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REVIEW ARTICLE

Standardization and quality evaluation of value-added pasta from underutilized vegetable stuffs

Priyadarshini B[1], Devadarshini C[1*] & Sahoo S S[2]

[1]Department of Food and Nutrition, College of Community Science, Odisha University of Agriculture and Technology, Bhubaneswar 751 003, India
[2]Department of Food Science and Nutrition, ASPEE College of Nutrition and Community Science, Sardarkrushinagar Dantiwada Agricultural University, Dantiwada 385 506, India

*Email: chitrotpalad.fn@ouat.ac.in

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Abstract

Pasta is one of the most trending processed items preferred by all age groups nowadays. Due to its low nutrient profile, there is a need to enhance its nutritional value by adding the underutilized nutritious vegetable stuff which is rich in protein, fibre and micronutrients. The present study was undertaken to develop pasta by incorporating underutilized vegetable stuffs i.e. tender jackfruit powder (TJP), jackfruit seed powder (JSP) and pumpkin leaf powder (PLP) with refined wheat flour (RWF). TJ_1 (90% RWF+10% TJP), JS_2 (85% RWF+15% JSP) and PL_1 (90% RWF+10% PLF) pastas were having higher overall acceptability than all the formulated pasta and control (100% RWF) pasta. The sensory parameters were evaluated through a nine-point hedonic rating scale. The nutrient compositions were analysed using standard AOAC methods. The moisture, ash, protein, fat, fibre, carbohydrate, calcium and phosphorous content of TJ_1 were 14.49%, 1.35%, 10.46%, 1.41%, 1.75%, 70.54%, 19.90 mg% and 106.24 mg%, respectively. JS_2 contained moisture (10.73%), ash (1.34%), protein (11.24%), fat (1.42%), fibre (1.64%) and carbohydrate (73.63%), calcium (25.41mg) and phosphorus (116.08 mg). PL_1 had moisture (8.64%), ash (3.31%), protein (7.91%), fat (1.34%), fibre (1.29%), carbohydrate (77.52%), calcium (54.93 mg) and phosphorus (116.13 mg). There were significant changes in proximate composition and microbial load during the storage period of 2 months. The pasta can be value added in terms of protein, fat, fiber and total ash content by using tender jackfruit, jackfruit seed and pumpkin leaf powder up to 10% without affecting the sensory qualities.

Keywords

jackfruit; nutrient composition; pasta; pumpkin leaf; sensory parameters; shelf-life

Introduction

Pasta is an Italian food made from durum wheat flour through extrusion (1). Generally, pasta is rich in starch and carbohydrate and contains less amount of dietary fibre and other micronutrients viz. minerals and vitamins. A 100 g pasta provides 158 Kcal, 5.8 g protein, 0.93 g fat, 0.27 g ash, 30.9 g carbohydrate, 1.8 g fibre, 7 mg calcium, 58 mg phosphorus, 0.51 mg zinc and 0.5 mg iron (2). Nowadays, more than half of the consumer class is suffering from lifestyle-related disorders such as obesity, diabetes mellitus, cardiovascular diseases, etc. as well as micronutrient deficiency diseases thus, needing to include more amount of fibre in the daily diet. Hence, to increase the fibre and micronutrient levels, pasta needs to be supplemented with nutrient-rich under-utilized stuff such as tender jackfruit, jackfruit seed and pumpkin leaf powder to enhance its overall nutritional and functional value.

Though vegetables are a rich source of dietary fibre, vitamins, minerals and other protective phytochemicals, most of the people daily discard many nutritious edible portions of different vegetables due to their ignorance. Hence, the focus of nutrition researchers is shifting towards wise utilization of all vegetables stuff in various dishes in such a way so that people will get optimum nutrition in all ways without any wastage. Jackfruit seeds, raw jackfruit pulp and pumpkin leaves are some of the most common underutilized vegetables which people don't use for consumption in any manner. A 100 g raw jackfruit and mature jackfruit seed provide 85.52% and 72.32% moisture, 1.98 and 5.79 g protein, 0.99 and 1.02 g ash, 0.35 and 0.44 g fat, 7.69 and 8.63 g fibre, 3.48 and 11.81 g carbohydrate and 26 and 76.66 Kcal energy, respectively (3). Jackfruit contains many carotenoids, including all-trans-ß-carotene which is an important antioxidant for human health. Jackfruit seeds contain 14% protein, 80% carbohydrate, 2% ash and 1% fat; starch isolated from jackfruit seed flour contains 20% amylose and 80% amylopectin (4, 5). Consumption of jackfruit seeds is quite beneficial since they promote digestion, exhibit anti-carcinogenic properties and prevent skin wrinkles. Also, with the presence of vitamins A, B, C and pectin compounds, jackfruit seeds help maintain pancreatic health and purify the blood (4). The amount of sodium (60.66 mg/kg), calcium (3087 mg/kg), potassium (14781 mg/kg), iron (130.74 mg/kg), manganese (1.12 mg/kg) and copper (10.45 mg/kg) are present in the jackfruit seed (6). Pumpkin pulp contains 8.29-12.56% protein and 1.15-2.63% fat (7). Pumpkin contains enough amount of dietary fibre, alkaloids, flavonoids, palmitic, oleic and linoleic acid providing antidiabetic, antioxidant, anticarcinogenic, anti-inflammatory and other significant therapeutic benefits (8, 9).

Many attempts have been made to prepare various processed food products such as bread, pasta, instant snacks and noodles, etc. by using these underutilized vegetable stuffs (10, 11, 12, 13). Though many underutilized vegetable stuffs are prevailing, due to the adequate availability of jackfruit and pumpkin leaf in the locality, the present study has been undertaken to develop value-added pasta using raw jackfruit powder, jackfruit seed powder and pumpkin leaf powder with the following objectives.

- To develop and standardize the value-added pasta
- To assess the sensory parameters and nutrient composition of developed pasta
- To study the shelf-life of developed pasta

Materials and Methods

Collection of raw materials

Refined wheat flour (RWF) was purchased from the local market in Bhubaneswar, Odisha. Jackfruit and pumpkin leaves were collected from the college nutritional garden. The pumpkin leaves were cleaned to remove dust and soil.

