Pumpkin powder (*Cucurbita maxima*)-supplemented string hoppers as a functional food

Anuruddika Malkanthi, Umadevi S. Hiremath

Department of Food Science and Nutrition, GKVK University of Agricultural Sciences, Bengaluru, Karnataka, India

Abstract

Background: Pumpkin has frequently been used as a functional food due to its nutritional and health benefits. In this study, a new application of dried pumpkin powder in string hoppers production is shown. **Aim:** The main aim of this work is to evaluate the addition of the dried pumpkin powder into rice flour on the physical, functional, nutritional, and sensory properties of string hoppers.

Materials and Methodology: String hoppers were prepared using white rice flour, which was substituted at 0%, 10%, 15%, and 20% with pumpkin pulp powder. Sensory evaluation was conducted to select best accepted combination. Nutrition analysis was carried out for the best accepted product.

Results: On sensory evaluation, 20% pumpkin pulp powder-incorporated string hoppers received the highest scores for appearance (8.06), color (7.93), aroma (8.02), taste (7.80), texture (7.93), and overall acceptability (8.13). This was selected as the best accepted pumpkin-incorporated string hoppers. The nutrient composition of 20% pumpkin pulp powder-incorporated string hoppers and control was moisture (47.79, 51.38%), ash (1.22, 0.059%), protein (6.12, 3.68%), and crude fiber (0.72, 0.29%), and significant increase of nutrients was observed in pumpkin pulp powder-incorporated string hoppers compared to control. Beta carotene content of the accepted string hoppers increased significantly (2.54 mg/100 g). Significant increase in potassium, calcium, magnesium, and phosphorus content was also observed (227.2 mg, 16.44 mg, 19.83 mg, and 18.83 mg/100 g, respectively). Nearly 20% addition of pumpkin pulp powder increased the antioxidant activity significantly (0.056 mmol/ascorbic acid equivalents/100 g).

Conclusion: Pumpkin pulp powder can be successfully supplemented into the traditional string hoppers and used as a functional food with its improved nutritional composition.

Keywords: Functional food, pumpkin, nutrient composition, sensory evaluation, string hoppers

Address for correspondence: Ms. Anuruddika Malkanthi, Department of Plant, Food and Environmental Science, Faculty of Agriculture, Nova Scotia, Canada.
E-mail: a.malkanthi@dal.ca

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INTRODUCTION

The term "functional food" was first introduced in Japan. The International Food Information Council describes functional foods as "dietary components with the health benefit beyond the basic nutrition."[1] Health Canada, on the other hand, describes food as the one capable to reduce the risk of chronic diseases.[2] Today, the focus is on the "optimal nutrition" to optimize daily diet quality in terms of its nutraceutical and functional value. Therefore, the demand of functional food has been increased due to health awareness.

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Pumpkin is one of the vegetables, which has long been used as a functional food. Pumpkin belongs to the *Cucurbitaceae* family, generally characterized by climbing herbaceous vine with tendrils, which is grown widely all over the world. Pumpkin flesh is rich in vitamins, proteins, minerals, and antioxidants (beta-carotene and tocopherols) and in addition to nutrient composition, it is composed of various biological active components such as polysaccharides, protein, peptide, sterols, and para-amino benzoic acids.[3] These biological active components have shown to possess a wide range of medicinal properties such as antidiabetic activity, antioxidant activity, anticarcinogenic effect, and antimicrobial effect.[4]

With these beneficial effects of pumpkin, it can be incorporated into different value-added products. Most parts of the pumpkin are edible, from fleshy parts to the seeds, and are consumed in many ways. Dried pumpkin pulp can be supplemented into many products such as soups, instant noodles, bakery products and flour mixes, jam, jelly, puree, and pickle.[5] Research indicates that pumpkin can be used as a primary vegetable to fulfill the children's carotenoid requirement.[6] Therefore, it is practical to develop pumpkin products rich in carotenoids.

String hoppers are a traditional dish in Kerala, Tamil Nadu, southern part of Karnataka, and Sri Lanka. It is rice flour made into dough, mixing with water and salt (either hot or cold water), pressed into noodle form, and then steamed. String hoppers are a cost-effective food product which is consumed by people as the main dish for both breakfast and dinner time. Hence, it can easily cater to the entire community without any social boundary. However, there are less exploitations on value addition to traditional foods such as string hoppers in Sri Lanka. Therefore, the purposes of this study are to develop dried pumpkin pulp powder-incorporated string hoppers and to analyze its physical and functional characteristics, nutrient composition, sensory characteristics, and antioxidant activity and to recommend it as a functional food.

