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Evaluation of Nutritional, Physicochemical and Functional properties of Yam Flour

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ABSTRACT: The aim of research study was to develop yam flour and to analyze its nutritional, physicochemical and functional properties. Yam is a staple food in tropical areas because it contains good amounts of carbohydrates, proteins, fiber and minerals. Yam can also be cooked, boiled, roasted, or fried. It has been thought of as an alternative to address micronutrient deficiencies in the child population. Yam tubers are a highly perishable foodstuff that require careful handling owing to pest infestation and physiological changes due to its high moisture content and rapid respiration rates. Preparation of yam flour reduces handling and transportion cost, also makes it suitable for incorporation in various products. For the preparation of yam flour cabinet dryer was used. The prepared yam flour composed of moisture 5.3%, ash 3.86%, total fat content 1.3%, total protein 3.7%. Yam flour was a good source of carbohydrate with 83.8% and crude fiber content of yam flour was 2.04%. Yam was found to be good source of potassium with 130.7±0.03 mg/100g. Tapped density was 0.714 g/ml and True density was 0.606 g/ml. Compressibility index of yam flour was 22.26%. Yam flour had angle of repose 36.02±0.03°. The hunter lab colorimeter readings for yam flour were L* lightness value was 76.35±0.015, a* value was 4.73±0.01 and b* value was 12.16± 0.015 while chroma (C*) and hue value (h*) were 13.05±0.005 and 68.78±0.015 respectively. The yam flour had WAC value of 254.2±0.6%. Oil absorption capacity was 125.0±1% and swelling index was 2.8. High water absorption capacity makes it suitable for use in soups as a thickening agent. Yams are underutilized tuber crops besides having such a good nutritional value. The production of yam flour increases its utilization in various products and helps in eradicating malnutrition.

Keywords: Yam flour, proximate composition, physical properties, swelling index, water absorption capacity.

INTRODUCTION

Yam is a nutritional staple food during times of famine, contains several health-improving nutrients. After potatoes, cassava and sweet potatoes, it is regarded as the fourth-most significant tuber crop. Yam contributes to about 10% to the total production of roots and tubers in the world. Additionally, yam contains bioactive elements which provide health benefits beyond nutrition called as bioactive compounds. These chemicals have a wide range of health advantages from treating degenerative diseases to preventing them. Recently, there have been additional advancements in the therapeutic use of yam compounds including diosgenin and dioscorin (Bailpattar, 2022).

The flour of yam is known as ‘Amala’ Yam flour is used in various ways across India. The paste prepared from yam flour is used as folk remedy over stomache in south India. Also, wheat flour can be replaced by yam flour up to certain extent in the preparation of chapati. It also acts as a thickener in soups and gravies. Edible roots and tubers flours are gaining lot of interest due to cheaper price and easy availability.

In the states of Andhra Pradesh, Tamil Nadu, Kerala and West Bengal, elephant foot yam is traditionally grown on a commercial basis. Yam is now a common element in many pharmaceuticals that are made today for both allopathic and homoeopathic treatment as well as for nutraceutical products. As a "natural alternative" to oestrogen therapy, yam is frequently recommended. According to department of agriculture marketing and cooperation the area under yam cultivation was 35 mha and production was 819 MT during year 2021-22 across the India.

These crops are referred to be "future crops" due of the growing demand for starch sources to meet the needs of the population, which is growing geometrically and the limited opportunity to further increase cereal crop production using the limited available land resources. As a result, yams are essential for meeting the diverse demands of the population and promoting food security and the eradication of poverty (Srinivas, 2012).

The yam contains 118 calories per 100 grams making it a good source of energy. A large number of oligosaccharides and polysaccharides are also present.