Preparation of tender jackfruit powder, jackfruit seed powder and pumpkin leaf powder

***Preparation of tender jackfruit powder (TJP)*:** The tender jackfruits were selected for the study. The outer skin was removed. The edible portion of the jackfruit was finely chopped and washed in water. The chopped jackfruit was sundried for 4 to 5 days up to 2 hr. The dried jackfruit was ground into a fine powder and stored in an airtight container for further study.

Preparation of jackfruit seed powder (JSP): The fresh and fully ripened jackfruit was selected for the study. The jackfruit seeds were separated by the opening of jackfruit and washed with the running water. They were cut into thin slices and laid on a tray. Then the seeds were sundried for 4 to 5 days up to 2 hr. After drying, the outer skin was removed. Then the dried samples were ground into a fine powder and stored in airtight container.

Preparation of pumpkin leaf powder (PLP): The pumpkin leaves were collected for the study. The stem and other foreign materials were extracted from the selected pumpkin leaves and washed with running water to remove dirt. Then, the pumpkin leaves were sun-dried for 2 to 3 days for up to 2 hr. The sun-dried sample was ground into a fine powder and stored in an airtight container for further experimentation.

Preparation of pasta: By blending tender jackfruit powder (TJP), jackfruit seed powder (JSP) and pumpkin leaf powder (PLP) in refined wheat flour twelve types of composite flour were formulated for the preparation of pasta in different proportions as shown in Table 1. To enhance the flavour, 5 g black pepper and 10 g salt were added to the standardized flour. The standardized flours were then introduced to the extruder's feed tank and thoroughly mixed until a consistent powder was produced by rotating action. To prevent lumps 30 mL of water was added to every 100 g of dry ingredients. After 30 min, the dough was run through a single screw extruder with an adjustable die. A knife was used to cut the spaghetti into consistent lengths as it passed over the outer die surface. In a tray, pasta was dried for 4 hr at 60°C.

Nutrient analysis of developed pasta: The nutritional composition of all the raw materials and pasta was analysed using the standard procedures for all treatments with three replications (14).

Table 1. Different treatments of pasta

Treatments	Flour (%)	Refined wheat flour (%)
Control (Co)	0	100
Tender jackfruit powder		
TJ_1(Type-1)	10	90
TJ_2(Type-2)	15	85
TJ_3(Type-3)	20	80
TJ_4(Type-4)	25	75
Jackfruit seed powder		
JS_1(Type-5)	10	90
JS_2(Type-6)	15	85
JS_3(Type-7)	20	80
JS_4(Type-8)	25	75
Pumpkin leaf powder		
PL_1(Type-9)	10	90
PL_2(Type-10)	15	85
PL_3(Type-11)	20	80
PL_4(Type-12)	25	75

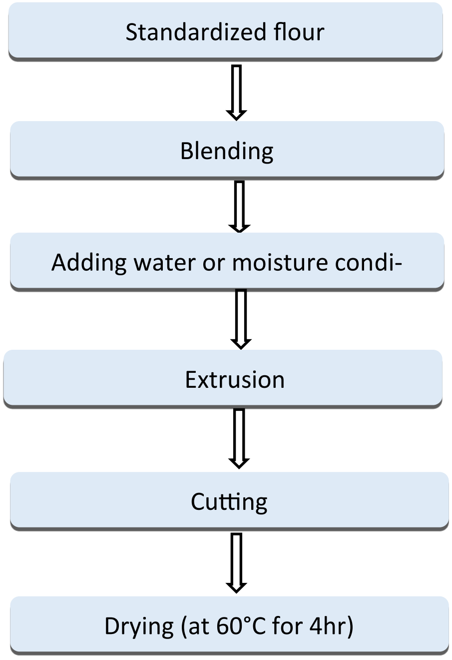

Fig. 1. Flow chart for preparation of pasta

Moisture: Moisture content was assessed by implicating the standard analysis method (14). 5 g of sample was taken in a pre-weighed petri dish and placed in an oven for drying at 105°C for 6 hr. The dried sample allowed to cool in a desiccator and reweighted. The loss in weight of the sample was taken as the moisture percentage and calculated from the following equation

$$\text{Moisture(\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where, W_1= weight of the sample (g), weight of the petri dish with sample, W_3=weight of the petri dish with the sample after drying

Ash: Ash content in the sample was assessed by implicating the standard analysis method (14). 5 g of sample was weighed and taken in a pre-weighed porcelain dish. The porcelain dish was charred and then converted into ash in a muffle furnace at 500°C for 6 hr until the ash was greyish or white. Then porcelain dish was cooled in a desiccator and reweighed. The residue is the ash content represented by the loss in weight and calculated from the following equation

$$\text{Ash (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where, W_1= weight of sample (g), W_2= weight of porcelain dish with the sample, W_3= weight of porcelain dish with ash

Crude fat: The standard procedure was followed for the estimation of crude fat using the Automatic SOCS plus Solvent Extraction System (14). In a pre-weighed extraction thimble, 1 g of moisture-free sample was taken and dried overnight. The washed beaker was dried in a hot air oven at 60°C for 20 min and weighed after cooling. The sample was kept in the beaker along with the thimble holder. Petroleum ether 90 mL was taken as a solvent with a boiling range of 40-60°C. The extraction was carried out for 1hr at 90°C then the temperature was raised at 110°C and the stopper was closed to collect solvent. After completion of the solvent collection the solvent compartment beaker was removed along with extracted fat and kept in a hot air oven at 60°C temperature for a few minutes. The fat

