Food and Nutrition Sciences, 2025, 16(2), 153-162
https://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

Development of Enriched Sweets Based on Jujube Powder (*Zizyphus mauritiana*), Baobab Fruit (*Andasonia digitata*), and Sweet Potato Puree (*Ipomae batatas*): Nutritional and Sensory Properties

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How to cite this paper: Ndiaye, N.F., Lopy, M.J.F.S., Niang, A., Sow, M.S. and Diouf, A. (2025) Development of Enriched Sweets Based on Jujube Powder (*Zizyphus mauritiana*), Baobab Fruit (*Andasonia digitata*), and Sweet Potato Puree (*Ipomae batatas*): Nutritional and Sensory Properties. *Food and Nutrition Sciences*, **16**, 153-162.
https://doi.org/10.4236/fns.2025.162009

Received: December 5, 2024
Accepted: February 2, 2025
Published: February 5, 2025

Abstract

Increasing access to locally produced, safe, nutritious and affordable complementary foods is essential to combat micronutrient deficiencies in young children in low- and middle-income countries. Two formulations of sweets based on jujube, baobab fruit powder and sweet potato puree were produced, and their nutritional values and sensory properties such as taste, smell, color and acceptability were assessed. The formulation containing the most jujube powder, baobab fruit and sweet potato puree gave the best nutritional value. The sweets are rich in calcium (259.80 mg/100 g), magnesium (67.98 mg/100 g), potassium (782.04 mg/100 g), vitamin C (32.37 mg/100 g), iron (6.45 g mg/100 g) and zinc (0.97 mg/100 g). Sensory tests on the two formulations showed acceptability scores ranging from 81.26% to 84.58%, well above the minimum acceptable threshold. Candies with jujube, baobab fruit powder and sweet potato puree could be an alternative for preventing micronutrient deficiencies.

Keywords

Sweets, Jujube, Baobab Fruit, Sweet Potato

1. Introduction

Micronutrient deficiency, also known as "hidden hunger" [1]-[3], is a widespread form of malnutrition [4], affecting nearly 821 million people, or one in nine people worldwide [5]. Some nutritional deficiencies bring high risks for individual health, particularly for children under the age of five and pregnant or breast-feeding women [6]. In Senegal, 18% of children under the age of 5 are stunted or chronically malnourished, and the prevalence of wasting increased slightly from 8% to 10% in 2015 [7].

Faced with this growing increase in these forms of malnutrition, it is important to find low-cost, accessible alternatives to help the population combat these deficiencies. The design of new products such as sweets, which are rich in micronutrients, deserves particular attention. Sweets, like biscuits, are widely consumed, so they can be used as a suitable vehicle for incorporating nutrients and as a matrix for fortifying foods [8]. The identification of one or more foods potentially rich in macronutrients and micronutrients with a view to improving the nutritional quality of the whole is suggested as an interesting, accessible and low-cost approach to combating malnutrition in developing countries [9]-[11]. Jujube is a highly nutritious fruit species, it is one of the richest sources of vitamin C after amla (*Phyllanthus emblica*) and guava (*Psidium guajava*), it is better than citrus fruits and apples [12]. The results of research carried out by Makalao *et al.* (2015) [13], even showed that jujube is richer in vitamin C and calcium than the pulp of the baobab fruit (*Andasonia digitata*). In the past, jujube played an important role in the diet of certain populations, particularly those who inhabited Libya in ancient times [14]. Whatever their origin, jujubes are rich in sugars, vitamin C, calcium and iron, equivalent to the iron content of bananas, dates and figs [15]. The fruit of the African baobab (*Andansonia digitata* L) is eaten in a variety of preparations, and is rich in dietary fiber, carbohydrates and potassium, with exceptionally high levels of calcium, magnesium and phosphorus. The pulp also contains copper, iron, manganese and zinc. The pulp has an interesting vitamin content, making it one of the fruits rich in vitamin C [16]-[21]. According to Silvia *et al.* (2002) [22], the pulp has very interesting antioxidant properties. The sweet potato (*Ipomea batatas*) is one of the most widely cultivated tuberous food plants in the world and is an energy-giving food. It is rich in vitamin A and is also a source of vitamin B6 and vitamin C. Sweet potatoes are also a source of manganese and potassium [23]. The high content of certain minerals and vitamins, as well as various antioxidant molecules, makes sweet potatoes an ideal food for combating malnutrition [24].

