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Studies on Nutritional and Functional Characteristics of Elephant Foot Yam Fortified Pasta

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Abstract

In the present investigation, efforts are made to develop elephant foot yam-fortified pasta by substituting elephant foot yam pulp with refined wheat flour (up to 40%). The developed yam-fortified pasta was evaluated on the basis of nutritional, functional and sensory properties to confirm elephant foot yam pulp concentration. Pasta samples fortified with 30% elephant foot yam pulp justified the consumer acceptability on the basis of higher organoleptic properties (color- 7.9, taste- 8.3, texture- 8.0 and mouthfeel- 8.1) and overall acceptability (8.3) scores as compared to other fortified samples. The moisture content (10.40 to 12.06%), crude fibers (0.49 to 1.0%) and ash (0.65 to 1.09%) of fortified pasta were increased with increase in elephant foot yam pulp (0 to 40%). However, fat (1.54 to 1.24%), protein (11.61 to 10.41%) and carbohydrates (75.31 to 74.10%) were decreased with increase in elephant foot yam pulp (0 to 40%). Pasta sample prepared with 40% elephant foot yam pulp recorded better functional characteristics (free radical scavenging activity- 27.28%, total phenol content- 4.29mg GAE/g; ascorbic acid content- 6.57mg/100g) as compared to other fortified pasta samples followed by 30% of elephant foot yam pulp with 27.09% free radical scavenging activity, 4.13mg GAE/g, total phenol and 6.26mg/100g ascorbic acid content.

Keywords: Elephant foot yam pulp, pasta, fortification

Introduction

In India, elephant foot yam (*Amorphophallus paeoniifolius*) is commonly known as *Suran* or *Jimmikand* and is traditionally cultivated on commercial scales in the states of Andhra Pradesh, Tamil Nadu, West Bengal and Kerala (Srinivas *et al*., 2005). In the northern and eastern states of India, local cultivars of this tuber crop grown in the wild form are generally used for making vegetables, pickles and indigenous ayurvedic preparations for various ailments (Srinivas *et al*., 2005). Elephant foot yam is a carbohydrate and protein-rich vegetable, loaded with zinc, phosphorous, potassium, vitamin B6, vitamin A and calcium. It also contains low fat (Krishna *et al*., 2022).

Elephant foot yam has widely been used as a natural medicinal product in Indian Ayurveda (De *et al*., 2010) and has been used for the treatment of many chronic and fatal diseases (Behera *et al*., 2014). The dry matter content in the tuber ranges from (17.50 to 24%), starch from (13.93 to 21.53%), sugar from (0.55 to 1.77%), protein from (0.84% to 2.60%) and fat from (0.07% to 0.37%) Chattopadhyay *et al*. (2009). The energy, carbohydrate, fiber, calcium and iron values of elephant foot yam were the more and respective values were 110kcal/100g, 20.33g/100g, 1.83g/100g, 62.42mg/100g and 4.43mg/100g (Yadav *et al*., 2018). It is nutritionally rich because it contains protein, calcium, vitamins, fats and the majority of carbohydrates (Harish *et al*., 2014). Elephant foot yam contains 18% of starch of the fresh weight of the tuber (Kandekar *et al*., 2020). This edible tuber has represented its status as a gastroprotective, analgesic, antibacterial, antioxidant, anti-tumor, anti-inflammatory, antifungal and cytotoxic agent in reducing the risk of various diseases (Khan *et al*., 2008).

Pasta is known to be one of the Italian-style extruded foods, spaghetti and lasagna, which originated from the Italian word for "dough". The world's pasta production amounts to approximately 14 million tons in 2014 (Nilusha *et al*., 2019). Unfortunately, the quality of pasta protein is low because of the limitations in the amounts of essential amino acids. Proteins are fundamental macronutrients in the human diet as they provide amino acids required for growth and maintenance (Laleg *et al*., 2019).

