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Physico-chemical properties of selected varieties of elephant foot yam (*Amorphophallus paeoniifolius*)

Anjali Yadav and Sadhna Singh

Abstract
The present study was done to assess the physico-chemical properties of flour developed from two varieties of elephant foot yam (*Amorphophallus paeoniifolius*). The corms of variety NDA-9 were found to have better physical quality. Flour of unblanched NDA-9 was of superior quality. The peel per cent of NDA-5 and NDA-9 were 17-80 and 11.60per cent, respectively. The moisture content of NDA-5 and NDA-9 were 77.50 and 76.93 per cent, respectively. The mean flour recovery (%) of blanched and unblanched were same i.e. 22.79 per cent. The mean water absorption capacity (%) of blanched and unblanched was 51 and 57, per cent, respectively. The mean moisture, dry matter, crude protein, crude fat, crude fibre, total ash, carbohydrate and energy values of NDA-5 were 11.20, 88.90, 7.43, 0.50, 2.69, 4.97, 73.42 per cent and 328 kcal respectively. The mean moisture, dry matter, crude protein, crude fat, crude fibre, total ash, carbohydrate and energy values of NDA-9 were 11.00, 89, 6.49, 0.65, 3.20, 4.87, 73.79 percent and 327 kcal respectively.

Keywords: Elephant foot yam, physico-chemical properties, elephant foot yam flour

1. Introduction
Elephant foot yam (*Amorphophallus paeoniifolius*) belongs to family Areceae and is basically a crop of South-East Asia. It is a tropical tuber crop having high production potential and popularity as a vegetable in various delicious cuisines. Tuber crops have been classified as the third most important food crops after cereals and legumes. They protect social security of resource poor farmers who depend on cultivation of tuber crops to sustain their livelihood security especially in the agriculture dominated country (Kalloo, 2006) [8]. It is a highly potential tuber crop of tropical and sub-tropical countries because of its yield potential and culinary properties (Ravindran and George, 2008) [13]. This crop can be grown under a wide range of conditions from small homesteads to large scale cultivation in the open fields and possess greater climate resilience. Elephant foot yam is widely grown and consumed in south eastern countries like India, Philippines, Malaysia and Indonesia. In India, it has gained the status of a cash crop due to its high production potential, market acceptability and lucrative economic returns with a production potential approximately 50-80 t ha-1 (Mishra et.al 2002). Optimal processing techniques and product development potential of these tuberous crop has not been utilized due to the lack of knowledge. In an attempt to increase people's preference towards this underutilized food source, there is a need to transform this into value added products such as flours or starches (Moorthy, 2002) [12]. Along with these physiological qualities, presence of higher amount of dietary fibre in these tuberous crops attributes to offer several other health benefits like preventing obesity, constipation, cardiovascular diseases, diabetes and colon cancer. Tuber flours could be rich in fibre content but also be devoid of gluten which may turn to be boon for celiac disease (CD) patients (Eliasson, 2004) [5].

2. Materials and methods
2.1 Sample collection
Elephant foot yam corms of two varieties namely NDA-5 and NDA-9 harvested during the month of April-May 2015 were procured from the Department of Vegetable Science, College of Horticulture, N.D.U.A.T Kumarganj, Faizabad. Other materials required for preparation of value added products were procured from the local market of kumarganj.

2.2 Physical Parameters of elephant foot yam

a) Colour and shape

The colour and shape of three randomly selected elephant foot yam corms was observed by visual appearance.

b) Size: Length and breath

Three randomly selected elephant foot yam corms were taken and their length was measured with the help of measuring tape/scale and expressed in centimeters.