Yams supply more than 20 % of the recommended daily amount of carbohydrates. Yam starches give off energy and support healthy mitochondrial activity. Yams also contain a lot of nutritional fiber (the chinese yam contain good amounts of dietary fiber). Starch makes up the majority of the carbohydrates in yams. Compared to other tubers, yam starches have greater amylose/amylopectin ratios. (McPherson and Jane 1999; Wu *et al.*, 2016). Yam proteins (about 1.53 g/100g- 5.0 g/100g) are rich in phenylalanine and threonine but contain limited amounts of the sulphur containing amino acids (cysteine and methionine) and tryptophan. They are also conjugated proteins that contain phytochemicals and minerals that are essential for good health. More protein is found near the peel (skin) (Ezeabara and Anona 2018).

The vitamins in various yam cultivars varies. The vitamin content of yams is also impacted by soil and environmental management strategies (Udensi *et al.*, 2008). Depending on the yam variety, vitamins B_1, B_3, B_5, B_6, C, E, biotin, folic acid and beta-carotene may be present in significant amounts (Ezeocha and Ojimelukwe 2012).

Health benefits of yam flour

- Diosgenin, a special compound found in yams, has been shown to increase neuron growth and improve brain function. Diosgenin has also enhanced mices memory and learning capabilities.
- Yams include a number of antioxidants that could have anti-cancer properties.
- Consuming yams greatly slowed the growth of colon tumours. Yam's antioxidant content was found to be responsible for these benefits, which raises the possibility that these tubers may fight cancer.
- Yam flour has a lot of dietary fibre which lowers low-density lipoproteins, one of the cholesterol transporters. Any heart-related diseases that caused because of excessive cholesterol in the body may be lessened as a result of yam consumption.
- People with diabetes are strongly advised to use it. It has a low glycemic index, which will help prevent a sharp rise in blood sugar levels. The amala's capacity to digest and absorb carbs slowly prevents any abrupt rise in blood sugar or insulin levels.
- Yam flour contains a lot of carbohydrates which give the body energy and help control blood sugar. These carbohydrates also aid in the digestion of fatty acids and the inhibition of ketosis.

- It also contains potassium and manganese, both of which are crucial for the development and health of bones.
- It also contains a lot of micronutrients, such as vitamin C, a potent antioxidant that supports a healthy immune system. Additionally, copper which helps in the creation of red blood cells.

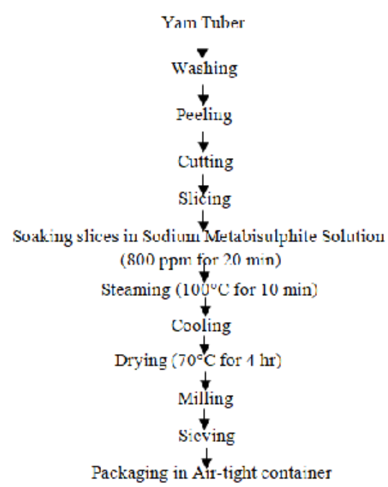
MATERIALS AND METHODOLOGY

Materials. Fresh yam tubers were procured from local market of Parbhani. The variety of yam used for flour preparation was elephant foot yam (*Amorphophallus paeoniifolius*).

Chemicals and glasswares. Chemicals and glasswares used during research study were available in the Department of Food Engineering, College of Food Technology V.N.M.K.V., Parbhani.

Method for preparation of yam flour. Yam tubers were purchased from Parbhani local market sorted on the basis of colour, texture, appearance and infestation. Yam tubers were first washed with potable water properly to remove the external soil and dirt. Washed yam tubers peel was removed and cut into pieces. These pieces were sliced into 5 mm thickness slices and sliced pieces soaked in 800 ppm concentration sodium metabisulphite solution for 20 minutes to prevent the enzymatic browning reactions. Steaming of slices were done at 100°C for 10 min and immediately cooled and dried in cabinet dryer at 70°C for 4 hr. These dried slices were milled in grinder to fine powder and stored in air-tight container.

Method for preparation of yam flour



Flow sheet 1: Preparation of yam flour.

Proximate composition of yam flour. The yam flour sample analysed for moisture content, fat content, protein content, ash content. Sample was analysed to their respective standard methods as described in AOAC. Proximate composition *viz.*, moisture, crude protein, ash, fat and crude fiber contents determined according to standard procedure of AOAC (2000) and AACC (1995).

