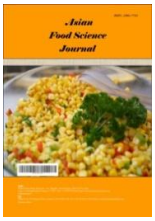

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Quality Characteristics of Soy Milk-Fluted Pumpkin Leaf Based Product

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to evaluate the effect of the addition of fluted pumpkin leaves extract on the physicochemical properties, microbiological quality and organoleptic attributes of the soy milk using standard methods. Five blend ratios and codes of 100:0 (Sample A), 95:5 (Sample B), 90:10 (Sample C), 85:15 (Sample D) and 80:20 (Sample E) were developed for soy milk and fluted pumpkin leaves extract respectively. Results from this study revealed that increase in fluted pumpkin leaves extract supplementation in the soy milk increased the moisture (80.06 to 82.68%), fiber (0.58 to 0.76%), ash (0.71 to 0.96%), pH (5.99 to 6.50), while decreasing the protein (3.57 to 2.80%), fat (2.78 to 2.30%), carbohydrate (12.30 to 10.38%), titratable acidity (0.17 to 0.13%), total solids (19.27 to 18.60%), total bacteria (3.30×10^5 to 1.45×10^5 cfu/mL) and fungi (2.40×10^4 to 6.0×10^2 cfu/mL) loads. The fluted pumpkin leaves extract also appeared to have a bactericidal effect on the product as bacterial load decreased with increase in the concentration of the extract. The sensory evaluation revealed that Sample C containing 90% soy milk and 10% fluted pumpkin

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leaves extract was the most preferred blend among the samples containing the leaves extract. The formulated product could be useful to individuals who have lactose intolerance or heart-related diseases since it is practically free from lactose and cholesterol. It is recommended that flavour masking agents should be used to improve the herbal flavour of the product, to enhance its general acceptability and encourage consumption.

Keywords: Soy milk; fluted pumpkin leaves extract; physicochemical properties; microbiological quality; organoleptic attributes.

1. INTRODUCTION

In recent years, different edible varieties of legumes have been identified that have high nutritional value, and therefore could help to address several diet-related problems globally [1]. Soybean contains 35-40% protein on a dry-weight basis [2]. Soy milk is a milk drink made from soybeans. It is a white emulsion which resembles cow milk (conventional milk) in both appearance and consistency [3]. Soy milk can be regarded as vegetable or imitation milk. It is an inexpensive source of protein and calories for human consumption which compares favourably with dairy milk and can be used as a vital and cheaper substitute for cow milk for solving problems in developing countries like Nigeria [4]. Soymilk has lower fat content than cow milk and contains no cholesterol [5]. The absence of lactose in soy milk also positions it as a solution to lactose intolerance for some consumers of dairy milk, especially infants with such biochemical challenge [3].

Fluted pumpkin (*Telfairia occidentalis*) leaves are one of the most popular leafy vegetables in Nigeria. It is widely cultivated because of its palatable and nutritious leaves which are used mainly as vegetables [6]. Because of its affordability, availability and the mineral elements it contains, it has become a popular vegetable consumed more than other vegetables in the population diet [7]. The leaves contain important mineral elements such as K, Ca, Mg, P, Fe and it is a good source of vitamin A, vitamin C, and vitamin E which is required for the production of blood, adequate supply of oxygen, building and maintenance of bones, cartilage and connecting tissues, and the maintenance of a healthier skin which in turn slows down ageing [6]. There is, therefore, increasing awareness of the value of this vegetable in contributing to a balanced diet.

Micronutrient deficiencies remain a major challenge in sub-Saharan countries such as Nigeria and are implicated as being responsible for mental retardation, preventable blindness, death during birth and a host of other diseases. A lack of micronutrients also has a profound impact on the body's immune system. Beyond the enormous health implications, micronutrients have a significant economic impact. The major problem associated with fluted pumpkin leaves is its high level of decay, yet it is one of the most sought after vegetables not only in Nigeria but also in Europe. There has also been a regular complaint among the consumers regarding the 'beany' flavour of soy milk [8]. The supplementation of fluted pumpkin leaves extract in the soy milk will not only enhance the therapeutic value and microbiological stability of the soy milk beverage, but it will also eliminate the beany flavour associated with it and minimize postharvest losses in fluted pumpkin leaves. Therefore, this study was aimed at evaluating the effect of the addition of fluted pumpkin leaves extract on the physicochemical properties, microbiological quality and organoleptic attributes of the soymilk.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Soybeans (*Glycine max*) was obtained from the Research laboratory at the Seed Technology Centre and the fluted pumpkin leaves were purchased at the University Mini market, all located at South core, University of Agriculture, Makurdi. The production and formulation of the product, as well as all the analyses carried out, were done at the laboratories in the Department of Food Science and Technology, University of Agriculture, Makurdi.