MATERIALS AND METHODOLOGY

Procurement of pumpkin and preparation of pumpkin pulp powder

Pumpkin (*Cucurbita maxima*), which was in the ripen stage, was purchased from the local market in Bengaluru. The pumpkin was washed, was cut into large pieces, its seeds were removed, and its fluffy portion (fibrous part) was peeled off and grated into small shreds using a kitchen grater. The shredded pumpkin was dipped in 0.1% of citric acid solution for 15 min.[5] It was drained and air dried for 30 min followed by conventional drying in a tray dryer (model: SST0331717) at 60°C for 18 h. The dried pumpkin shreds were ground into fine powder using a kitchen grinder and sieved through a 180 micrometer size scientific seiver (no. 80, ASTM E-11, USA). The prepared pumpkin pulp powder was stored in an airtight container at 8°C in a refrigerated condition for further study. All analyses were carried out with three replicates, and all chemicals used in the experiment were of analytical grade.

Analysis of physiochemical and functional characteristics of pumpkin powder

Bulk density (BD) of pumpkin powder was measured by weighing 20 g of flour into a measuring cylinder and tapped 100 times. Volume of pumpkin pulp powder was recorded" and BD was measured by dividing the weight over volume.[7] pH was measured using a digital pH meter taking 10 g of the sample dissolved in 100 ml of water after thorough mixing and standing for 15 min.[8] Water absorption capacity (WAC), oil absorption capacity (OAC), and gelatinization temperature were measured based on the method described in literature.[9,10]

Nutrient analysis

Nutrient analysis was carried out for the pumpkin pulp powder and for the best accepted pumpkin pulp powder-incorporated string hoppers. Moisture, ash, protein, fat, crude fiber, and carbohydrate content were estimated according to the method described in the Association of Official Agricultural Chemists manual.[11]

Estimation of minerals

Minerals were estimated using mineral solutions made from respective samples. Calcium and magnesium were estimated by titrating mineral solutions against 0.01 N ethylenediaminetetraacetic acid in the presence of alkaline condition.[12] Phosphorus was measured taking aliquot of the digested material in the presence of vanadium (V^{5+}) and molybdenum (Mo^{6+}). Orthophosphate forms a yellow-colored "Phospho Vanado Molybdate" complex which was measured using a spectrophotometer (Manufacturer- Systronics Indai Ltd, Model- Visiscan- 167, country- India) at 430 nm.[13] Potassium was estimated using a flame photo meter (Model: Systronics-128),[11] and iron and zinc content of the sample was estimated by using atomic absorption spectrophotometer (model: PerkinElmer-700, Japan).

Estimation of vitamins

Estimation of Vitamin C

Estimation of Vitamin C was carried out by 2,6-dichlorophenol indophenol titration method.[14] 5 ml from the working solution (40 μg/ml) of ascorbic acid and 5 ml of 4% oxalic acid were titrated against the dye solution till pink color appeared, which persisted for 15 s in order to calculate the dye factor. Sample extraction was carried out by taking 10 g of the sample, which was homogenized with 20 ml of 4% oxalic acid and volumized up to 50 ml with 4% oxalic acid following the centrifugation. An aliquot of 10 ml of sample extract was titrated against standard dye to a pink end, which persisted for 15 s. Vitamin C content was calculated using dye factor and the titer value of the sample.