In India pasta is used as fast food and if the nutritional properties of the pasta will be enhanced then it can be easily used as regular food. Pasta is an extruded type of food prepared with refined wheat flour in a variety of shapes and is made available in dried form which is cooked before eating. Pasta with ideal sensory and physical quality is characterized by elasticity and strength of the dough and minimum cooking losses. Pasta products are widely accepted by children and elder people, but the major problem is that they are not accepted as healthy food due to their low nutrients and dietary fibers. The pasta can be made healthier and more acceptable by incorporating elephant foot yam pulp having nutraceutical value.

In the current situation, people are becoming more concerned with their diet and lifestyle. People are getting aware of the terminologies of high-nutrient and immune-boosting foods. Increased awareness of people toward nutrition and healthy food has amplified the demand for highly valued nutritious and health-benefit-oriented food products. That has also generated opportunities for the food processing sector to develop nutritious and immune-boosting food products. The development of extruded food products like pasta using elephant food yam which is not only a powerhouse of nutrients but also a good immune booster will leave no stone unturned in the evolution of extruded product industry.

Methodology

Plate 1: Elephant foot yam pulp

Preparation of elephant foot yam fortified pasta

The fresh elephant foot yam tubers were procured from the local market in Pune and subjected to washing, peeling, chopping and blanching (80°C for 10min) (Kumar *et al.*, 2017). For a homogenous pulp, the blanched pieces were mechanically ground in a domestic grinder. The pulp was squeezed from the muslin cloth to separate the fine pulp. The raw ingredients (refined wheat flour and salt) were mixed with the prepared elephant foot yam pulp followed by a kneading process. Water was added during dough preparation as per the requirement for desired consistency of dough. After 5min of rest sheeting and cutting were carried out by using a sheeting machine and manual pasta cutter, respectively to obtain a uniform size of pasta strands. The cut pasta strands were steam-blanched (5min) to ensure optimal pasta gelatinization. The gelatinized pasta was dried in a cabinet dryer (50°C for 5h) (Shere *et al*., 2018) followed by packaging in HDPE bags. The five different yam-fortified pasta samples were prepared by substituting elephant foot yam pulp with refined wheat flour (0, 10, 20, 30 and 40g) as indicated in Table 1.

Plate 2: Elephant foot yam fortified pasta

Table 1: Formulation for elephant foot yam fortified pasta

Ingredients	Refined wheat flour (g)	Elephant foot yam pulp (g)	Salt (g)
S_0	100	0	2
S_1	90	10	2
S_2	80	20	2
S_3	70	30	2
S_4	60	40	2

S_0 – Control (100% refined wheat flour)

S_1 – 10g elephant foot yam pulp with 90g refined wheat flour

S_2 - 20g elephant foot yam pulp with 80g g refined wheat flour

S_3 - 30g elephant foot yam pulp with 70g refined wheat flour

S_4 - 40g elephant foot yam pulp with 60g refined wheat flour

Proximate composition

Moisture

The amount of water present in the elephant foot yam and pasta was determined by using the method given by Ranganna, (2015).

$$\%\ \text{Moisture Content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Fat

Fat content was estimated by using the soxtron apparatus (Ranganna., 2015).

$$\%\ \text{Crude fat} = \frac{\text{Weight of dried ether soluble matter}}{\text{Weight of sample}} \times 100$$

Protein

The protein content was determined with Micro-Kjeldhal method as per the method given by AOAC, (2019).

$$\%\ \text{Nitrogen} = \frac{\text{TS} - \text{TB} \times \text{Normality of acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Where,

TS = Titre volume of the sample (ml)

TB = Titre volume of Blank (ml)

% Protein = Nitrogen × 6.25

Crude fiber

The procedure given by AOAC, (2019) was used for the determination of crude fiber.