2.2 Sample Preparations

2.2.1 Procedure for milk extraction from soybeans

The milk extraction was done using an earlier method of Oyeniyi et al. [9] with some modification. Briefly, soybeans (500 g) were cleaned, sorted and weighed. The weighed

soybeans were soaked for 6 h. The rehydrated soybeans were dehulled by rubbing between palms and the hulls were drained away in excess water by the process of water floatation. The dehulled soybeans were blanched at 80°C for 4 min and wet-milled with enough water added to give the desired consistency to the final product (soy milk). The slurry was strained and the recovered milk was boiled for about 20 min at 82°C while stirring continuously with a wooden stirrer to prevent it from burning. The milk was homogenized using a blender and cooled to 45°C.

2.2.2 Procedure for fluted pumpkin leaves extraction

The extraction of the fluted pumpkin leaves was carried out following a previous method described by Idris [10] with some modification. Fluted pumpkin leaves were destalked and washed with tap water then rinsed with distilled water to remove debris, insects and other contaminants. The cleaned leaves were weighed and chopped after which they were blended. Blended pumpkin leaves were filtered to obtain the extract.

2.2.3 Blend formulation of soymilk-fluted pumpkin leaves extract

The fluted pumpkin leaves extract was added to the soy milk at 5%, 10%, 15% and 20% levels respectively as shown in Table 1. The blends were agitated to achieve homogenization. The product was then bottled and pasteurized at 75°C for 5 min.

2.3 Determination of Physicochemical Properties

The moisture, crude protein, fats, fibre and ash contents of the fortified soymilk samples were determined according to the standard methods of AOAC [11]. The total carbohydrate was determined by difference: % Carbohydrate = 100%– (% moisture + % protein + % fat + % crude fiber+ % ash). The Titratable acidity (TTA) and pH were determined by standard methods of AOAC [12], while the Total solids were determined by the method of Akusu et al. [13].

2.4 Microbiological Analysis

Total Viable and fungi counts were determined using the pour plate method as outlined by Adegoke [14].

2.5 Sensory Evaluation

The organoleptic characteristics of the supplemented soymilk samples were evaluated by a 15 member semi-trained panellists drawn from Department of Food Science and Technology, University of Agriculture, Makurdi. The panellists were provided with a questionnaire. The samples were evaluated for appearance, flavour, taste and general acceptability using a modified 5-point hedonic scale (where 5= like very much and 1= dislike very much) [15].

Table 1. Blend formulation of soymilk-fluted pumpkin leaves extract

Sample	Soy milk (%)	Fluted pumpkin leaves extract (%)
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20

A= 100% soy milk (Control); B= 95% soy milk: 5% fluted pumpkin leaves extract; C= 90% soy milk: 10% fluted pumpkin leaves extract; D= 85% soy milk: 15% fluted pumpkin leaves extract and E= 80% soy milk: 20% fluted pumpkin leaves extract

2.6 Statistical Analysis

The data obtained were subjected to Analysis of Variance (ANOVA) and Duncan Multiple Range Test was used to separate means where significant differences existed and data analyses were achieved using the Statistical Package for Social Statistics (SPSS) software version 20.0.

3. RESULTS AND DISCUSSION

3.1 Effect of Fluted Pumpkin Leaves Extract on the Physicochemical Properties of Soy Milk

The result presented in Table 2 showed the physicochemical properties of the soy milk-fluted pumpkin leaves extract product. The moisture, fibre, ash, carbohydrate and pH of the soy milk-fluted pumpkin leaves extract samples increased, while the crude protein, fat, TTA and TS decreased. The trend observed in this study could be attributed to the increasing addition of the fluted pumpkin leaves extract to the soy milk at supplementation levels of 5%, 10%, 15% and 20% respectively. Moisture plays a very important role in the keeping quality of foods and high moisture can harm their storage stability

