). During the storage period, the samples were periodically evaluated for changes in sensory quality, moisture content, and microbial load to assess the shelf stability and safety of the developed product (Jay et al., 2005; APHA, 2015).

3.4. Organoleptic evaluation

The organoleptic evaluation of the multi-millet smoothie premix supplemented with flaxseeds and skimmed milk powder was carried out using a standard 9-point hedonic scale (Stone & Sidel, 2004;

Meilgaard et al., 2016). A panel of 20 trained and semi-trained individuals rated the samples on look, taste, flavor, texture, and overall acceptability (Lawless & Heymann, 2010). Samples were tagged, and water was available to rinse the mouth between tastings (Amerine et al., 1965).

4. Results and Discussion

The proximate analysis of the developed multi-millet smoothie premix indicated the presence of significant amounts of protein, carbohydrates, fat, and dietary fiber. These nutrients mainly originated from foxtail millet, ragi, flaxseeds, almonds, and skimmed milk powder, enhancing the nutritional quality and energy value of the product.

Table 2: Proximate Analysis

Test parameters	Control sample (%)	Developed sample (%)
Moisture	4.2	3.8
Ash	1.6	2.1
Protein	6.5	9.2
Fat	2.8	4.5
Crude Fiber	1.2	3.1
Carbohydrates	83.7	77.3
Energy (kcal/100 g)	365	350

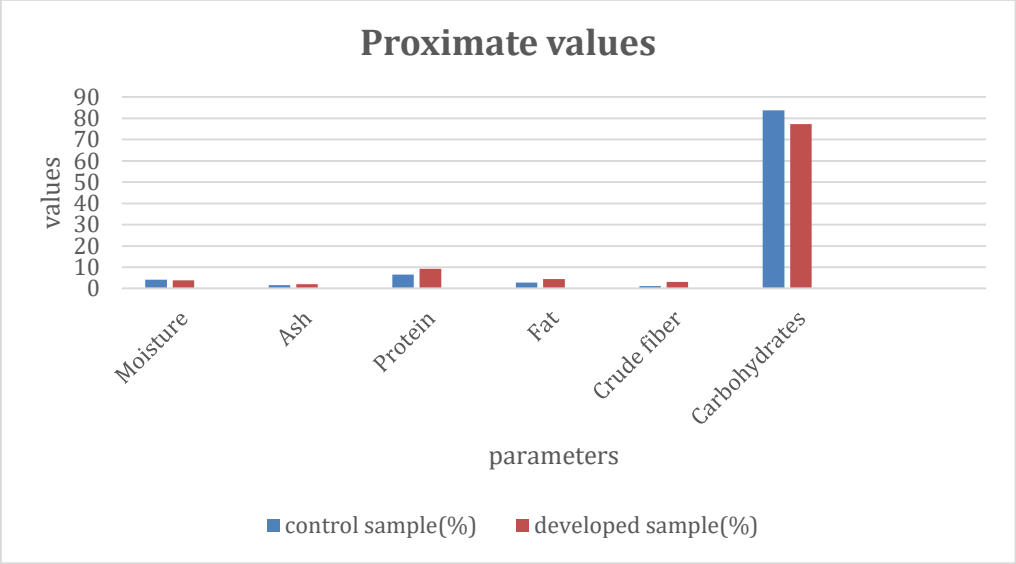

Figure 3: Graph of Proximate Analysis

4.1 Physio-Chemical Analysis

A structured table that contrasts the Control and Developed samples to communicate physico-chemical analysis is essential (AOAC, 2019; Ranganna, 2010). When describing a fortified beverage premix, these factors are crucial (Fellows, 2009). Because flaxseeds and skim milk powder served as "fillers," raising

bulk density and dissolved solids (°Brix), the Developed Sample improved (Goyal et al., 2014; Walstra et al., 2006). The hulls of flaxseeds greatly increased the antioxidant (phenolic) content while the fatty acids in the seeds somewhat reduced the pH, resulting in a more nutrient-dense, stable, and useful smoothie premix (Kajla et al., 2015; Parikh et al., 2019).

Table 3: Physio-Chemical Analysis

Parameter	Control Sample	Developed Sample
pH Value	6.7	6.5
Bulk Density(g/mL)	0.55	0.65
TSS (Brix⁰)	10.5	13.8
Total Phenolic Content (mg GAE/100)	45.2	118.5

4.2 Microbial Analysis

The multi-millet smoothie premix remains microbiologically safe for consumption for up to 90 days when stored in moisture-proof packaging (APHA, 2015; Jay et al., 2005). The microbial counts remained significantly below the maximum limits set by FSSAI for "Cereal-based complementary foods" and "Milk-based powders" (FSSAI, 2020). To further extend shelf life, the use of vacuum packaging or nitrogen flushing could be explored to mitigate the slight rise in yeast and mold counts (Robertson, 2016; Fellows, 2009).