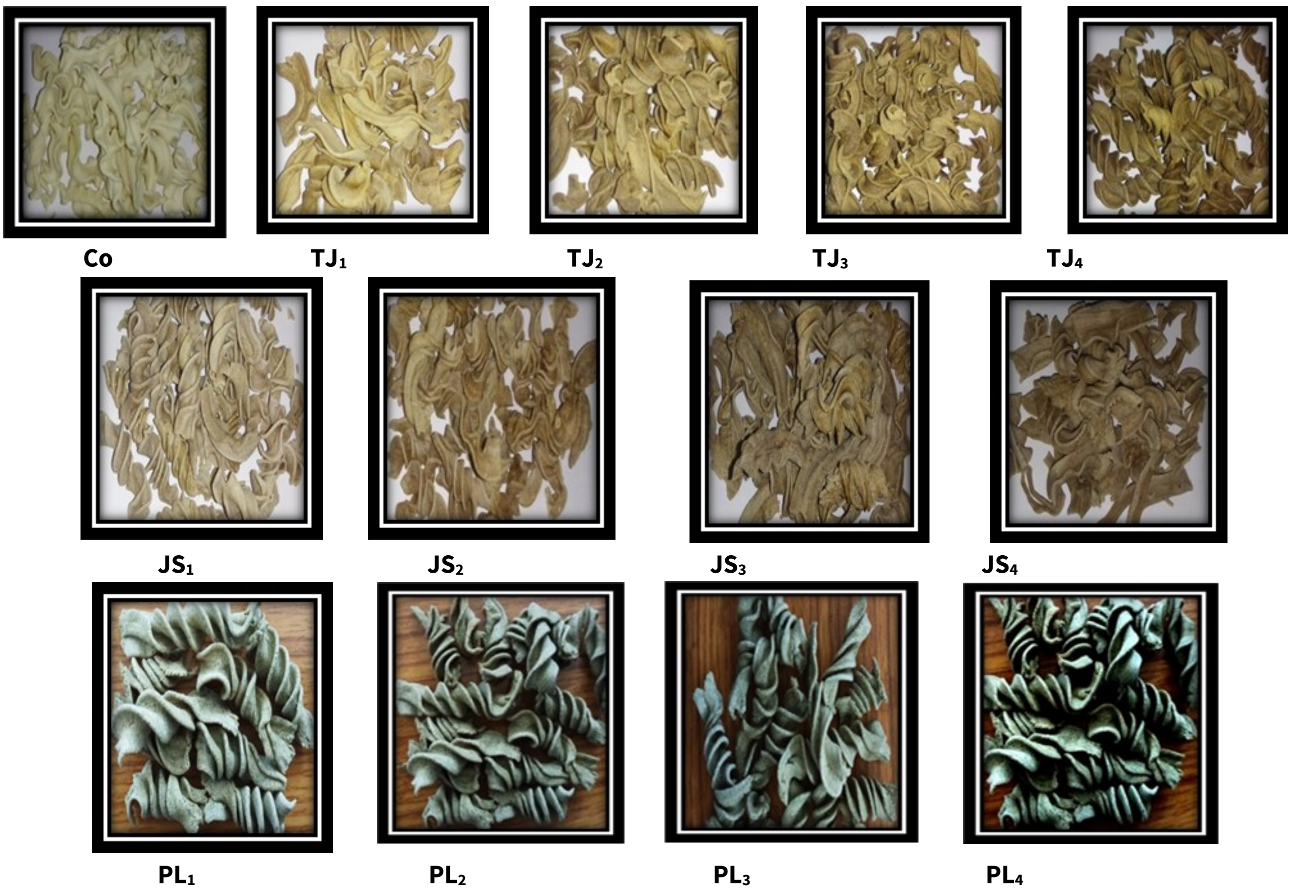

Fig. 2. Different treatments of pasta

collected beaker was cooled in a desiccator and weight was taken. Fat percentage was calculated from the following equation.

$$\text{Fat (\%)} = \frac{W_3 - W_2}{W_1} \times 100$$

Where, W_1=weight of sample (g), W_2= weight of empty beaker, W_3= weight of beaker with fat

Crude fibre: Crude fiber content was determined by the method of AOAC (14). 1 g of moisture-free and the defatted sample was weighed and kept in a pre-weighed crucible. The crucible was placed in the crude fibre apparatus. Then sulphuric acid (1.25%) up to 150 mL notch was added and boiled for 30 min exactly from the onset of boiling. After boiling connect to a vacuum for draining sulphuric acid. After completion of draining 150 mL of sodium hydroxide solution (1.25%) was added and allowed 30 min for boiling. The crucible was removed after cooled and reweighed with the insoluble matter then placed in an oven for drying at 105°C for 1hr up to constant weight. Reweighed the crucible with ash after cooled in a desiccator. The crude fibre percentage was calculated as follows

$$\text{Crude Fibre(\%)} = \frac{W_1 - W_2}{W} \times 100$$

Where, W=weight of the sample (g), W_1= weight of crucible with the insoluble matter, W_2= weight of crucible with ash

***Crude protein**:* To estimate the crude protein content in the sample, Kjeldahl method was used. This included digestion followed by distillation and followed by titration by using the KELPLUS Automatic Nitrogen Estimation System. By the standard Kjeldahl method nitrogen content of the sample was estimated Temperature was set at 420°C in the controller. The sample was taken (0.25-0.3 g) and digested on the KEL PLUS apparatus after adding 5 mL of commercial grade sulphuric acids and 1.5 g of digestion mixture until it became clear. After the tube was cooled, water was poured slowly along the neck of the tube so that the contents present on the neck of the tube would mix with the digested content present on the bottom of the tube. Then the sample was followed for the distillation process. The digested sample was first loaded in the space provided in the apparatus and one empty conical flask was placed on the receiver side, then prog of the equipment was allowed to run for the distillation process. 20 mL of boric acid was automatically dropped into the conical flask and then 40 mL of 40% NaOH in automatically filled slowly in order of 10 mL each time in the tube. After completion of adding 40% NaOH into the tube, the colour changed from blush green to brown precipitate. Then process was set and the colour in the conical flask changed from pink to green which indicate the end point of the distillation process. The solution present in the conical flask was titrated with 0.025N sulphuric acid till the colour changed from green to permanent pale pink colour. Value of the blank was subtracted from sample readings. The crude protein content of the sample was estimated by the following formula.