2.3 Standardization of flour preparation technology

The elephant foot yam was subjected to following processing for preparation of flour. Two methods were followed preparation of elephant foot yam flour:

Method 1	Method 2
Elephant foot yam	Elephant foot yam
↓	↓
Washing and weighing	Washing and weighing
↓	↓
Peeling	Peeling
↓	↓
Again washing	Again washing
↓	↓
Grating	Grating
↓	↓
Sun drying	Blanching in 1% salt solution for 15 sec
↓	↓
Milling	Sun drying
↓	↓
Sieving	Milling
↓	↓
Packaging	Sieving
↓	↓
Storing	Packaging
	↓
	Storing

2.4 Peel percent (%)

Elephant foot yam was taken washed, weighed and peeled. Then weight of peels was recorded and expressed as percentage.

2.5 Flour recovery

Weight of peeled and dried elephant foot yam was recorded. The weight of sun dried yam was recorded and results are expressed in terms of percentage

Colour of the elephant foot yam flours was observed visually. The water absorption capacity of flour was determined by the method of Singh and Singh (1991) [15].

2.5.1 Nutritional composition of elephant foot yam (*Amorphophallus paeoniifolius*) flour

Moisture content was determined by employing the standard method of analysis (AOAC, 2000) [1]. Crude protein was estimated by standard method of analysis (AOAC, 2000) [1], using KEL PLUS Automatic Nitrogen Estimation System. Crude fat was estimated by employing the standard method of analysis (AOAC, 2000) [1] using the Automatic SOCS plus Solvent Extraction System. The crude fibre was estimated by employing the standard method of analysis (AOAC, 2000) [1]. Ash in the sample was estimated by employing the standard method of analysis (AOAC, 2000) [1]. Moisture value was subtracted from 100; the difference gave values of available dry matter. Carbohydrates are calculated by adding the values of moisture, crude protein, crude fat, crude fibre, total ash and subtracted from 100. The difference gave the values of available carbohydrate. The energy content was calculated by factorial method.

3. Result and discussion

Table 1: Physical parameters and moisture content of selected varieties of elephant foot yam (*Amorphophallus paeoniifolius*):

Parameters/ Variety	NDA-5	NDA-9
Colour	Brown	Brown
Average weight (g)	400	430
Shape	Irregular	Irregular
Length (cm)	17	18
Breath (cm)	13	13
Peel (%)	17.80	11.60
Moisture content (%)	77.50	76.93

Values are mean of three replications

Table 4.1 shows the physical parameters of selected varieties of elephant foot yam namely NDA-5 and NDA-9. The colour and shape of both the varieties was similar i.e. brown and irregular. The mean weight (g), length (cm) and breadth (cm) of NDA-9 was higher than NDA-5. The respective values for NDA-9 were 430g, 18 cm, and 13 cm, respectively.

Loy (1994) [10] reported that the colour and diameter of elephant foot yam corm was depressed dark brown in colour and 20-25 cm in diameter. Kay (1987) [9] reported that the corms are large globose depressed tubers usually dull-yellow to brownish-yellow in colour with diameter of 30 cm or more and weight about 7-9 kg by the fourth season.

The peel per cent of NDA-5 and NDA-9 were 17-80 and 11.60per cent, respectively. The moisture content of NDA-5 and NDA-9 were 77.50 and 76.93 per cent, respectively.

Datta *et al. (*2014) showed that *Amorphophallus campanulatus* contained 66.08 ± 1.98 g/100g moisture. (Kay, 1987) [9] Reported that the edible portion of the corms of *A. paeoniifolius* contained 72-79 per cent water, which are almost similar to our findings.

(Kay, 1987) [9] Showed that Hawaiian konnyaku (fresh), Japanese konnyaku (fresh) and Japanese konnyaku (canned) contained 96.6, 97.4 and 96.48 per cent water, respectively. Dutta (2003) reported that Elephant foot yam contained 72 to 89 percent moisture.