$$\%\ \text{Crude fiber} = \frac{\text{W1} - \text{W2}}{\text{W}} \times 100$$

Where,

W1 = Weight of Gooch crucible and contents before ashing

W2 = Weight of Gooch crucible containing asbestos and ash

W = Weight of the dried material taken for the test

Ash content

The procedure given by AOAC, (2019) was used for the determination of ash content % Ash content $= \frac{AW}{IW} \times 100$

Where,

AW = Weight of Ash

IW = Initial weight of dry matter

Carbohydrates

The total carbohydrate content of the sample was calculated by difference (AOAC., 2005).

$$\text{Carbohydrates (\%)} = 100 - (\text{\% moisture} + \text{\% fat} + \text{\% protein} + \text{\% fiber} + \text{\% ash})$$

Assessment of functional characteristics

Free radical scavenging assay

DPPH free radical scavenging activity was measured by using DPPH (1, 1 diphenyl 1-2 picrylhydrazyl) assay (Mahloko *et al.*, 2019). The methanol solution was prepared by mixing 90% methanol, 9% acetic acid and 1% acetic acid. 4g of sample extract was centrifuged in 4ml of 90% methanol solution at 5000 rpm for 5min and the supernatant was collected. 3.9ml DPPH solution and 0.1ml supernatant were added to the cuvette. Absorbance was measured at 515 nm and free radical scavenging activity was expressed as percent inhibition of DPPH was calculated.

$$\text{Inhibition (\%)} = \frac{A0 - A1}{A0} \times 100$$

Where,

A0 = Absorbance of control

A1 = Absorbance of the sample

Total phenol content

Pasta sample of (2g) was refluxed with 20ml of methanol containing 1% HCl for 2h at 600°C to produce phenolic extracts. The mixtures were centrifuged at 4000 rpm for 25min. Total phenolic contents were determined by Folin-Ciocalteu colorimetric method described by Mahloko *et al.* (2019). In a volumetric flask, 0.1ml acidified methanolic extract was combined with 5ml distilled water, 2.5ml Folin-reagent Ciocalteu's and 7.5ml 15 percent sodium carbonate solution was added to the mixture. The liquid was properly mixed and increased to a volume of 50ml before being allowed to react for 30min. In a spectrophotometer, the absorbance was read at 700nm after 30min. A calibration curve was created using a standard solution of gallic acid (R^2= 0.9993) and total phenolic content was represented as mg of gallic acid equivalent (GAE) per gram of the sample.

Estimation of ascorbic acid

The working standard solution was prepared by diluting 100ml of stock solution in 100ml of 4%oxalic acid. The concentration of the working standard is 100µg/ml. 5ml of the working standard solution was pipetted out into a 100ml conical flask. 10ml of 4% oxalic acid was added and titrated against the dye (V_1). The amount of the dye consumed is equivalent to the amount of ascorbic acid. The exact 1g of sample was added in 4% oxalic acid to make up the volume of 100ml and centrifuged at 2000 rpm for 20min. 5ml of this supernatant was added to 10ml of 4% oxalic acid and titrated against the dye (V_2). The % ascorbic acid was calculated by (Ranganna, 2015).

$$\text{Ascorbic acid (\%)} = \frac{0.5\text{ml}}{\text{V1}} \times \frac{\text{V2}}{15} \times \frac{100\text{ml}}{\text{wt. of sample}} \times 100$$

Sensory Evaluation

The sensory evaluation of prepared pasta was carried out using a 9- point hedonic rating (1-Extremely dislike to 9- Extremely like). The scorecard suggested by Ranganna, (1986) was used for judging the elephant foot yam pasta. The cooked pasta samples were served to the judges to assess sensory parameters (color, taste, texture, mouthfeel and overall acceptability) of elephant foot yam pasta on the basis of 9- point hedonic rating. The judges were also requested to give comments on each attribute of the samples. The final score for each attribute was obtained by taking the mean of the scores of all the panelists.

Results and Discussion

The proximate composition of refined wheat flour and elephant foot yam is shown in Table 2.