$$\text{Crude protein (\%)} = \frac{14.01 \times [\text{titrant (ml)} - \text{blank (ml)}] \times N \times 6.25}{W \times 1000} \times 100$$

Where 6.25 is the factor for converting nitrogen into the crude protein of the sample

N= Normality (0.1)

W= Weight of the sample taken for digestion

***Carbohydrate**:* The carbohydrate content of the sample was determined by the difference in the value obtained when all the proximate composition values were subtracted from 100%, i.e., by subtracting the sum of the values (per 100 g) for moisture, total ash, crude fat, crude fibre and crude protein from 100 as follows

Carbohydrate (%) = 100- (moisture% + ash % + crude fat % + crude fibre % + crude protein %)

***Mineral estimation**:* 0.5 g of sample was taken in a 100 mL conical flask. 10 mL of concentrated HNO_3 was added to each flask and kept undisturbed overnight. Samples in the flask were heated on a hot plate till a brown flame evolved. To each flask 5 mL of the di-acid mixture (HNO_3: $HClO_4$ (70%) :: 3:2 by volume) was added and the heating process was continued till the white fume evolved reducing the volume of content to about 2 mL. Then conical flasks were removed from the hot plate and allowed to cool. Thereafter, 15 mL of warm distilled water was added to each flask. To a 50 mL volumetric flask content of the conical flask were transferred followed by twice rinsing with distilled water and the volume was made up to 50 mL. The aliquot was filtered through Whatman No.42 filter paper and the extract was kept for estimation of minerals. Perkin Elmer Avio™ 200 dual view instruments equipped with Syngistix™ software for inductively coupled plasma optical emission spectrometry (ICP-OES) were used to measure the calcium and phosphorous concentrations of the resultant sample solutions.

Sensory evaluation of developed pasta: Before testing, the designed pasta products were cooked to prepare them for sensory evaluation. Using a nine-point hedonic scale and twenty semi-trained panel members, the cooking was done for the ideal amount of time and delivered hot to the panel members who evaluated it for its sensory attributes such as appearance, colour, flavour, texture, taste and overall acceptability. Between each sample, the panelists were given a glass of water and instructed to drink it and clean their mouths.

Shelf-life study of developed pasta: The control and the most highly accepted pasta were packed in zip-locked LDPE pouches and stored for 2 months at room temperature. Both treatments were evaluated for their sensory parameters using the nine-point hedonic scale in 30 days intervals. The effect of storage on proximate contents of the control and highly accepted treatments was conducted by following standard AOAC methods (14). Microbial analysis of the developed pasta was conducted through TPC (Total Plate Count).

Results

Nutritional composition of raw materials and the developed products

The nutrient content of raw ingredients used to develop the pasta is depicted in Table 2. The moisture content of RWF was found to be maximum i.e. 12.69% and the same for JSP was minimum i.e. 4.48%. The ash content of PLP was maximum i.e. 20.52% followed by TJP and JSP. The RWF contained minimum ash content. The protein content RWF was highest i.e. 10.9% followed by JSP, PLP and TJP. JSP contained the highest fat content i.e. 2.82% and the RWF contained the lowest fat content i.e. 1.06%. The fibre content was observed to be highest in PLP i.e. 8.4% followed by TJP, JSP and RWF. RWF contained the lowest amount of fibre i.e. 0.77%. The carbohydrate content of JSP was highest (73.13%) and that of PLP was lowest (52.44%). PLP contained the highest amount of calcium (389.97%) followed by JSP (48.03%), TJP (29.03%) and RWF (22.47%). The phosphorus content of RWF and PLP were similar and TJP contained the lowest amount of phosphorus.

The control pasta which was prepared from RWF only contained 13.95% moisture, 0.71% ash, 9.84% protein, 0.82% fat, 1.06% fibre and 73.62% carbohydrate. The moisture, ash, protein, fat and fibre contents were found to be significantly ($p<0.05$) increased, whereas carbohydrate percentage decreased significantly ($p<0.01$) in TJ_1, TJ_2, TJ_3, TJ_4 composite flour developed pasta products (Table 3). The pasta prepared by incorporating tender jackfruit powder (TJP) with refined wheat flour was subjected to proximate and mineral analysis and result obtained were presented in the table 3. The results reported that with increasing amount of TJP up to 20% there was increase in amount of moisture (14.49-15.32%), ash (1.35-2.72%), fat (1.41-2.93%), protein (10.46-11.19%) and fibre (1.75-4.63%) whereas carbohydrate content was decreased (70.54-63.22%). The protein, fat, moisture, fibre and ash content increased with an increase in TJP levels. It was observed that calcium and phosphorus content increased i.e. 19.90-23.46 mg and 106.24-112.40 mg per 100 g sample, respectively with increasing levels of TJP incorporation.

The pasta developed from RWF contained 13.95% moisture, 0.71% ash, 9.84% protein, 0.82% fat, 1.06% fibre and 73.62% carbohydrates. The moisture, ash, protein, fat and fibre contents increased and the carbohydrate content decreased significantly ($p<0.05$) in all four types of jackfruit seed powder composite flour pasta products (Table 4). Moisture, ash, crude protein, crude fat, crude fibre and carbohydrate ranged from 10.27 to 11.31%, 1.27 to 1.44%, 10.98 to 11.36%, 1.12 to 1.53%, 1.34 to 1.77% and 75.03 to 72.58% respectively. The mineral contents of calcium (24.87-28.18 mg) and phosphorus (115.39-118.43 mg) per 100 g of JSP pasta products increased with the level of JSP substitutions up to 20%.