Table 2: Flour recovery and flour water absorption capacity of selected varieties of elephant foot yam (*Amorphophallus paeoniifolius*)

Parameters/ Variety/ Treatments	NDA-5 Blanched	NDA-9 Blanched	Mean	NDA-5 Unblanched	NDA-9 Unblanched	Mean
Flour recovery (%)	22.5	23.07	22.79	22.5	23.07	22.79
Flour colour	Off White	Off white		White	White	
Water absorption capacity (%)	50	52	51	58	56	57

Flour recovery and flour water absorption percentage of elephant foot yam has been presented in Table 2. The mean flour recovery (%) of blanched and unblanched were same i.e. 22.79 per cent. The mean water absorption capacity (%) of blanched and unblanched was 51 and 57, per cent, respectively. Adejumo *et al.* (2013) [2] showed that the blanching water temperature and soaking time has significant effects ($P< 0.05$) on water absorption capacity of yam flour. Singh (2015) [14] reported that the water absorption capacity of *Amorphophallus paeoniifolius* starch was 70.35per cent. Babu and Parimallavalli (2012) reported that the water absorption capacity of elephant foot yam starch and cush-cush yam starches were 0.22-0.64 ml/g and 0.39-0.41 ml/g, respectively. Harrijeno *et al.* (2013) [7] reported that the blanched yellow water yam flour has higher water absorption capacity than the unbalanched i.e. 2.02 g/g.

3.1 Nutritional composition of selected variety of elephant foot yam flour

Table 3: Moisture content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	11.37	10.83	11.10
NDA-9	10.50	11.50	11.00
Mean	10.93	11.17	11.04

C.D. (0.05)
Between variety (v) - NS Between treatments (t)- NS
Between variety x treatment (v x t)- 0.91

Data presented in Table 3 shows no significant difference between varieties and treatments i.e. blanched and unblanched elephant foot yam flour with respect to moisture content of elephant foot yam flour. The mean values of blanched and unblanched were 11.17 and 10.93 per cent respectively. Singh (2013) reported that the moisture content of *Amorphophallus paeoniifolius* on dry weight basis was 4.72 per cent. Kay (1987) [9] showed that konjac mannan flour or Kanako contained 17per cent of water.
Babu and Parimalavalli (2012) reported that the moisture content of elephant foot yam starch was 9.99 to12.13 per cent and in cush-cush yam contained 14.66 to 17.50 per cent of moisture. Kay (1987) [9] showed that konjac mannan flour contained 17 per cent water.

Table 4: Dry matter content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	88.63	89.17	88.90
NDA-9	89.50	88.50	89.00
Mean	89.07	88.83	88.95

C.D. (0.05)
Between variety (v) - NS Between treatments(t)- NS
Between variety x treatment (v x t) - 0.91

The data illustrated in Table 4 shows there is no significant difference between varieties (NDA-5 and NDA-9) and treatments blanched and unblanched with respect to dry matter content of elephant foot yam flour. The mean values of dry matter of varieties NDA-5 and NDA-9 were 88.90 and 89.00 per cent, respectively and the mean values of treatments i.e. unblanched and blanched were 89.07 and 88.83 per cent, respectively.
Babu and Parimalavilli (2012) reported the range of dry matter content of elephant foot yam starch and cush-cush yam starch and values were 88.46 to 89.99 per cent and 82.33 to 86.12 per cent, respectively.

Table 5: Crude Protein content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	7.16	7.69	7.43
NDA-9	6.41	6.57	6.49
Mean	6.79	7.13	6.96

C.D. (0.05)
Between variety (v) - 0.04 Between treatments (t)- 0.04
Between variety x treatment (v x t)- 0.06

The data presented in Table 5 shows that varieties differed significantly with respect to crude protein content present in NDA-5 and NDA-9 flour. NDA-5 had higher value of protein as compared to NDA-9. The mean values for protein were 7.43 per cent for NDA-5 and 6.49 per cent for NDA-9. Blanching was found to have significant effect on protein content of elephant foot yam flour. The mean protein content of blanched and unblanched flour were 7.13 per cent and 6.79 per cent, respectively.
Chattopadhyay *et al.* (2009) [3] reported that *Amorphphoallus corm* contained 0.8 to 2.60per cent of protein whereas; Srivastava *et al.* (2014) [14] reported that *Amorphophallus companulatus* corm contained 11.53 per cent of protein. However, Singh (2015) [14] reported that *Amorphophllus* flour contain 9.72g/100g protein which were higher than values found in the present study. Adejumo *et al.* (2013) [2] studied the effect of blanching on protein content and reported that the blanching of fresh yam cubes before the yam flour production resulted in higher protein content. Similar results have also been observed in the present study.