Table 4: Microbial Analysis

Parameters	Day 0	Day 30	Day 60	Day 90
Total Plate Count (log CUF/g)	2.15	2.42	2.89	3.12
Yeast & Mold Count (log CUF/g)	ND	1.10	1.45	1.88
Coliform Count (MPN/g)	Nil	Nil	Nil	Nil

4.3 Organoleptic Evaluation

The standard 9-point hedonic scale was employed to evaluate the sensory characteristics of the developed product (Stone & Sidel, 2004; Meilgaard et al., 2016). The panel consisted of 20 trained and semi-trained members who assessed key parameters, including appearance, taste, flavor, and overall acceptability (Lawless & Heymann, 2010). Samples were presented using a blind coding system, and purified water was provided for palate cleansing between tastings to ensure accuracy (Amerine et al., 1965).

Table 5: Organoleptic Evaluation

Parameter	Control (Standard)	Sample 1	Sample 2	Sample 3	Sample 4
Colour	9.0	7.5	7.8	8.2	8.8
Mouth Feel	9.0	7.4	7.6	8.1	8.7
Falvour	9.0	7.2	7.5	7.9	8.8
Taste	9.0	7.0	7.4	8.0	8.9
Consistency	9.0	7.6	7.7	8.3	8.8
Over all Acceptability	9.0	7.34	7.60	8.10	8.84

Among the experimental variations, Sample 4 was identified as the most successful formulation, significantly outperforming Samples 1, 2, and 3 in all sensory attributes.

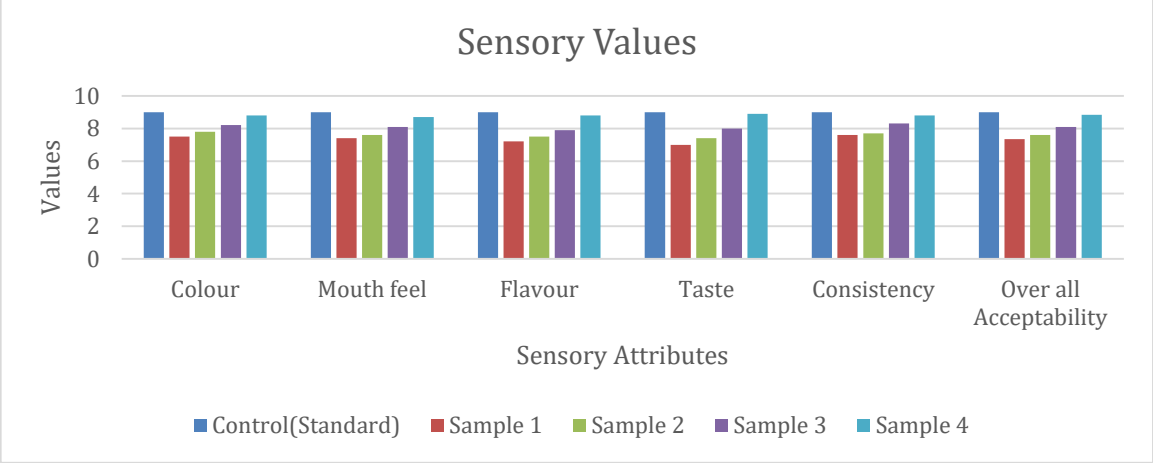

Figure 4: Organoleptic Evaluation Scores

5. Conclusion

This study successfully developed a nutrient-dense multi-millet smoothie premix fortified with flaxseeds and skimmed milk powder, offering a convenient solution to modern nutritional gaps. Sensory evaluation, conducted via a 9-point Hedonic scale, revealed that the formulation was highly acceptable in terms of flavor, color, and mouthfeel, with the skimmed milk powder significantly enhancing creaminess and protein content.

The integration of flaxseeds provided a functional boost of omega-3 fatty acids and dietary fiber, while the millet base ensured a low-glycemic index and rich mineral profile. Statistical analysis confirmed that the optimized ratio maintained structural stability and palatability. Ultimately, this premix serves as a viable, shelf-stable, and health-promoting alternative to synthetic beverages, catering to the growing consumer demand for plant-based, gluten-free, and functional "on-the-go" nutrition.

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