Estimation of beta-carotene

Extraction of beta-carotene from the sample was carried out by taking 10 g of samples into a mortar and pestle, 25 ml of acetone was added to the sample, and it was homogenized till it became colorless. Extraction was carried out for four times. The extracted beta-carotene was transferred to a separating funnel, and 150 ml of distilled water and 10 ml of hexane were added with a pinch of calcium carbonate. The solvent mixture was mixed thoroughly and allowed to stand for 10–15 min. Extraction was repeated till the acetone–water layer became colorless. Total extraction was pooled together and marked up to 25 ml using hexane, and the absorbance was measured at 450 nm. A standard beta-carotene curve was developed to calculate the beta-carotene content of the sample.[15]

Estimation of phytochemicals

Total phenolic compounds were estimated using Folin–Ciocalteu reagent method.[16] Gallic acid was used to develop the standard curve. Total phenolic content was calculated using the standard curve, and the results were expressed as Gallic acid equivalents (GAE). The antioxidant activity was determined by using 2,2'-difenil-1-picrilhidrazil radical method. Ascorbic acid was used to prepare the standard curve. Absorbance was measured at 517 nm, and the antioxidant activity was calculated using standard curve and expressed as ascorbic acid equivalents (AAE).

Formulation of pumpkin pulp powder string hoppers

Three variations of string hoppers were formulated incorporating different percentage of pumpkin pulp powder with the rice flour and other ingredients [Table 1]. Rice flour was sieved through a 180 micrometer size scientific siever (No. 80, ASTM E-11, USA) before blending with the pumpkin pulp powder.

Organoleptic evaluation of pumpkin pulp powder string hoppers

Organoleptic evaluation was performed by twenty semi-trained members from the Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru, on a 9-point hedonic scale (9 – like extremely, 8 – like very much, 7 – like moderately, 6 – like slightly, 5 – neither like nor dislike, 4 – dislike slightly, 3 – dislike moderately, 2 – dislike very much, and 1 – dislike extremely) for appearance, color, aroma, taste, texture, and overall acceptability.

Textural analysis of pumpkin pulp powder string hoppers

The hardness of string hoppers and dough was evaluated by using a rating scale (0 – no hardness, 1 – slightly hard, 2 – moderately hard, and 3 – very hard) with twenty semi-trained panel members from the Department of Food Science and Nutrition, University of Agricultural Sciences, GKVK, Bengaluru.

Statistical analysis

Statistical analysis was performed through the statistical software SPSS 16.0 version (SPSS Inc, Chicago, USA). Analysis of variance was carried out to test the significant difference, and means were compared using least significant difference. All parametric variables were expressed as mean ± standard deviation. $P < 0.05$ was considered as statistical significance.

RESULTS AND DISCUSSION

Physical and functional properties of pumpkin pulp powder

The density of the pumpkin pulp powder was 0.58 ± 0.23 g/ml, whereas the pH of the pulp powder was found to be 5.75 ± 0.05. BD can be prone to considerable variation with respect to the particle size, microstructure, and composition. In one study, it was observed that pH of the pulp ranged from 3.7 to 4.6, which was slightly lower than the studied sample.[17] Dried pulp powder was found to exhibit higher WAC (480.98%). OAC of pumpkin pulp powder was 119.68% ±1.43%, and gelatinization temperature was shown to be low (49°C ±1.00°C). WAC is an important physical characteristic, which correlates the function of hydrophilic molecules such as protein and carbohydrates. OAC is a measure of flavor retention in food products, and it also measures the oil absorbed by the food materials during cooking.[18] Higher water-holding capacity of pumpkin was reported (270%) in one study, which was far below the value obtained in this study.[19] The values obtained from this study were on par with a study which reported that the water-holding capacity of pulp powder was 491.75%.[20] Gelatinization is attributed to the functionality of starch. Gelatinization and pasting characteristics are used in a wide variety of food applications. The gelatinization temperature of pumpkin pulp was found to be at 49°C. Because the water-holding capacity of the pulp powder is high, it reflects the higher starch content in pumpkin pulp powder, which showed that the pulp powder gelatinized at a lower temperature.

Nutrient composition of pumpkin pulp powder

The nutrient composition of dehydrated pumpkin pulp powder is presented in Table 2. It was reported in a similar study that pumpkin flour had 9.9 g moisture, 2.3 g fat, 3.07 g protein, and high amount of fiber (11.46 g) and ash (15.98 g/100 g), which were higher than that of the present study.[21] Further, in another experiment, it was reported that pumpkin powder contained 7.10%, 3.10%, 1.80%, 5.70%, and 82.30% of protein, fat, moisture, ash, and carbohydrates, respectively.[22] Beta-carotene is a precursor for Vitamin A, and it was found to be 32.87 mg/100 g in dried pumpkin pulp powder. In contrast, 25.56 to 29.9 mg/100 g of beta-carotene was reported in a study, which was low compared to the current study.[19] Moreover, the analysis of beta-carotene content in different varieties of fresh *C. maxima* was reported, and it ranged from 1.4 to 7.4 mg/100 g.[23] Values obtained from these studies are in line with these reported results. A good agreement of those values with the values from the present study can be seen, which revealed that dehydrated pumpkin powder had 42.2 mg/100 g beta-carotene.[24] Vitamin C content of fresh pumpkin pulp was 54.6 mg/100 g. However, dried pumpkin