The high nutritional value of baobab pulp, jujube and sweet potato is the reason why they were chosen as a basic raw material to produce sweets. The aim of this work is to develop a new product based on jujube, sweet potato and baobab fruit with good nutritional quality.

2. Material and Methods

2.1. Preparation of the Raw Material

Production of jujube flour, baobab pulp and sweet potato puree

- The sweet potato is processed into a puree. After washing, the tubers are peeled, boiled and then pureed.

- Baobab powder: the seeds and fibers are separated from the pulp using a dry process. A mortar is used for crushing, followed by sieving with a 0.5 mm mesh sieve (chopin) to obtain a powder.
- Jujube powder is obtained by crushing ripe, dried fruit, followed by sieving with a 0.5 mm mesh sieve to obtain a powder.

2.2. Preparation of Blends

The baobab and jujube pulp powders were mixed with the sweet potato puree using a blender.

Two blends at different percentages were studied, a first blend with 18% Baobab fruit powder, 18% Jujube powder and 18% sweet potato puree (BBJP18) and a second blend with 20% Baobab fruit powder, 20% Jujube powder and 20% sweet potato puree (BBJP20).

2.3. Production of Sweets

The different mixtures of sweet potato puree and jujube and baobab fruit powders were laminated and die-cut. These operations were followed by baking (Logidiuce Forni) and packaging.

2.4. Physico-Chemical Analysis

Moisture

The moisture content is determined using the method described in AOAC (2018). The sample is oven dried (105˚C ± 2˚C) for four hours to constant weight. The weight loss is calculated as the moisture content of the sample.

Proteins

Protein content is determined using the Kjeldahl method described in AOAC (2018), the technique of which consists of measuring the nitrogen in the sweets. The finely ground candy sample is mineralized under heat using concentrated sulphuric acid in the presence of a catalyst. After several transformation processes, the nitrogen yields ammonia, which is distilled, covered in a boric acid solution and titrated with a sulphuric acid solution. The nitrogen content multiplied by a coefficient (6.25) gives the protein content.

Ash content

Ash is defined as the inorganic residue obtained after removal of moisture and organic matter by heat treatment. The mineral matter or crude ash content is determined using the method described in AOAC (2018). This involves calcining the finely ground candy sample contained in a porcelain crucible on a hot plate. The sample is then incinerated in an oven at 550˚C for four hours until ash is obtained.

Fat content

The fat content is determined by extracting the lipids with an organic solvent (N hexane), evaporating the solvent and weighing the lipid extract after oven drying at 105˚C for (30 mn) (AOAC, 2018).

Crude fiber

Crude fiber content is determined according to the method described in AOAC (2018). The finely ground sample is subjected to two acid and base hydrolyses, followed by complexation with EDTA. The residue obtained is then filtered, dried in an oven at 130˚C and then calcined in an oven at 400˚C for (two hours). The difference in weight between the two stages gives the crude fiber content.

Carbohydrates

The carbohydrate content of sweets is obtained by calculating the difference between the dry extract and the sum (protein + fat + crude fiber and mineral matter).

Mineral elements

Calcium, potassium, iron and zinc are measured by Atomic Absorption Spectrophotometry using the method described in AOAC (2018). After incinerating the samples and dissolving the ash in hydrochloric acid, the concentrations of the various minerals in the samples are determined from calibration curves established with a range of standard solutions characteristic of each element.