Proximate analysis of raw materials

The physicochemical composition of raw material projected higher moisture content (71.12%), crude fiber (3.29%) and ash (4.03%) in elephant foot yam pulp as compared to refined wheat flour (moisture content 9.40%, crude fiber- 0.58%, ash- 0.89%). However, lower fat (1.23%), protein (7.14%) and carbohydrate (13.19%) were recorded in elephant foot yam pulp than in refined wheat flour (fat- 1.65%, protein- 11.82 and carbohydrate- 75.66%). The results are in agreement with several researchers Basu *et al*. (2014), Yadav *et al*. (2016), Theresia *et al*. (2017) and Dobhal *et al*. (2021).

Table 2: Proximate composition of raw material

Raw Material	Moisture (%)	Fat (%)	Protein (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)
Refined wheat flour	9.40±0.18	1.65±0.70	11.82±0.23	0.58±0.11	0.89±0.13	75.66±1.35
Elephant foot yam	71.12±0.15	1.23±0.50	7.14±0.27	3.29±0.18	4.03±0.16	13.19±1.26

(The values represent mean ± standard deviation of triplicate observation)

Sensory profile of pasta samples

The sensory evaluation of fortified pasta with different proportions of elephant foot yam pulp was carried out in comparison with the control sample (non-fortified) and average sensory scores (color, taste, texture, mouth feel and overall acceptability parameters) are presented in graphical format (Fig.3). The fortified pasta sample (30g elephant foot yam pulp in 70g refined wheat flour) recorded improved sensory scores (taste, texture and mouthfeel) as compared to the non-fortified control sample. The color score of 30g elephant foot yam pulp-fortified pasta was observed to be lower (7.9) but very close to control pasta (8.0). Among all the fortified pasta samples (10, 20, 30 and 40g elephant foot yam pulp), pasta prepared with 30g elephant foot yam pulp and 70g refined wheat flour was found to have the highest organoleptic scores for color (7.9), taste (8.3), texture (8.0) and mouthfeel (8.1). The overall acceptability of pasta fortified with 30g yam (8.3) recorded the highest overall acceptability followed by non-fortified pasta (8.0). However, 10g yam-fortified pasta recorded the lowest overall acceptability (7.4) followed by 40g yam pasta (7.5) and 20g yam (7.7). Thus, pasta samples fortified with 30g elephant foot yam pulp justifies its market potential on the basis of higher organoleptic properties (color, taste, texture and mouthfeel) and overall acceptability scores as compared to other fortified samples.