Table 1: Formulation of string hoppers with different variations of pumpkin pulp powder

Ingredient	Control	Treatment I	Treatment II	Treatment III
Rice flour (g)	100	90	85	80
Pumpkin pulp powder (g)	-	10	15	20
Boiling water (ml)	132	102	102	102
Salt (g)	1.5	1.5	1.5	1.5

Table 2: Nutrient composition of pumpkin pulp powder

Parameters	Pumpkin pulp powder
Moisture (g)	14.80±1.2
Ash (g)	5.56 ±0.18
Protein (g)	8.95±0.05
Crude fiber (g)	3.25±0.89
Fat (g)	0.86±0.03
Carbohydrate (g)	67.00
Energy (kcal)	313.00
Vitamin C (mg)	6.19±2.6
Beta-carotene (mg)	32.87±0.61
Potassium (mg)	2690.54±12.54
Calcium (mg)	21.30±1.90
Magnesium (mg)	154.46±9.51
Phosphorus (mg)	39.15±1.07
Zinc (mg)	2.28±0.18
Iron (mg)	8.33±2.29
Total polyphenol content (mg GAE/100 g)	192.84±5.15
Antioxidant activity (mmol AAE/100g)	0.53±0.005

GAE: Gallic acid equivalent, AAE: Ascorbic acid equivalent

Table 3: Organoleptic characteristics of pumpkin pulp powder-blended string hoppers

Products	Appearance	Color	Aroma	Taste	Texture	Overall acceptability
Control	7.86±1.06[a]	7.86±1.06[a]	7.96±0.89[a]	6.86±1.88[a]	7.60±1.05[a]	7.60±1.05[a]
10% PPSH	7.66±1.11[a]	7.60±1.29[a]	7.80±0.65[a]	7.26±1.16[a]	7.66±0.97[a]	7.73±1.03[a]
15% PPSH	8.06±0.70[a]	7.80±0.67[a]	7.88±0.68[a]	7.46±1.18[a]	7.73±0.96[a]	7.86±0.91[a]
20% PPSH	8.06±0.88[a]	7.93±0.88[a]	8.02±0.89[a]	7.80±1.08[a]	7.93±0.70[a]	8.13±0.74[a]

Same superscripts in the same column indicate no statistically significant difference ($P>0.05$). PPSH: Pumpkin pulp powder string hopper

pulp showed 6.19 mg/100 g of Vitamin C. A high amount of potassium content was observed in the pulp powder. This was in accordance with a study which reported that pumpkin pulp powder contained 3283 mg/100 g of potassium, while calcium, magnesium, iron, zinc, and phosphorus were found to be 269.61 mg, 154.82 mg, 3.74 mg, 1.24 mg, and 295.75 mg, respectively.[17] The antioxidant activity of pumpkin pulp was 0.53 mmol AAE/100 g, and the total phenolic content was found to be 192 mg GAE/100 g in dried pulp powder [Table 2]. The antioxidant activity and total phenolic content were analyzed in pumpkin products in a range of studies; in pumpkin puree, it was found to be 23.6 mg/100 g of phenol content and 0.102 mmol trolox/100 g antioxidant activity.[25] Another experiment revealed that the phenolic content of pumpkin pulp powder ranged from 159.69 to 35.94 mg GAE/L, whereas the antioxidant activity ranged from 0.284 to 0.135 mmol AAE/L.[26]

