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Process optimization of plant-based millet and fruit blends: A focus on non-dairy beverages

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Abstract
Millets are preferable as nutritious grains and play an important role in the diet of the people across the world. Although it offers wealth of essential nutrients such as proteins, dietary fiber, vitamins, and minerals than cereals. Despite these benefits, millet consumption remains largely confined to traditional consumers. So, the present study was focused to developed millet -based beverage from foxtail millet, kodo millet and sapota. The flavoring essence and stabilizer was used for taste and stability of the beverage. The developed beverage was evaluated for their quality attribute (pH, TSS, acidity, sedimentation index, separation rate and heat stability). The result showed that developed beverage had TSS ºBrix (24.66±0.5), pH (6.96±0.03), acidity (0.33±0.1), sedimentation index (0.25±0.9 g/ml), separation rate (10.5±0.03 ml/h) and heat stability (7.5±0.6 minutes). Millets are nutrient dense that have significant health advantages. Millets may be processed into a variety of products including flour, snacks, and beverages and their commercial popularity can be increased through innovative product development approach and strategic marketing.

Keywords: Millets, non-dairy beverage, plant based milk

1. Introduction
In recent years, health concerns have led to a change in consumer choices and views of food. Because of this, there have been frequent and significant dietary adjustments, which has sparked the creation of functional and designer foods that have both the intended nutritional benefits and additional health advantages. The development of non-dairy functional beverage is one such advancement as the use of bovine milk sources causes hypercholesteremia, allergies and lactose intolerance in populations [1]. These non-dairy beverages are created by extracting plant materials such as soy, nuts, and rice, and mixing them with water. These extracted materials are then homogenized. After homogenization, they undergo thermal treatment and improves the suspension of particles and extends the shelf life of the beverage [2].

Plant-based milk alternatives can be either wet milled or soaked, or the raw material can be dry milled and the flour being extracted in water afterward. In order to exclude insoluble plant components and the grounded particles, the resulting mixture undergoes filtration or decanted [3]. The first plant-based milk alternative to be sold commercially is soymilk. Non-dairy milk substitutes can also be made from plant materials such as quinoa, rice, almonds, coconut, and oats in instead of soy [4]. Plant-based milks are a great dairy-free substitute because they lack some of the ingredients found in dairy products such as cholesterol, saturated fats, lactose, and antigens. However, they are good source of minerals, non-allergic proteins, essential fatty acids, and other nutrients [5].

Millets are the most economical raw ingredient for the development of non-dairy beverages as they can flourish in a range of agro-ecological conditions, such as low rainfall and low soil fertility [6]. The Indian government designated millets as "Nutri-Cereals" in 2018–19 and initiated the "National Mission on Nutri-Cereals" to encourage their cultivation and consumption and acknowledged as an essential component of the food basket to combat malnutrition [7]. The United Nations (UN) General Assembly proclaimed 2023 to be the “International Year of Millets” and promoting millets on national and international level. Apart from this, the objective of program is to achieve several Sustainable Development

Goals (SDG) include- SDG 1: No Poverty, SDG 2: Zero Hunger, SDG 3: Good Health and Well-being, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth and SDG 13: Climate Action [8].

The need to produce plant-based milk substitutes is growing because they are seen to be a viable replacement for cow milk for a number of reasons including hypercholesteremia, lactose intolerance, allergy to the protein in cow's milk, and the presence of antibiotic residue [9]. Plant source contains proteins, dietary fiber, vitamins, minerals, phytochemicals, and antioxidants that contribute to a number of health-promoting qualities, including anti-diabetic, anti-carcinogenic and anti-cholesterimic effects [10]. However, the nutritional content of plant-based milk replacements is primarily influenced by the kind of raw material used, the processing technique, the presence of anti-nutritional elements and type of fortifying agent used [11]. The forthcoming trends in the food sector center on consumer health and wellbeing in addition to meeting customer demand for appealing and appetizing therapeutic beverages. It has become important for manufacturers to provide such types of beverages, which offer both health and nutritional advantage. In order to fulfill these demands the underutilized fruits play a significant [12].

Therefore, the present study was focused to process optimization of millet and fruit blended beverage and to analyse quality attributes of developed beverage.

2. Materials and method

Foxtail millet **(***Setaria italic)*, Kodo millet *(Paspalum scrobiculatum)* and sapota *(Manilkara zapota)* and flavoring essence were purchased from the local market of Udaipur, Rajasthan. Millets and sapota were used for the formulation of millet and fruit blended beverage. The developed beverage was evaluated for quality attributes (pH, TSS, acidity, sedimentation index, separation rate and heat stability).