Phosphorus content

Phosphorus is determined in the form of phosphate by the UV-visible spectrophotometric method using the vanadate-molybdate reagent. Phosphorus is combined with ammonium molybdate to form a phosphomolybdic complex which, in the presence of ammonium metavanadate, gives an orange yellow color. The absorbance of the latter is measured at a wavelength of 470 nm.

Vitamin C

Vitamin C is determined according to the Chemicals Analysis of Food method (1st edition), the oxidation of vitamin C by dichlorophenol indophenol (DCPIP) which has several characteristics (Blue in basic medium, red in acid medium) and color less in its reduced form.

Add 3% metaphosphoric acid solution to 40 ml, homogenize and filter. Take 1 to 5 ml of this solution in a small beaker, add 2.5 ml of acetone if Sulphur dioxide is present and titrate with the DCPIP solution until pink coloration persists for at least 15 seconds. To standardize, dissolve 0.1 g of pure ascorbic acid in a 100 ml flask with 3% metaphosphoric acid. Take 1 ml of this solution and titrate with DCPIP until the pink coloration persists for at least 15 seconds.

2.5. Determining the Energy Value

The energy value of the various foods is calculated using the At Water method as described in the US Department of Agriculture's Manual No. 74 entitled "Energy Value of Foods - Basics and Derivation".

The At water coefficients are 9 kcal/g for lipids, 4 kcal/g for proteins and 4 kcal/g for carbohydrates. The energy value is obtained by summing the three contents with their respective coefficients. EV = 4G + 9L + 4P in Kcal.

2.6. Sensory Test

A 9-point hedonic scale, conforming to the NF V09-500 standard, was used as the basis for the sensory analysis. The panelists were asked to rate their appreciation on a scale of 1 to 9, ranging from "don't like at all" to "like a lot", with each point representing a different level of satisfaction. Sixty (60) panelists aged between 21 and 50, including 28 students, 8 researchers and 24 food industry specialists, evaluated organoleptic characteristics such as appearance, freshness, flavor, texture and general acceptability of the sweets. The scores obtained were used to calculate the acceptability index (AI) using the equation of Fernandes & Mellado, (2017) [25]: $\text{IA} = \frac{\text{Score} * 100}{\text{Hedonic scale}}$.

Foods will be considered acceptable if they have an acceptability index ≥ 70% [26].

2.7. Statistical Analysis

For statistical processing of the data, a data analysis package Minitab Statical Software was used. A statistical evaluation of the differences observed with analysis of variance (ANOVA) at significance level $p \leq 0.05$. For the sensory tests, the variables were expressed as percentages.

For all these statistical analyses, a significance level of 0.05% was used.

3. Results and Discussion

3.1. Nutritional Composition of Sweets

The results of the nutritional analyses carried out on the sweets are presented in **Table 1** below:

Table 1. Characterization of sweets.

Parameters / Sweets	BBJP18	BBJP20
Ash%	1.71 ± 0.01^b	2.26 ± 0.02^a
Protein%	4.43 ± 0.13^a	3.02 ± 0.22^b
Carbohydrate%	75.91 ± 0.15^a	73.93 ± 0.07^b
Crude fiber%	2.71 ± 0.88^b	3.46 ± 0.02^b
V.E (kcal/100 g)	323.16 ± 0.38^a	315.36 ± 0.43^b
Zn (mg/100 g)	0.7 ± 0.01^c	0.97 ± 0.04^d
Fe (mg/100 g)	5.47 ± 0.08^b	6.77 ± 0.02^a
Ca (mg/100 g)	216.09 ± 1.13^b	259.80 ± 0.35^a
P (mg/100 g)	22.24 ± 0.12^c	47.82 ± 0.25^d
K (mg/100 g)	585.40 ± 0.25^b	782.04 ± 0.24^a
Fat%	0.20 ± 0.11^b	0.84 ± 0.25^a
Magnésium (mg/100 g)	57.70 ± 0.34^b	67.98 ± 0.45^a
Vitamin C (mg/100 g)	25.95 ± 0.05^b	32.37 ± 0.02^a
Sodium (mg/100 g)	67.42 ± 0.15^b	61.11 ± 0.26^b