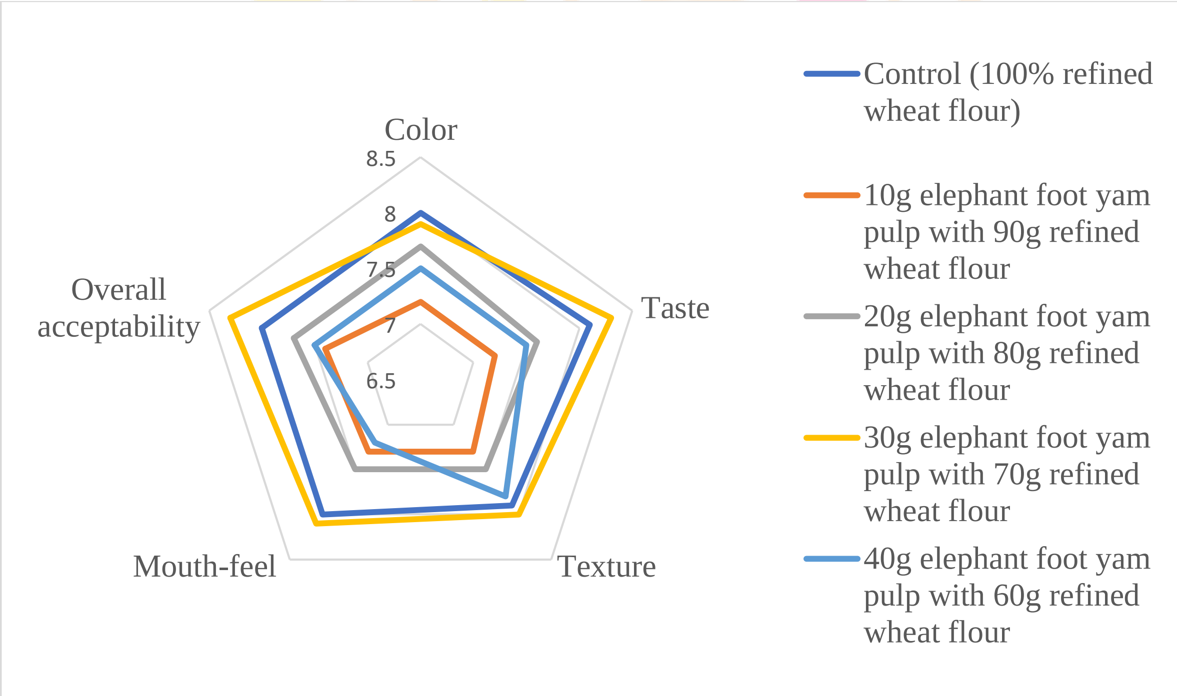

Fig. 3: Effect of elephant foot yam pulp on sensory profile of pasta

Proximate composition of elephant foot yam fortified pasta

The proximate composition (moisture, fat, protein, crude fiber, ash and carbohydrates) of elephant foot yam fortified pasta was analyzed and results are reported in Table 3.

The moisture content of formulated pasta was observed to be in the range of 10.40-12.06%, presenting a non-significant increase in moisture content with increase in elephant foot yam pulp (0 to 40g). The higher moisture content of elephant foot yam fortified pasta may be due to the higher water-holding capacity of fiber in elephant foot yam pulp during dough formation (Eko Nurcahya *et al.*, 2011). The fat content was recorded in the range of 1.24-1.54% in formulated pasta. A significant decrease (1.54 to 1.24%) in the fat content of pasta observed with increase in elephant foot yam pulp (0 to 40g) may be due to the presence of low-fat content of elephant foot yam pulp (Bhutkar *et al*., 2015). The protein content of formulated pasta was observed to be in the range of 10.41-11.61%. A non-significant decrease (11.61 to 10.41%) in the protein content of pasta was recorded with increase in yam pulp. This might be due to the lower percentage of protein in elephant foot yam pulp (Eko-Nurcahya *et al*., 2011). Fiber plays a vital role in the nutritional composition of food. The fiber content of fortified pasta was significantly increased (0.49 to 1.10%) with increase in elephant foot yam pulp (upto 40g). This might be due to increasing proportion of elephant foot yam pulp (Bhutkar *et al*., 2015). The ash content resembling total minerals in the food product recorded a non-significant effect of elephant foot yam fortification. It was recorded in the range between 0.65 and 1.09% in formulated pasta. The increase in ash content of pasta with increasing level of elephant foot yam pulp might be due to presence of more minerals in elephant foot yam as compared to refined wheat flour (Eko-Nurcahya *et al*., 2011). Carbohydrate contents were observed to be in the range of 74.10-75.31% in formulated pasta. A non-significant decrease (75.31 to 74.10%) in carbohydrates content of pasta was recorded with an increase in elephant foot yam pulp. This might be due to the addition of elephant foot yam pulp in pasta (Bansode *et al*., 2019).