Moisture content. The moisture content of raw material and product were determined by hot air oven drying method (AOAC, 2000). The moisture percentage present in sample calculated by using following formula:

$$\% \text{ Moisture} = \frac{\text{Initial weight - final weight}}{\text{Total weight of sample}} \times 100$$

Protein content. Protein content were determined by using kjeldahl apparatus as described in (AACC, 2000). Method No. 46-30.

% Nitrogen (N) =

$$\frac{(\text{Sample - Blank}) \times \text{N of } H_2O\ SO_4 \times 0.014 \times \text{D.F.}}{\text{Weight of sample (g)}} \times 100$$

% Protein = % Nitrogen × 6.25

Fat content. Total fat content was determined by using Soxhlet apparatus as per the procedure of (AACC, 2000). Method No. 30-25. The crude fat content calculated by using following formula:

% Crude Fat =

$$\frac{\text{Final weight of flask - Empty weight of flask}}{\text{Weight of sample}} \times 100$$

Crude fiber. Crude fiber was determined by following the method No. 32-10 as described in (AACC, 2000).

The percent crude fiber content calculated by using following formula:

$$\% \text{ Crude Fiber} = \frac{\text{Weight of residue} - \text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Ash content. Ash content were estimated by using standard method of ash estimation muffle furnace combustion method (AOAC, 2000).

The percent ash content calculated by using following formula:

% Ash =

$$\frac{\text{Weight of crucible with ash} - \text{Weight of empty crucible}}{\text{Total weight of sample}} \times 100$$

Carbohydrates. Following is the difference method's calculation of carbohydrates:

% Carbohydrate = 100 – % (moisture + fat + protein + ash+ crude fiber)

Determination of minerals. Two grams of defatted sample was weighed and heated at 550. Then obtained ash is digested with HCL. To the crucible containing ash 0.5-1 ml of distilled water and 5 ml of strong HCl were added and the mixture was then evaporated to dryness on a hot plate. As before mentioned, 5 ml of strong HCl was once again added and evaporated to dryness. Finally, 5 ml of distilled water and 4 ml of HCl were added. On a hot plate, this solution was warmed before being filtered using whatman no. 42 filter paper into a 100 ml volumetric flask. After cooling, 100 ml of distilled water was added to the volume and a sufficient quantity was utilized to estimate the presence of minerals.

True density. True density was calculated by toluene displacement method (Mohsenin, 1980). 20 g of powder was weighed and filled in measuring cylinder containing toluene earlier filled. The increase in the level of toluene by addition of soup powder was measured. The true density was calculated by following formula.

True density (ρ_t) =

$$\frac{\text{Weight powder sample (g)}}{\text{Increase in volume after addition of powder (ml)}} \times 100$$

Bulk density determination. Bulk density was determined by using the gravimetric method as described by (Okaka & Potter, 1976).

Bulk density (ρ_b) =

$$\frac{\text{Mass of soup powder transferred (g)}}{\text{Volume occupied (ml)}}$$

Tapped density. Tapped density for given powder samples were determined by using method (Sarkar *et al.,* 2018). Weighed sample powder added to measuring cylinder and tapped for 150 times and volume occupied by powder was noted.

Tapped density =

$$\frac{\text{Mass of powder (g)}}{\text{Volume occupied by powder after tapping (ml)}}$$

Compressibility index

Compressibility index is important to know the flowability characteristics of powders (US Pharmacopeia, 2005). It was calculated by using bulk density, tapped density.

Compressibility index (%) **=**

$$\frac{\text{Tapped density - Bulk density}}{\text{Tapped density}} \times 100$$

Hausner ratio. The tapped density and bulk density readings were used to calculate the Hausner ratio. The tapping caused the powder to get compacted. Powders are categorized using the Hausner ratio depending on their flowability (Juliano and Barbosa-Canovas 2010).

$$\text{Hausner ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

Angle of repose. Food powders were left to fall from a height of 20 cm onto a plate with a known diameter to determine the angle of repose. measuring the diameter and height of the strength heap (Joshi *et al.,* 1993).