According to the confectionery sector study of 1255 references, collected in 2017 and covering at least 78% of the confectionery market [27], the protein content of sweets made with sweet potato, baobab fruit and jujube exceeds the average (2.1%/100 g) recorded for the confectionery sector. Part (27%) of the daily nutritional recommendations for children aged 6 to 59 months could be met by consuming 100 g of sweet potato, jujube and baobab fruit-based sweets.

Fiber levels exceed the average amount of fiber in sweets, at 1.7 g/100 g [27]. Fiber is essential for a healthy digestive tract, and helps prevent colorectal cancer, type II diabetes and cardiovascular disease [28]. The fiber content of BBJP18 and BBJP20 covers 18% and 23% respectively of the daily fiber requirements of children aged 2 to 5. The fiber content of sweets is higher than that of wheat-based biscuits in the study by Yadav *et al.* (2016) [29], biscuits made with composite flours (wheat/rice) [30] and biscuits enriched with shea fruit pulp [31], but lower than that of rice biscuits enriched with baobab fruit in the study by Pauline *et al.* 2018 [8]. Mineral elements changed with increasing incorporation rates of sweet potato, baobab fruit and jujube. Similar results were obtained by Vitali *et al.* (2007) [32] who showed that fortified biscuits as additional sources of calcium, magnesium, copper and manganese significantly altered the amounts of total minerals in the final product.

Sweets have a potassium content representing 73% to 97% of the daily intake of children aged 1 to 4 [33]. The potassium content could be attributed to the sweet potato (288 mg/100 g) [33] and the baobab fruit (231 mg/100 g) [8]. For adults, jujube, baobab fruit and sweet potato sweets cover almost 25% of the daily intake, which could be in line with a potassium-rich diet recommended by the WHO [34] to reduce blood pressure and lower the risk of cardiovascular disease, stroke and coronary heart disease.

The results of the calcium content cover 61 to 74% of the daily calcium intake for children aged 1 to 3 years [35]. Sweets have a higher calcium content than the rice and baobab biscuits presented in the study by Pauline *et al.* and the biscuits enriched as additional sources of calcium in the work by Vitali *et al.* (2007) [32]. These calcium levels could be explained by the presence of baobab fruit and jujube, which are very rich in calcium. Calcium is necessary for numerous biological functions such as neuromuscular excitability, blood coagulation, membrane permeability, hormone release, enzyme activation and cell signaling [35]. Sweets contribute up to 35% of daily requirements for pregnant and breastfeeding women. According to the author Hofmey Gj *et al.* (2010) [36], the impact of calcium supplementation could reduce the incidence of premature births.

Iron content increased from 5.47 mg/100 g for BBJP18 to 6.45 mg/100 g with BBJP20. Consumption of 100 g of sweet potato, baobab and jujube-based sweets covers 93% of iron requirements in children aged 1 - 3 years (RDA/6.9 mg) [35]. Iron is an essential trace element that performs numerous functions in the body. The most well-established consequence of iron deficiency is anaemia, and the populations most at risk are those with high iron requirements due to their growth and physiological state (infants, children, pregnant women) [37].

The vitamin C contained in BBJP20, which is known to promote the absorption of non-haem iron from plant-based foods, is very high and covers 100% of the daily requirements of children aged 1 to 3 [35]. Vitamin C is a reducing agent involved in antioxidant defences as a scavenger of reactive oxygen and nitrogen species [28]. The high vitamin C content could be explained by the high levels of vitamin C found in jujube, baobab fruit and sweet potatoes [33]. In fact, the vitamin C content of jujube is higher than that of oranges and lemons [15]. According to studies by Chadare (2008) [38], 40 g of baobab fruit covers the daily needs of pregnant women (aged 19 - 30).