Table 3: Effect of elephant foot yam pulp on proximate composition of pasta

Samples	Moisture (%)	Fat (%)	Protein (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)
S_0	10.40	1.54	11.61	0.49	0.65	75.31
S_1	10.95	1.48	11.29	0.79	0.82	74.67
S_2	11.24	1.42	10.65	0.89	0.91	74.89
S_3	11.67	1.33	10.63	1.02	1.04	74.31
S_4	12.06	1.24	10.41	1.10	1.09	74.10
SE	0.03	0.004	0.03	0.002	0.04	0.22
CD @5%	0.12	0.01	0.09	0.007	0.14	0.71

(The values represent average of triplicate observations)

S_0 – Control (100% refined wheat flour)

S_1 – 10g elephant foot yam pulp with 90g refined wheat flour

S_2 - 20g elephant foot yam pulp with 80g g refined wheat flour

S_3 - 30g elephant foot yam pulp with 70g refined wheat flour

S_4 - 40g elephant foot yam pulp with 60g refined wheat flour

Functional characteristics of elephant foot yam fortified pasta

The effect of elephant foot yam fortification on functional characterization of pasta depicted in Table 4 reflected on changes in free radical scavenging activity, total phenol and ascorbic acid content with an increase in elephant foot yam pulp concentration.

The antioxidant activity of formulated pasta was observed to be in the range of 26.47 to 27.28%. A non-significant increase (26.47 to 27.28%) in antioxidant activity of pasta was recorded with an increase in elephant foot yam pulp (0 to 40g). This might be due to antioxidant potential of elephant foot yam pulp (Nataraj *et al*.,

2009) reported elephant foot yam as a powerful natural antioxidant on the basis of flavonoids present in it.

The total phenol content of formulated pasta was observed to be in the range of 3.58 to 4.29mg GAE/G. A non-significant increase (3.58 to 4.29mg GAE/g) in total phenol content of pasta with increase in the level of elephant foot yam pulp might be due to the rising level of the elephant foot yam (Kumar *et al*., 2017).

The ascorbic acid content recorded non-significant increase (0 to 6.57mg/g) in fortified pasta with increase in level of elephant foot yam pulp. This can be attributed to higher concentration of ascorbic acid in elephant foot yam pulp as compared to refined wheat flour (Singh *et al*., 2015).

Table 4: Effect of elephant foot yam pulp on functional characteristics of pasta

Samples	Free radical scavenging activity (% Inhibition)	Total phenol content (mg GAE/g)	Ascorbic Acid (mg/100g)
S_0	26.47	3.58	0
S_1	26.73	3.82	2.64
S_2	26.97	4.04	4.44
S_3	27.09	4.13	6.26
S_4	27.28	4.29	6.57
SE	0.33	0.07	0.73
CD @5%	1.06	0.22	NS

(The values represent mean of triplicate observations)

S_0 – Control (100% refined wheat flour)

S_1 – 10g elephant foot yam pulp with 90g refined wheat flour

S_2 - 20g elephant foot yam pulp with 80g g refined wheat flour

S_3 - 30g elephant foot yam pulp with 70g refined wheat flour

S_4 - 40g elephant foot yam pulp with 60g refined wheat flour

Conclusion

The level of elephant foot yam pulp incorporation was found to be acceptable up to 30g per 100g refined wheat flour without affecting the sensorial qualities of the pasta. Pasta samples fortified with 30g elephant foot yam pulp justifies consumer acceptability on the basis of higher organoleptic properties (color- 7.9, taste- 8.3, texture- 8.0 and mouthfeel- 8.1) and overall acceptability (8.3) scores as compared to other fortified samples. The moisture content (10.40 to 12.06%), crude fibers (0.49 to 1.0%) and ash (0.65 to 1.09%) of fortified pasta were increased with increase in elephant foot yam pulp (0 to 40g). However, fat (1.54 to 1.24%), protein (11.61 to

10.41%) and carbohydrates (75.31 to 74.10%) were decreased with increase in elephant foot yam pulp (0 to 40g). Pasta sample prepared with 40g elephant foot yam pulp recorded better functional characteristics (free radical scavenging activity- 27.28%, total phenol content- 4.29mg GAE/g; ascorbic acid content- 6.57mg/100g) as compared to other fortified pasta samples followed by 30g of elephant foot yam pulp with 27.09% free radical scavenging activity, 4.13mg GAE/g, total phenol and 6.26mg/100g ascorbic acid content.

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