It was observed that the control treatment of pasta contained 13.95% moisture, 0.71% ash, 9.84% protein, 0.82% fat, 1.06% fibre and 73.62% carbohydrates. All the nutrient contents except carbohydrates were found to be significantly ($p<0.05$) increased in all four types of pumpkin leaf powder composite flour pasta (Table 5). Moisture, ash, protein, fat, fibre and carbohydrate ranged from 8.6-13.78%, 3.31-5.87%, 7.91-9.11%, 1.34-1.85%, 1.29-2.15% and 67.24-77.52%, respectively. Control pasta contained calcium 24.17 mg/100g and phosphorus 121.57 mg/100g which was significantly ($p<0.05$) increased with increased levels of incorporation of PLP and varied from 54.93 to 59.07 mg/100g and 116.13 to 121.27 mg/100g, respectively.

Sensory parameter scores of developed pastas

The scores for the appearance of TJ_1, TJ_2, TJ_3 and TJ_4 pastas were 7.7, 7.2, 5.4 and 4.5, respectively (Fig. 3). Mean value of scores for the appearance of TJ_1, TJ_2, TJ_3 and TJ_4 pastas

Table 2. Nutritional composition of raw materials (per 100 g on dry matter basis)

Raw materials	Moisture (%)	Ash (g)	Protein (g)	Fat (g)	Fibre (g)	Carbohydrate (g)	Calcium (mg)	Phosphorus (mg)
RWF	$12.69^a±0.01$	$3.53^d±0.01$	$10.9^a±0.04$	$1.06^c±0.01$	$0.77^d±0.02$	$71.03^b±0.04$	$22.47^d±0.34$	$120.46^b±0.35$
TJP	$8.16^c±0.01$	$10.43^b±0.01$	$3.25^d±0.03$	$1.21^c±0.05$	$7.65^b±0.07$	$69.30^c±0.12$	$29.03^c±0.76$	$39.63^d±0.43$
JSP	$4.48^d±0.02$	$5.55^c±0.01$	$8.87^b±0.10$	$2.82^a±0.02$	$5.14^c±0.02$	$73.13^a±0.10$	$48.93^b±0.49$	$97.13^c±0.50$
PLP	$8.20^b±0.00$	$20.52^a±0.01$	$8.65^c±0.32$	$1.80^b±0.09$	$8.40^a±0.19$	$52.44^d±0.59$	$389.97^a±1.27$	$120.67^a±0.41$
CD@5%	0.03	0.04	0.17	0.33	0.56	0.99	2.6	1.4
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Values are mean ± SE three independent replications. Mean with the same superscript (a, b, c, d, e) in the same column differ significantly($p<0.05$)

Table 3. Nutritional composition of tender jackfruit powder incorporated pasta (per 100 g on dry basis)

Treatment	Moisture (%)	Ash (g)	Protein (g)	Fat (g)	Fibre (g)	Carbohydrate (g)	Calcium (mg)	Phosphorus (mg)
Co	$13.95^e±0.04$	$0.71^d±0.001$	$9.84^d±0.004$	$0.82^e±0.02$	$1.06^e±0.03$	$73.6^a±0.013$	$24.17^a±0.18$	$121.57^a±0.43$
TJ_1	$14.49^d±0.06$	$1.35^c±0.12$	$10.46^c±0.05$	$1.41^d±0.01$	$1.75^d±0.03$	$70.54^b±0.019$	$19.90^e±0.15$	$106.24^e±0.18$
TJ_2	$14.65^c±0.07$	$1.75^b±0.02$	$10.82^b±0.03$	$2.24^c±0.01$	$3.61^c±0.01$	$66.93^c±0.05$	$21.30^d±0.21$	$108.23^d±0.58$
TJ_3	$15.15^b±0.03$	$1.87^b±0.02$	$11.09^a±0.07$	$2.88^b±0.00$	$4.11^b±0.04$	$64.89^d±0.15$	$22.17^c±0.18$	$108.70^c±0.38$
TJ_4	$15.32^a±0.03$	$2.72^a±0.09$	$11.19^a±0.05$	$2.93^a±0.02$	$4.63^a±0.01$	$63.22^e±0.15$	$23.46^b±0.29$	$112.40^b±0.28$
CD@5%	0.15	0.21	0.04	0.08	0.15	0.42	0.65	0.08
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Values are mean ± SE three independent replications. Mean with the same superscript (a, b, c, d, e) in the same column differ significantly ($p<0.05$)

Table 4. Nutritional composition of jackfruit seed powder incorporated pasta (per 100 g on dry matter basis)

Treatments	Moisture (%)	Ash (g)	Protein (g)	Fat (g)	Fibre (g)	Carbohydrate (g)	Calcium (mg)	Phosphorus (mg)
Control	13.95^{a}±0.04	0.71^{d}±0.00	9.84^{c}±0.04	0.82^{d}±0.02	1.06^{d}±0.03	73.62^{b}±0.13	24.17^{d}±0.18	121.57^{a}±0.43
JS_1	10.27^{e}±0.03	1.27^{c}±0.03	10.98^{b}±0.06	1.12^{c}±0.05	1.34^{c}±0.06	75.03^{a}±0.09	24.87^{d}±0.44	115.39^{e}±0.45
JS_2	10.73^{d}±0.12	1.34^{b}±0.02	11.24^{a}±0.04	1.42^{b}±0.01	1.64^{b}±0.06	73.63^{b}±0.06	25.41^{c}±0.27	116.08^{d}±0.23
JS_3	10.82^{c}±0.06	1.43^{a}±0.02	11.31^{a}±0.02	1.51^{a}±0.01	1.69^{b}±0.01	73.24^{c}±0.07	26.33^{b}±0.34	117.24^{c}±0.39
JS_4	11.31^{b}±0.13	1.44^{a}±0.01	11.36^{a}±0.04	1.53^{a}±0.01	1.77^{a}±0.02	72.58^{d}±0.19	28.18^{a}±0.22	118.43^{b}±0.23
CD @5%	0.27	0.07	0.08	0.14	0.13	0.38	0.96	1.14
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Values are mean ± SE three independent replications. Mean with the same superscript (a, b, c, d, e) in the same column differ significantly (p<0.05)

were 8.0, 8.2, 6.3 and 4.5 respectively. The mean values of sensory characteristics flavour of TJ_1, TJ_2, TJ_3 and TJ_4 pastas were 8.1, 7.2, 3.3 and 2.9, respectively. The scores for texture of TJ_1, TJ_2, TJ_3 and TJ_4 pastas were 8.1, 6.9, 4.6 and 2.9, respectively. The mean value of scores for the taste of TJ_1, TJ_2, TJ_3 and TJ_4 pastas were 8.4, 7.1, 5.0 and 3.9, respectively. The mean score for the overall acceptability of TJ_1, TJ_2, TJ_3 and TJ_4 pastas were 8.0, 7.1, 4.6 and 3.6, respectively. TJ_1 and TJ_4 pasta scored maximum and minimum overall acceptability scores, respectively.