Zinc, an essential trace element involved in many cellular functions, contains 32% of the recommended dietary allowance for children aged 1 to 4 [39] [40]. Young children are at greater risk of zinc deficiency because of the increased need for zinc during growth. Zinc acts as a cofactor in more than 300 enzymes while modulating enzyme activity, and therefore plays a crucial role in many physiological and pathological processes [41] [42].

The magnesium content of BBJP18 and BBJP20 sweets covers 67% to 80% of the daily intake of a child aged between 1 and 3 years. Sweets are richer in magnesium than the baobab fruit and rice-based biscuits in the study by Pauline *et al.* [8] and the mixed-flour, green banana, pigeon pea and sweet potato-based biscuits by Adeola *et al.* [43]. Magnesium is one of the most abundant minerals in the body, regulating carbohydrate and lipid metabolism in muscle, heart and nerve tissue.

3.2. Sensory Analysis of Sweets

The results of the sensory analysis of the sweets are shown in **Figure 1**.

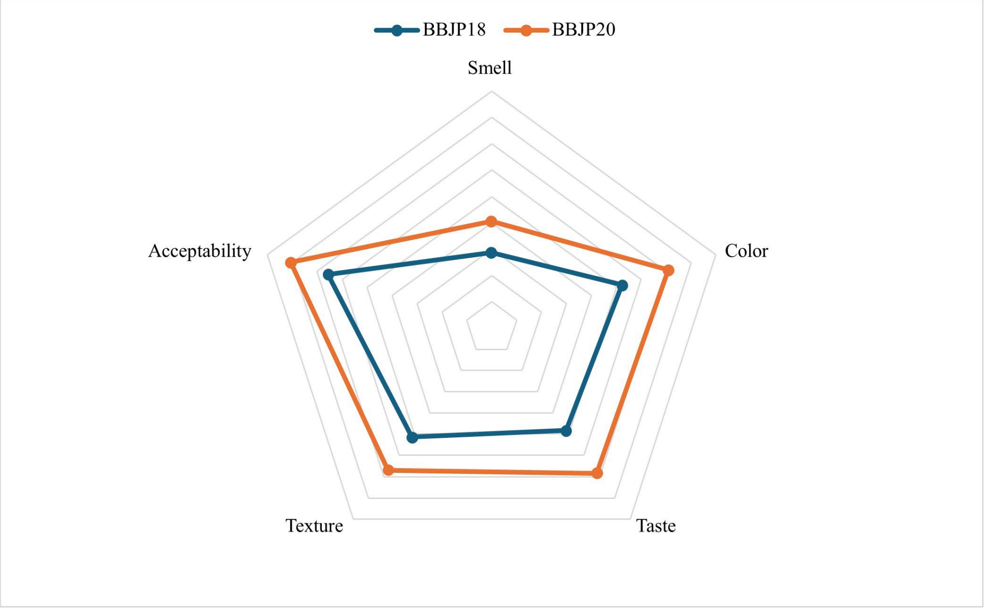

Figure 1. Sensory analysis of sweets.

Sensory analysis is an important criterion for assessing quality in the development of new products and for meeting consumer expectations. The results of the sensory analyses showed significant differences across all parameters (taste, color, smell, texture and acceptability). Overall, the blends were well rated, with an acceptability of 7.31 for BBJP18 and 7.61 for BBJP20, exceeding the threshold index of 5 and placing these new sweets in the good quality food category [44]. On the other hand, the BBJP20 sample was the most appreciated. The general acceptability indices for the two mixtures BBJP18 (81.26%) and BBJP20 (84.58%) were well above the minimum score of 70% for food to be acceptable [26] and marketable [45].

4. Conclusion

This study allowed us to know that the incorporation of these local products with high nutritional value such as jujube, baobab fruit powder and sweet potato puree in confectionery constitute a promising alternative to combat micronutrient deficiencies.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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