Table 6: Crude Fat content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	0.51	0.48	0.50
NDA-9	0.63	0.67	0.65
Mean	0.57	0.58	0.57

C.D. (0.05)
Between variety (v) - 0.09 Between treatments (t)- NS
Between variety x treatment (v x t) - NS

Table 6 shows that varieties differed significantly with respect to crude fat content. The mean values of crude fat in NDA-5 and NDA-9 elephant foot yam flour were 0.50 and 0.65 per cent, respectively. NDA-9 had higher fat content as compared to NDA-5.
The same table shows no significant difference between treatments. The mean crude fat values of blanched and unblanched elephant foot yam flour were 0.58 and 0.57 per cent, respectively.
Chattopadhyay *et al.* (2009) [3] reported that *Amorphophallus* contained 0.7 to 0.40 per cent fat. Srivastava *et al.* (2014) [14] showed that *A. campanulatus* corm has 3.52 per cent fat while Kay (1987) [9] reported that *A. paeoniifolius,* Kannyako and Japanese Konnyaku (canned) flour containeded 0.2 to 0.4, 0.6 and 0.01 per cent fat, respectively. Singh (2015) [14] reported that *Amorphophallus* flour contained 0.31g/100g of total fat. Gopalakrishnan (2007) [6] reported that tubers of elephant foot yam contained 2 per cent fat while Harijono *et al.* (2013) [7] showed crude fat content of yellow and purple yam ranging for 0.4 to 0.55 per cent. Almost similar results were found in the present study. Adejumo *et al.* (2013) [2] also showed that processing have no significant effect on the fat content of yam. In present investigation also blanching did not showed any effect on fat content of flour.

Table 7: Crude Fibre content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*)

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	2.73	2.64	2.69
NDA-9	3.17	3.23	3.20
Mean	2.95	2.94	2.94

C.D. (0.05)
Between variety (v) - 0.04 Between treatments (t)- NS
Between variety x treatment (v x t) - 0.55

Data with respect to crude fiber content (%) of elephant foot yam flour present in different varieties and treatments are given in table 7. The crude fiber content was higher in NDA-9 as compared to NDA-5. The table shows significant differences between varieties but no significant difference between treatments was found. The mean crude fibre content of elephant foot yam flour of NDA-5 and NDA-9 were 2.69 and 3.20 per cent, respectively.
Srivastava *et al.* (2014) [14] showed that *A. campanulatus* corm contained 14.32 per cent fibre while, Kay (1987) [9] reported that *A. poeoniifolius*, Hawaiian kannyaku (fresh), Japanese konnyaku (fresh) and Japanese konnyaku (canned) contained 0.8, 0.06, 0.1 and 0.37 per cent fibre, respectively. Singh (2015) [14] reported that *Amorphophallus* flour contained 12.15 g/100g of total dietary fibre while, Harijeno *et al.* (2015) showed dietary fibre content of yellow and purple water yam ranging from 16 to 26 per cent.

Table 8: Total ash content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	4.40	5.53	4.97
NDA-9	5.27	4.47	4.87
Mean	4.83	5.00	4.92

C.D. (0.05)
Between variety (v) NS Between treatments (t)- NS
Between variety x treatment (v x t)- 0.27