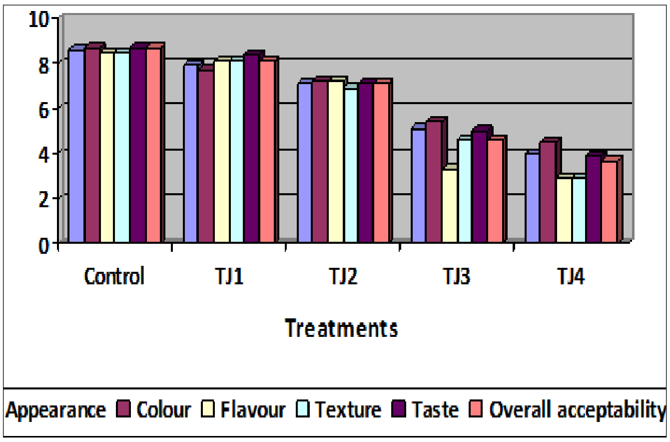

Fig. 3. Sensory scores of tender jackfruit powder pasta

The mean scores for colour of JS_1, JS_2, JS_3 and JS_4 pastas were 8, 8.1, 6.5 and 4.1, respectively. JS_2 scored a maximum score i.e. 8.1 and JS_4 scored a minimum score i.e. 4.1 for colour (Fig. 4). Mean value of scores for flavour of JS_1, JS_2, JS_3 and JS_4 were 7.7, 8.3, 6.6 and 3.4, respectively. JS_2 and JT_4 scored maximum and minimum scores for flavour, respectively. The scores for texture of JS_1, JS_2, JS_3 and JS_4 were 7.9, 8.1, 6.7 and 4.3, respectively. The mean value of scores for the taste of JS_1, JS_2, JS_3 and JS_4 were 8.1, 8.3, 5.9 and 3.6, respectively. JS_2 and JT_4 scored maximum and minimum taste scores, respectively. The mean score for the overall acceptability of JS_1, JS_2, JS_3 and JS_4 were 7.9, 8.1, 4.6, 4.0 and 3.9, respectively. JS_2 and JS_4 scored maximum and minimum overall acceptability scores.

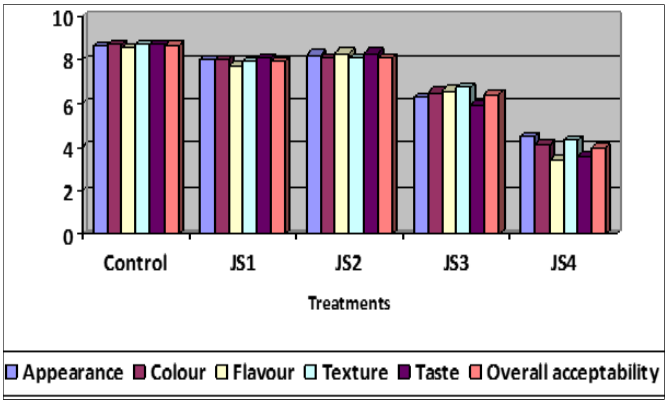

Fig. 4. Sensory scores of jackfruit seed powder pasta

The mean scores for colour of PL_1, PL_2, PL_3 and PL_4 pastas were 6.7, 3.8, 2.8 and 1.9, respectively (Fig. 5). PL_1 and PL_4 scored maximum and minimum appearance scores, respectively. The mean value of flavour of PL_1, PL_2, PL_3 and PL_4 were 7.0, 4.9, 3.3 and 2.2, respectively. PL_1 scored maximum and PL_4 scored minimum flavour scores. The mean score for the texture of PL_1, PL_2, PL_3 and PL_4 were 7.5, 3.7, 2.0 and 1.8, respectively. PL_1 and PL_4 scored maximum and minimum texture scores, respectively. The mean value of taste of PL_1, PL_2, PL_3 and PL_4 were 7.6, 4.0, 2.4 and 1.9, respectively. The mean score for the overall acceptability of PL_1, PL_2, PL_3 and PL_4 were 7.1, 4.1, 2.5 and 2.0, respectively. PL_1 and PL_4 scored maximum and minimum overall acceptability scores.

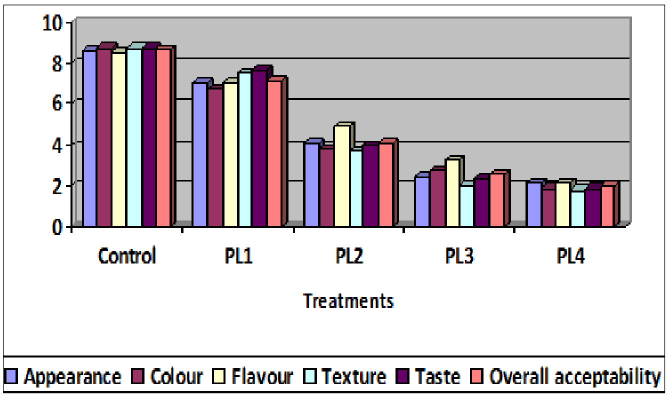

Fig. 5. Sensory scores of pumpkin leaf powder pasta

Table 5. Nutritional composition of pumpkin leaf powder incorporated pasta (per 100 g on dry matter basis)