Organoleptic evaluation of pumpkin pulp powder-incorporated string hoppers

The mean sensory scores for the organoleptic characteristics of pumpkin pulp powder string hoppers are shown in Table 3. The mean sensory scores were not significantly different for all the sensory characteristics tested in different variations of pumpkin powder-incorporated string hoppers. 20% pulp powder-incorporated string hoppers had the highest scores for color (7.93), aroma (8.02), taste (7.80), texture (7.93), and overall acceptability (8.13) compared to other variations. It was observed that with the increase of pumpkin pulp powder, there was an increase in taste, texture, and overall acceptability. This may be due to the bright yellow color and desirable taste in 20% pumpkin pulp powder-incorporated string hoppers compared to control. Therefore, 20%-incorporated pumpkin pulp string hoppers were selected as the best accepted product by the panelists. Studies reported that pumpkin was superior in terms of organoleptic characteristics than other vegetables such as carrot, eggplant, and green pepper, when incorporated into noodles or pasta.[27] String hoppers supplemented with soy flour at 25% revealed significantly inferior sensory characteristics in comparison to control.[28] Therefore, pumpkin pulp powder might be the best source for the supplementation of string hoppers.

Nutrient composition of 20% pumpkin pulp powder-blended string hoppers

20% pumpkin pulp powder-incorporated string hoppers [Table 4] had significantly higher nutrient content compared to control. The nutrient composition of white rice string hoppers reported that 200 g of string hoppers contained 75 g of digestible carbohydrates, 3.76 g of total dietary fiber, and 7.34 g of protein.[29] The beta-carotene content can be changed based on the processing method, moisture content, and surface area of the product.[30] In the present study, string hoppers with 20% pumpkin pulp powder had 2.54 mg/100 g beta-carotene, which can be considered as a good source of Vitamin A. Furthermore, pumpkin pulp powder-incorporated string hoppers have significantly increased nutrient content and antioxidant activity compared to control.

Table 4: Nutrient composition of 20% pumpkin pulp powder-incorporated string hoppers

Parameters	String hoppers	
	Control	20% PPSH
Moisture (g)	51.38±0.21	47.79±0.32*
Ash (g)	0.059±0.00	1.22±0.01*
Protein (g)	3.68±0.14	6.12±0.000*
Fat (g)	0.55±0.025	0.45±0.025
Crude fiber (g)	0.29±0.04	0.72±0.21*
Carbohydrates (g)	44.33±0.23	44.42±0.56
Energy (kcal)	196.99±1.20	206.21±1.12*
Vitamin C (mg)	ND	3.78±0.24*
Beta-carotene (mg)	ND	2.54±0.03*
Potassium (mg)	25.78±0.35	227.20±3.58*
Calcium (mg)	8.68±0.98	16.44±0.92*
Magnesium (mg)	10.19±3.44	19.83±1.17*
Phosphorus (mg)	6.62±0.22	18.83±0.22*
Zinc (mg)	0.55±0.06	0.68±0.02
Iron (mg)	1.33±0.03	1.90±0.10

*Significant difference at $P<0.05$. PPSH: Pumpkin pulp powder string hoppers, ND: Not detected

Hardness of pumpkin string hoppers

No significant difference was found between the mean scores for control (0.01) and 20% pumpkin pulp powder string hoppers (0.40) in terms of hardness. In this study, water proportion was higher in rice flour (100%) compared to pumpkin powder and rice flour mixture. Therefore, hardness increased slightly in pumpkin pulp powder-incorporated string hoppers compared to control even though no significant hardness was observed.

CONCLUSION

This study demonstrated that, dehydrated pumpkin pulp powder is a rich source of protein, Vitamin C, bets-carotene, and phytochemicals such as polyphenols, and has antioxidant activity. Pumpkin string hoppers exhibited improved nutrient content and high consumer acceptability compared to control. Therefore, pumpkin powder can be supplemented successfully into food products to enhance the nutrient content, and it can be used to develop therapeutic and functional food products. As a recommendation, pumpkin pulp powder-incorporated string hoppers can be used as a functional food product to be promoted among people. Based on these findings, further investigation is warranted on pumpkin pulp powder supplementation in other Sri Lankan traditional food products such as *pittu, wandu*, and *hoppers*. With the current knowledge at the present time, there is no instant pumpkin pulp powder-incorporated string hopper mixture in the consumer market in Sri Lanka, so future work must be focused on the development of instant string hopper hopper mixture with the pumpkin pulp powder to commercialize among consumers in order to maximize the utilization of nutrient - rich pumpkin.

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Conflicts of interest

There are no conflicts of interest.

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