[16]. There were significant variations in virtually all the samples analyzed for proximate composition, TTA, pH and Total solids. Crude fibre enhancement is beneficial to soy milk consumers since dietary fibre is believed to reduce the incidence of colonic cancer, diabetes, heart and certain digestive diseases [17]. Thus, the increase in fibre shows that the product is a good source of dietary fibre. Fibre is well known to aid digestion and add bulk to the diet. The ash content of a food product is an indication of its total mineral element content [18]. The increase in ash indicates that the product has been enriched with micronutrients which are required by the body in minute quantities for the facilitation of body processes. The carbohydrate content of the product increased with an increase in the number of fluted pumpkin leaves extract added. This could be attributed to the fact that fluted pumpkin leaves are slightly higher in carbohydrate compared to soy milk [10]. Carbohydrate is a fuel provider to the body [18]. The carbohydrate content of a food material indicates its glycemic index (i.e. its impact on blood glucose level upon digestion and absorption) [19]. The result obtained for protein content in the present study was in agreement with that of Sowonola et al. [20] for soymilk beverage. However, this is in contrast with Bolarinwa et al. [21] who reported lower values for soy-walnut milk drinks (1.70 - 2.87%). This difference could be ascribed to the processing method adopted. The fat content of the drink samples which ranged from 2.30-2.78% was significantly (P≤0.05) reduced by heat treatment of the soybean. Fat is an important energy-yielding nutrient just like carbohydrate which can be an integral part of the human diet. Legumes seeds are generally low in fats and oil [22]. Individuals who are intolerant to lactose or have heart-related diseases should be encouraged to consume this product as it is practically free from lactose and cholesterol.

Table 2 also revealed an inverse relationship that exists between titratable acidity (TTA) and pH. It was observed that the higher the pH, the lower will be the TTA and vice versa. This trend in the TTA-pH relationship has also been reported by quite a number of researchers [23-25]. pH value gives a measure of the acidity or alkalinity of the food samples. The total solids are used in characterizing the quality of the product. The total solids of the samples containing the fluted pumpkin extract were lower than the control sample (100% soy milk).

Table 2. Effect of fluted pumpkin leaves extract on the physicochemical properties of soy milk

Parameter	Sample				
	A	B	C	D	E
Moisture (%)	80.06^{e}±0.03	81.50^{d}±0.00	81.99^{c}±0.00	82.34^{b}±0.00	82.68^{a}±0.00
Crude protein (%)	3.57^{a}±0.04	3.43^{b}±0.00	3.39^{c} ±0.00	3.16^{d}±0.00	2.80^{e}±0.00
Crude fat (%)	2.78^{a}±0.03	2.63^{b}±0.00	2.54^{c}±0.00	2.50^{d}±0.00	2.30^{e}±0.00
Crude Fibre (%)	0.58^{e}±0.04	0.63^{d}±0.00	0.68^{c}±0.00	0.72^{b}±0.00	0.76^{a}±0.00
Ash (%)	0.71^{e}+0.02	0.82^{d}±0.00	0.86^{c}±0.00	0.90^{b}±0.00	0.96^{a}±0.00
CHO (%)	12.30^{a}±0.02	10.99^{b}±0.00	10.54^{c}±0.00	10.38^{e}±0.00	10.50^{d}±0.00
TTA (%)	0.17^{a} ±0.02	0.15^{a}±0.00	0.14^{a} ±0.01	0.13^{a} ±0.00	0.13^{a} ±0.00
pH	5.99^{e} ±0.01	6.10^{d}±0.00	6.30^{c} ±0.00	6.31^{b} ±0.00	6.50^{a} ±0.00
TS (%)	19.27^{a} ±0.09	19.01^{b}±0.00	18.70^{c} ±0.00	18.63^{d}±0.00	18.60^{e}±0.00

Values are mean ± standard deviation of duplicate determinations. Means with different superscripts within the same column are significantly different (P≤0.05)

Sample A = 100% soymilk, B =95% soymilk: 5% fluted pumpkin leaves extract, C=90% soymilk: 10% fluted pumpkin leaves extract, D=85% soymilk: 15% fluted pumpkin leaves extract, E=80% soymilk: 20% fluted pumpkin leaves extract, CHO= carbohydrate, TTA=titratable acidity and TS=total solids

Table 3. Effect of fluted pumpkin leaves extract on the microbiological quality of soy milk

Parameter	Sample				
	A	B	C	D	E
TVC (cfu/ mL)	3.30×10^{5}	3.10×10^{5}	2.65×10^{5}	2.10×10^{5}	1.45×10^{5}
FC (cfu/ mL)	2.40×10^{4}	7.55×10^{3}	7.25×10^{3}	4.09×10^{3}	6.0×10^{2}