Treatments	Moisture (%)	Ash (g)	Protein (g)	Fat (g)	Fibre (g)	Carbohydrate (g)	Calcium (mg)	Phosphorus (mg)
Control	13.95^{a}±0.04	0.71^{e}±0.00	9.84^{a}±0.04	0.82^{c}±0.02	1.06^{c}±0.03	73.62^{c}±0.13	24.17^{e}±0.18	121.57^{a}±0.43
PL_1	8.64^{e}±0.16	3.31^{d}±0.08	7.91^{e}±0.08	1.34^{b}±0.02	1.29^{c}±0.07	77.52^{a}±0.12	54.93^{d}±0.41	116.13^{e}±0.38
PL_2	9.22^{d}±0.12	3.84^{c}±0.03	8.22^{d}±0.06	1.73^{a}±0.01	1.48^{c}±0.05	75.52^{b}±0.04	56.43^{c}±0.15	117.47^{d}±0.38
PL_3	12.40^{c}±0.16	4.64^{b}±0.10	8.83^{c}±0.08	1.77^{a}±0.00	1.78^{b}±0.00	70.57^{d}±0.14	58.13^{b}±0.39	119.57^{c}±0.52
PL_4	13.78^{b}±0.06	5.87^{a}±0.06	9.11^{b}±0.11	1.85^{a}±0.03	2.15^{a}±0.04	67.24^{e}±0.12	59.07^{a}±0.40	121.27^{b}±0.20
CD@5%	0.37	0.2	0.06	0.14	0.24	0.36	1.03	1.25
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Values are mean ± SE three independent replications. Mean with same superscript (a, b, c, d, e) in the same column differ significantly (p<0.05)

Effect of storage on proximate composition and microbial count of accepted treatment

The results depicted that on the first day of storage there was no bacterial count found in control sample as well as TJ_1 and JS_2 samples (Table 6). But some bacteria were found in the sample PL_1 i.e. 1.20×10^5, respectively. On the 30th days of storage there was no bacterial count found in sample TJ_1 but there was some bacterial count found in control, JS_2 and PL_1 sample i.e. 2.2×10^5, 1.00×10^5 and 1.7×10^5, respectively. After 60 days, the bacterial count was observed in all the samples (control, JT_1, JS_2 and PL_1) i.e. 5.4×10^4, 3×10^5, 1.2×10^4 and 2×10^5, respectively.

The moisture contents of control pasta increased slightly with increase in storage period. The protein content declined slightly from the initial day to the 60th day. Fat contents of different treatments were observed to be decreased slightly from the initial day to the 60th day which was non-significant. The total ash contents were found to be 0.71%, 1.35%, 1.34% and 3.31% for control, TJ_1, JS_2 and PL_1 pasta, respectively. The crude fibre contents of control, TJ_1, JS_2 and PL_1 pasta were observed to be 1.75%, 1.06%, 1.64% and 1.29%, respectively. The total ash and crude fibre content remained constant during 60 days of storage. The carbohydrates were increased from the initial day to the 60th day in all types of pasta. Among all types of pasta PL_1 (90:10) had the highest carbohydrates i.e. 77.55 g per 100 g. Overall, there were no significant changes observed in fat, moisture and carbohydrate in all the accepted treatments (TJ_1, JS_2 and PL_1) throughout the entire storage period of 60 days. The fibre and total ash content of all the treatments of pasta remained the same during the study period.

Discussion

The study was undertaken to develop pasta by utilizing locally available underutilized vegetables such as tender jackfruit, jackfruit seed and pumpkin leaves to increase the overall nutritional value of the product. As pasta is one of the most preferred ready to cook products consumed by almost all age groups people, especially adolescents and they are prone to have juvenile onset lifestyle disorders due to their sedentary habit with excessive junk food intake, there is a need to prepare pasta with a combination of nutrition and preference.

- The carbohydrate, crude fat, crude protein, crude fibre, calcium and phosphorous contents of raw ingredients used to develop pasta has been depicted in Table 2. Maximum crude fat was found in refined wheat flour and the TJP contained the lowest amount of fat. PLP contained the highest crude fibre, calcium and ash content and RWF contained the lowest quantity of the same. JSP and RWF contained the highest and lowest crude fat content, respectively. Phosphorus content of RWF and PLP were similar and TJP contained the lowest amount of phosphorus (15, 16, 17).
- The data in Table 3 shows that with an increasing amount of TJP up to 10%, there was an increase in the amount of moisture, ash, fat and fibre with the decrease in carbohydrate content It was observed that calcium and phosphorus content also increased with increasing level of TJP incorporation. In TJ_4 maximum moisture, ash, fat and fibre contents whereas minimum carbohydrate contents were observed. In TJ_1 minimum moisture, ash, crude fat and crude fibre whereas maximum carbohydrate contents were observed. All four types of composite flour-based pasta products differ significantly ($p<0.05$) in their nutrient compositions (18).
- The data in Table 4 indicates that with increased concentration of JSP, the crude fat, moisture, ash, crude fat and crude fibre contents of pasta increased gradually and the total carbohydrate content decreased. The maximum nutritional composition was observed in JS_4 and minimum in JS_1 formulated composite flour. All four types of jackfruit seed powder formulated developed pasta products differ significantly ($p<0.05$) in their proximate compositions. The amount of calcium and phosphorus per 100 g of JSP pasta products increased with the level of JSP substitutions up to 10% (11, 19, 20, 21, 22, 28).
- The data in Table 5 shows that with the incorporation of PLP, the nutritional composition of pasta differed significantly from that of control pasta. Maximum moisture, ash, fat and fibre content obtained in PL_4 except