2.1 Formulation of millet and fruit blended beverage

The foxtail millet and kodo millet (100g) of each were cleaned to remove unwanted particles and millets were soaked in excess water for overnight. At the end of steeping time, the grains were cleaned and extra water was drained. The soaked grains were ground for 10-15 minutes in a mixer. After that millet slurry was diluted with ratio of 1:6(millet to water). This was followed by passing it through double layers muslin cloth. The filtrate was double-boiled for a short period of time after adding 70% of sapota (chiku) pulp. Chocolate essence was added as a flavoring essence and also stabilizer was added in between to maintain the beverage's texture and taste while preventing separation of the ingredients over time. The developed millet -based beverage was stored in sterilized glass bottles.

2.2 Determination of Quality Attributes

2.2.1 pH and TSS

The pH of developed beverage was measured with a digital pH meter at 25° C. Total soluble solid was estimated by digital refractometer.

2.2.2 Sedimentation index

Sedimentation rate was determined by phase separation analysis using analytical centrifuge at 1000 rpm for 30 min at 24ºC.The sediment weight was calculated and expressed as g of sediment /volume of centrifuge tube [13].

2.2.3 Separation rate

Separation test was performed by filling graduated cylinders with beverage at 25ºC and graduated cylinder was observed for 1 h and expressed as ml/h [14].

2.2.4 Heat stability

Heat stability was determined by placing the sample in a beaker sealed with aluminum foil and immersing it in a thermostatically controlled water bath at 75°C. The heat coagulation time was visually observed and recorded as the time in minutes [15].

2.2.5 Acidity

The acidity of the sample was determined using Ranganna's (1986) [16] method where the sample was dissolved in water to make volume, filtered, and then titrated with 0.01 N NaOH using phenolphthalein as an indicator. The titration was repeated to ensure consistent results, with the acidity reported as a percentage based on the volume of NaOH required to reach the endpoint.

2.3 Statistical Analysis

The results obtained from various experiments were carried out in triplicates to ensure accuracy and reliability of results and expressed as mean ± standard deviation.

3. Results and Discussion

The qualitative parameter of millet and fruit blended beverage includes pH, total soluble solids, acidity, sedimentation index, separation rate and heat stability are represented in table 1.

The pH of developed millet and fruit blended beverage was 6.96 ± 0.03% while the total soluble solids (°Brix) content of millet and fruit blended beverage was 24.66± 0.5. Balasaheb sonwalker *et al.*, [17] studied that inclusion of jackfruit pulp in flavored milk has a higher percentage of total soluble solids (23.57%) than skim milk (9.53%). The acidity of millet and fruit blended beverage was evaluated and it was 0.33 ± 0.1%. When the acidity of beverage was reduced the pH of the all plant beverage increased and vice versa. Salve *et al.*, [18] developed peanut beverage by using ultrasonication, hydrodynamic cavitating, and high temperature short time processing methods. It was reported that pH and acidity values ranged from 6.6 to 6.7 and 0.13 to 1.08%, respectively.

The stability of the particles in the beverages is measured by the sedimentation index. The less dense particles float on top of the liquid, whereas denser particles settle to the bottom. The sedimentation index of beverage was *0.25* ± 0.9 g/20ml.

The separation rate of millets and fruit blended beverage was 10.5±0.03 ml/hr. Rincon *et al.*, (2020) [19] shown that pure chickpea beverage had a greater separation rate (49 ml/h) while the addition of coconut beverage to chickpea beverage decreased the phase separation (18 ml/h). The millet beverage's heat stability is a crucial factor that influences the duration it takes for the millet to coagulate. The primary nutrition in millet beverages is starch, which gelatinizes at 75 degrees Celsius. Heat stability of the millet and fruit blended beverage was in the range of 7.5 to 10 minutes.

Table 1: Quality attributes of millet and fruit blended beverage

Quality attributes	Millet based beverage
TSS (ºBrix)	24.66±0.5
pH	6.96 ± 0.03
Titrable - acidity(%)	0.33 ± 0.1
Sedimentation index (g/ml)	0.25 ± 0.9
Separation rate (ml/h)	10.5±0.03
Heat stability (minutes)	7.5 ±0.6

4. Conclusion

The millet and fruit blended beverage was formulated that shows the quality attributes and provide valuable insights regarding overall characteristics and suitability for consumption. The TSS (total soluble solids) indicates balanced sweetness level that is essential for improving palatability whereas pH contributing to flavor balance and overall sensory appeal. The beverage also exhibited good heat stability and minimal phase separation over time, ensuring good consistency and appearance collectively and also contribute to its appeal as a nutritious and enjoyable beverage choice. The findings underscore the beverage's potential as a reliable choice for consumers seeking both health benefits and sensory satisfaction in their dietary choices.

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