$\theta = \tan^{-1}(2H/D)$

Where,

θ = Angle of repose,

H = Height of the heap formation,

D = Diameter of powder occupied after falling.

Colour analysis of yam flour. Colour analysis of the soup powders were done using a Hunter Lab Color Flex 45/0 optical sensor (Hunter Associates Laboratory Inc., Reston, VA, USA) and the 34 bases of L*, a* and b*, the colour of the soup powder was analysed. The instrument was calibrated using a standard light yellow reference tile (L* = 77.14, a* = 1.52, b* = 21.88) with 10° observers and 45°/0° geometry. L*, a* and b* readings were recorded in a glass cell containing soup powder that was positioned above the light source and covered with a white plate. The lightness, redness and yellowness of soup powder are indicated by the colour index. L* indicates lightness, L*= 0 black colour, L*= 100 pure whiteness, a* positive (+) indicates red colour and a* negative (-) indicates green colour, b* positive (+) indicates yellow colour, b* negative (-) indicates blue colour, C* stands chroma, h* stands hue angle (Pankaj *et al.*, 2013).

Water absorption capacity (WAC). The WAC was calculated using the procedure described by (Sosulski *et al.*, 1976). 10 ml of water were added to a centrifuge tube containing 1g of material. After standing for 10 minutes, the mixture was centrifuged for 30 minutes at 3000 rpm. Following entirely draining the water, the tube was angled at a 45-degree angle and measured. WAC was calculated using the formula below.

WAC (%) =

$$\frac{\text{Weight of water absorbed} \times \text{Density of water}}{\text{Weight of sample}} \times 100$$

Swelling Index. Swelling index was calculated using a method described by (Ukpabi and Ndimele 1990). 50 ml of a graduating cylinder were filled with a 5 g soup sample. 30 ml of cold water were put to a 50 ml graduating cylinder and the mixture was left to stand for 4 hours. The swelling index calculated by using following formula:

$$\text{Swelling Index} = \frac{\text{Increase in volume of sample}}{\text{Original volume of sample}}$$

RESULTS AND DISCUSSION

Physical properties of yam flour. The physical properties of yam flour which are taken into consideration were bulk density, tapped density, compressibility index, true density, angle of repose. Bulk density property used to determine the mass or amount of raw materials can fit in a space such as blender or a hopper. The bulk density of yam flour was found to be 0.555±0.002 g/ml. Igyor *et al.* (2004) reported bulk density values of 0.50-0.62 g/ml for the raw flour samples of *D. cayenensis, D. bulbifera* and *D. rotundata*. Tapped density was 0.714±0.001g/ml and true density was 0.606±0.002 g/ml. True density is absolute density eliminates the volume of pores and voids. Bulk density and true density required for packaging and storage of powders. Compressibility index of yam flour was 22.26±0.01%. Compressibility index indicates flowability characteristics of yam flour. Flowability characteristics of food powder required for flow of powders from hoppers and silos or bins into mixing system or packaging machines. Angle of repose required for flow of powder granules and hopper designing. Yam flour had angle of repose 36.02±0.03°.

Table 1: Physical properties of yam flour.

Parameters	Yam flour
Bulk density (g/ml)	0.555± 0.002
Tapped density (g/ml)	0.714± 0.001
Compressibility index (%)	22.26±0.01
Hausner ratio	1.286±0.015
Angle of repose (°)	36.02±0.03
True density (g/ml)	0.606± 0.002

Colour analysis of yam flour. Table 2 has indicated the values of L*, a* b*, a*/b*, C*, h* for yam flour by using hunter lab colorimeter. The readings for yam flour were L* lightness value was 76.35±0.015, a* value was 4.73±0.01 and b* value was 12.16±0.015 while chroma (C*) and hue value (h*) were 13.05±0.005 and 68.78±0.015 respectively. This indicates that yam flour was light in colour. The results for yam flour were in line with results reported by Setyawan *et al.* (2021). The ratio a*/b* indicates ratio of redness to yellowness. It was found to be 0.388±0.002 in case of yam flour.