Sample A = 100% soy milk, B =95% soy milk: 5% fluted pumpkin leaves extract, C=90% soy milk: 10% fluted pumpkin leaves extract, D=85% soy milk: 15% fluted pumpkin leaves extract, E=80% soy milk: 20% fluted pumpkin leaves extract, TVC= total viable count and FC=fungi count

Table 4. Effect of fluted pumpkin leaves extract on the organoleptic attributes of soy milk

Parameter	Sample				
	A	B	C	D	E
Appearance	4.33^{ab}	3.90^{b}	4.47^{a}	3.87^{bc}	3.40^{c}
Flavour	4.11^{a}	4.01^{a}	4.00^{a}	3.27^{b}	2.80^{b}
Taste	4.13^{a}	3.84^{b}	4.18^{a}	2.87^{b}	2.83^{b}
General acceptability	4.43^{a}	3.47^{b}	4.60^{a}	3.53^{b}	3.07^{b}

Values are mean ± standard deviation of duplicate determinations. Means with different superscripts within the same column are significantly different (P≤0.05)

Sample A = 100% soy milk, B = 95% soy milk: 5% fluted pumpkin leaves extract, C= 90% soy milk: 10% fluted pumpkin leaves extract, D= 85% Soy milk: 15% fluted pumpkin leaves extract and E= 80% soy milk: 20% fluted pumpkin leaves extract

3.2 Effect of Fluted Pumpkin Leaves Extract on the Microbiological Quality of Soy Milk

Microbial examinations are usually used as monitoring indices of food spoilage [26]. The result for microbiological evaluation of soy milk fluted pumpkin based product as shown in Table 3 indicated that sample A had the highest count for both bacteria and fungi. As the amount of the extract concentration increases in the product, the microbial load decreases. This result suggests that fluted pumpkin leaves extract may have a bactericidal effect on the milk; since it suppresses microbial growth and multiplication in the product. The study revealed that all the samples were microbiologically safe for human consumption since the microbial loads do not exceed the acceptable limits of $>10^5$ recommended by the International Commission of Microbiology Specifications of Foods, [27]. Therefore, with adequate monitoring and adherence to quality control measures during production, an acceptable standard is achievable in the production of soy milk [28].

3.3 Effect of Fluted Pumpkin Leaves Extract on the Organoleptic Attributes of Soy Milk

The mean sensory scores for the soy milk with inclusions of fluted pumpkin leaves extract are presented in Table 4. The result revealed that there was a preference for Sample C (90% soy milk: 10% fluted pumpkin leaves extract) among the blends containing the addition of fluted pumpkin leaves extract based on appearance (4.47), taste (4.18) and general acceptability (4.60). Only Sample C appeared to be comparable to Sample A (Control). There was a significant (P≤0.05) difference between all the samples in terms of appearance. With the addition of the fluted pumpkin leaves extract, the beany flavour usually associated with soybean was eliminated. However, the product developed a herbal flavour whose intensity increased with increasing supplementation levels of fluted pumpkin leaves extract. The sample A was statistically similar to samples B and C and they had superior flavour attribute, when compared to Samples D and E. Samples A and C were also statistically similar in terms of taste and showed superior taste attribute when compared with samples B, D and E. In terms of general acceptability, sample C (90% soy milk: 10% fluted pumpkin leaves extract) was comparable to the control sample A (100% soy milk) and was preferred over Samples B, D and E. This implies that panellists preferred a product with moderate quantity of fluted pumpkin leaves extract; when added in higher amounts, it gave the product an undesirable flavour and taste, while too little of it seemed to be inadequate. Flavour masking agents should be used to improve the herbal flavour of the product, to enhance its general acceptability and encourage consumption.

4. CONCLUSION

The study revealed that an organoleptically acceptable beverage drink could be produced from soy milk and fluted pumpkin leaves extract. Generally, increase in the fluted pumpkin leaves extract concentration at 5%, 10%, 15% and 20% in the soy milk increased the moisture, fibre, ash, carbohydrate and pH, while decreasing the protein, fat, titratable acidity, total solids, bacterial and fungi loads. The increase in the ash content showed that the micronutrient content of the product has been enhanced. The fluted pumpkin leaves extract also appeared to have a bactericidal effect on the product as bacteria load decreased with increase in the extract concentration. All the formulated samples were scored above average by the sensory panellists implying its potential acceptability when

commercialized. It is recommended that the blend of soy milk-fluted pumpkin in the ratio 90:10 should be adopted for commercialization. Further studies should be carried out to determine the product's storage stability and the quantities in which the micronutrients present occur.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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