Table 6. Effect of storage on proximate composition of accepted treatments

Days of storage	Proximate composition (g per 100 g)											
	Moisture				Ash				Fat			
	Co	TJ_1	JS_2	PL_1	Co	TJ_1	JS_2	PL_1	Co	TJ_1	JS_2	PL_1
1st	13.95±0.001	14.49±0.002	10.73±0.003	8.64±0.001	0.71±0.002	1.35±0.001	1.34±0.002	3.31±0.001	0.82±0.000	1.41±0.001	1.42±0.001	1.34±0.001
30th	13.95±0.002	14.56±0.001	10.79±0.002	8.68±0.002	0.71±0.001	1.35±0.001	1.34±0.001	3.31±0.001	0.80±0.001	1.38±0.002	1.40±0.001	1.31±0.001
60th	13.98±0.002	14.59±0.004	10.83± 0.002	8.75±0.001	0.71±0.001	1.35±0.002	1.34±0.004	3.31±0.002	0.80±0.001	1.36±0.003	1.36±0.002	1.30±0.002
p-value	>0.01	>0.01	<0.01	<0.01	>0.01	>0.01	>0.01	>0.01	>0.01	<0.01	<0.01	<0.01

Days of storage	Proximate composition (g per 100 g)											
	Fibre				Protein				Carbohydrate			
	Co	TJ_1	JS_2	PL_1	Co	TJ_1	JS_2	PL_1	Co	TJ_1	JS_2	PL_1
1st	1.06±0.001	1.75±0.002	1.64±0.001	1.29±0.001	9.84±0.002	10.46±0.002	11.24±0.001	7.91±0.003	73.82±0.001	70.54±0.002	73.63±0.003	77.51±0.001
30th	1.06±0.002	1.75±0.001	1.64±0.001	1.29±0.002	9.84±0.001	10.39±0.001	11.24±0.002	7.87±0.002	73.64±0.003	70.53±0.001	73.55±0.002	77.50±0.002
60th	1.06±0.003	1.75±0.001	1.64±0.003	1.29±0.002	9.81±0.001	10.35±0.003	11.20±0.004	7.86±0.003	73.68±0.002	70.58±0.003	73.71±0.004	77.55±0.001
p-value	>0.01	>0.01	>0.01	>0.01	>0.01	<0.01	>0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: Values are mean ± SE three independent replications.

carbohydrate. Minimum moisture, ash, fat and fibre are obtained in PL_1 whereas maximum carbohydrates contains obtained in PL_1. All four types of developed pasta products differ significantly ($p<0.05$) in their proximate values. Maximum mineral content was observed in PL_4 and minimum contents in PL_1. All four formulated pastas differed significantly ($p<0.05$) in their calcium and phosphorus contents (16, 23, 24, 29).

- Results in the Fig. 3 indicated that with an increase in the concentration of tender jackfruit powder up to 20%, there was a decline in the sensory attributes appearance (7.9 to 4.0), taste (7.7 to 3.9), colour (8.1 to 4.5), flavour (8.1 to 2.9), texture (8.4 to 2.9) and overall acceptability (8.4 to 3.6). TJ_1 pasta made from 90% RWF and 10% TJP and TJ_2 pasta made from 85% RWF and 15% TJP were more acceptable among all four types of tender jackfruit formulated and were comparable to control pasta (25).
- As indicated in Fig. 4 increment of JSP substitutions adversely affected the sensory score of appearance (8.0 to 4.5), taste (8.1 to 3.6), colour (8.0 to 4.1), flavour (7.7 to 3.4), texture (7.9 to 4.3), overall acceptability (7.9 to 3.9) with a decreasing trend. JS_2 pasta was more acceptable along with control (26, 27, 28).
- The data shown in Fig. 5 describes the increased level of incorporation of PLP reduced the sensory scores appearance (7.0 to 2.2), colour (6.7 to 1.9), flavour (7 to 2.2), texture (7.5 to 1.8), taste (7.6 to 1.9) and overall acceptability (7.1 to 2.0). However, PL_1 (90:10) composite pasta had the highest sensory scores among all the four treatments and was compared with control pasta. The negative effect on sensory scores with increased pumpkin leaf powder concentrations on pasta was due to a slightly higher bitter taste (10,16).
- The changes in proximate composition during 60 days are shown in Table 6. The moisture content of all highly accepted treatments of pasta increased slightly with an increase in the storage period from the 1^{st} day to the 60^{th} day which is non-significant. The moisture contents of control pasta remained almost constant whereas in the treatments TJ_1, JS_2 and PL_1, it varied non-significantly. This increase in moisture content might be the absorption of moisture from the storage atmosphere. The fat content of all highly accepted treatments of pasta was degraded slightly from the initial day to the 60^{th} day. It might be due to the enzymatic breakdown of fats or proteolysis of the raw ingredients used to prepare pasta (16). Fat content decreased slightly from the initial day to the 60^{th} day which might be due to the conversion of lipids into fatty acids. The ash and crude fibre content remained constant during 60 days of storage. The carbohydrates were found to be increased from initial day to 60^{th} day in all types of pasta due to synthesis of simple sugars (27, 28).
- There were some bacterial growths noticed in PL_1 treatment on the 30^{th} day. This might be because an increase in the water content of food ingredients affects the durability of food against microbial attack (16, 29). The higher the water content, the more likely that the food to get easily damaged, wherein the water content can be utilized by microorganisms, especially molds to grow and multiply. The increase in moisture content during storage might have created favourable conditions for the growth of microorganisms in water activity or aerobic conditions (29).
- There was no significant difference noticed in the time required for pasta treatments to be properly cooked. Thus, the addition of plant products in powdered form showed no significant effects on the cooking time of pasta. It might be due to the addition of plant parts whether seed, leaves or pulp in dried and finely powdered form had its hard fibre or roughage part disintegrated or disrupted.

Conclusion

The use of tender jackfruit powder, jackfruit seed powder and pumpkin leaf powder in pasta improved the nutritional quality of pasta concerning the proximate and mineral contents. There was a significant increase in fat, fibre, ash, calcium and phosphorous content with increasing levels of tender jackfruit, jackfruit seed and pumpkin leaf powder. All the treatments having higher sensory scores can be stored safely for up to two months. Thus, underutilized vegetable stuff can be used in various processed products to gain optimum nutrition for all age groups people.

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Authors' contributions

PB carried out the product development studies, participated in the sequence alignment and drafted the manuscript. DC carried out the nutrient analysis. SS participated in the sequence alignment. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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