Table 2: Colour analysis of yam flour.

Values	Yam flour
L*	76.35±0.015
a*	4.73±0.01
b*	12.16± 0.015
a*/b*	0.388±0.002
C*	13.05±0.005
h*	68.78±0.015

Chemical composition of yam flour. Chemical parameters like moisture content, protein, fat, carbohydrate, crude fiber and ash content of the yam flour were estimated and obtained results are noted in Table 3 as below. From Table 3 the study revealed that the moisture content of the yam flour was 5.3 ±0.01%, ash content of yam flour was 3.86±0.05%, total fat content of yam flour was 1.3±0.02% and total protein content of yam flour was 3.7±0.01%. Yam flour is a good source of carbohydrate with 83.8±2%. Crude fiber content of yam flour was 2.04±0.1%. The results of proximate composition were found near to results expressed by Adeola *et al.* (2012).

Table 3: Chemical composition of yam flour

Parameters	Yam flour
Moisture (%)	5.3±0.01
Protein (%)	3.7±0.01
Fat (%)	1.3±0.02
Carbohydrates (%)	83.8±0.15
Crude fiber (%)	2.04±0.1
Ash (%)	3.86±0.05

Table 4. Functional properties of yam flour.

Ingredient	WAC (%)	OAC (%)	Swelling index
Yam flour	254.2±0.6	125.0±1	2.8±0.4

Functional properties of yam flour. The yam flour had WAC value of 254.2±0.6%, oil absorption capacity was 125.0±1% and swelling index was 2.8±0.4. The capability of flour to absorb water and swell for better food consistency is known as the water absorption capacity. The greater water absorption capacity of yam flour suggests that it contains more hydrophilic ingredients, like polysaccharides. Yam flour has high capacity to absorb water made it helpful in foods like soups and gravies where a high degree of viscosity is required. For soup to thicken, a high water absorption capacity is needed. The swelling index and water absorption capacity are connected. A high swelling index value suggested that the associative forces in yam flour were stronger. The presence of proteins and fats in flours may be the cause of the variance in the values of water absorption capacity and oil absorption capacity. Consequently, proteins have both hydrophilic and hydrophobic components.

Mineral composition of yam flour. The results expressed in Table 5 found that yam flour had calcium content 17.2±0.14 mg/100 g, magnesium content 85.2±0.02 mg/100 g, potassium content 130.7±0.03 mg/100 g, iron content 6.238±0.2 mg/100 g, zinc content 1.758±0.1 mg/100 g, copper content 0.893±0.9 mg/100 g and manganese content 1.592±0.03 mg/100 g. These results were in agreement with results given by Tortoe *et al*. (2017).

Table 5: Mineral composition of yam flour.

Mineral (mg/100 g)	Yam flour
Calcium	17.2±0.14
Magnesium	85.2±0.02
Potassium	130.7±0.03
Iron	6.238±0.2
Zinc	1.758±0.1
Copper	0.893±0.9
Manganese	1.592±0.03

CONCLUSION

Yam flour is becoming important and food producers, marketers, consumers are drawing attention to it. It can generate high income for farmers because of high market value and profitability. The information given above shoes that yam flours have great potential for production of various food products where high viscosity is desired. Functional properties of yam flour depend on starch content and to less extent on flour. Also, yam flour has good nutritional and therapeutic value. So, it can be used for eliminating health related problems and serves as food security.

FUTURE SCOPE

Yam flour can be used in variety of products like chapati, soups, gravies etc. The incorporation of yam flour in these products helps in eliminating micronutrient deficiencies. High starch content of yam flour makes it suitable for use as thickener and adds to energetic value. Diosgenin a bioactive component present in yam flour improves brain function and memory. Also, it has antioxidants which can helps in preventing cancer.

Conflict of Interest. None.

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