Data presented in table 8 showed that is no significant difference between varieties and treatments with respect to total ash content (%) of elephant foot yam flour. The mean value of ash content of elephant foot yam flour of NDA-5 and NDA-9 were 4.97 and 4.87 per cent, respectively.
Srivastava *et al.* (2014) [14] showed that the ash content of *A. Campanulatus* was 6.90 per cent this value was higher than the results of present study whereas, a range of 0.7 to 1.3 per cent total ash in *A. paeoniifolius* corm was reported by Kay (1987) [9]. Singh (2015) [14] reported the total ash and acid insoluble ash content of *Amorphophallus* flour. The respective values were 4.0 and 2.0 per cent. Kay (1987) [9] reported that kanjac mannan flour contained 4.5 per cent of ash and Hawaiian Kannyaku fresh contained 0.24 per cent ash while, Japanese konnyaku fresh and canned contained 0.1 per cent and 0.19 per cent total ash, respectively. Adejumo *et al.* (2013) [2] also suggested that processing or treatments have no significant effect ($p \leq 0.05$) on ash contents of yam flour. Similar observations were also found in present study.

Table 9: Carbohydrate content (%) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	73.69	73.15	73.42
NDA-9	74.02	73.57	73.79
Mean	73.86	73.36	73.61

C.D. (0.05)
Between variety (v)- NS Between treatments(t)- NS
Between variety x treatment (v x t)- NS

The table 9 showed no significant difference between varieties and treatments for carbohydrate content. The mean values of carbohydrate content of flour of NDA-5 and NDA-9 were 73.42 and 73.79 per cent respectively.
Srivastava *et al.* (2014) [14] found 70.75 per cent carbohydrates in elephant foot yam flour while, Singh (2015) [14] reported 73.48/100g carbohydrates in *Amorphophallus* flour which are almost similar to our findings. Dutta (2003) reported that on dry weight basis carbohydrate is the major component of elephant foot yam. Adejumo *et al.* (2013) [2] found that processing had significant effect ($p \leq 0.05$) on carbohydrate content of yam flour.

Table 10: Energy content (kcal) of sun dried elephant foot yam (*Amorphophallus paeoniifolius*) flour

Variety/Treatment	Unblanched	Blanched	Mean
NDA-5	328	328	328
NDA-9	327	327	327
Mean	328	328	328

C.D. (0.05)
Between variety (v) - NS Between treatments (t) - NS
Between variety x treatment (v x t) - NS

Table 10 illustrated that there is no significant difference between varieties and treatments with respect to energy content of elephant foot yam flour. The mean values of energy content of flour of NDA-5 and NDA-9 were 328 kcal and 327 Kcal, respectively.
Chattopadhyay *et al.* (2009) [3] reported that *Amorphophallus* corm contained 236-567 KJ/100g of energy while, Kay (1987) [9] reported the energy content of *A. Paeoniifolius* corm, Hawaiian Konnyaku (fresh) and Japanese Konnyaku (canned) and respective values were 330 KJ/100, 50KJ/100 and 54KJ/100.

4. Summary and conclusion

Among selected varieties the physical parameters of elephant foot yam namely NDA-5 and NDA-9 the colour and shape of both the varieties was similar i.e. brown and irregular. The mean weight (g), length (cm) and breadth (cm) of NDA-9 was higher than NDA-5. The respective values for NDA-9 were 430g, 18 cm, and 13 cm, respectively. The peel per cent of NDA-5 and NDA-9 were 17-80 and 11.60per cent, respectively. The moisture content of NDA-5 and NDA-9 were 77.50 and 76.93 per cent, respectively. The mean flour recovery (%) of blanched and unblanched were same i.e. 22.79 per cent. The mean water absorption capacity (%) of blanched and unblanched was 51 and 57, per cent, respectively. The mean moisture content of blanched and unblanched were 11.17 and 10.93 per cent respectively. The mean values of dry matter of varieties NDA-5 and NDA-9 were 88.90 and 89.00 per cent, respectively and the mean values of treatments i.e. unblanched and blanched were 89.07 and 88.83 per cent, respectively. The mean values for protein were 7.43 per cent for NDA-5 and 6.49 per cent for NDA-9. Blanching was found to have significant effect on protein content of elephant foot yam flour. The mean protein content of blanched and unblanched flour were 7.13 per cent and 6.79 per cent, respectively. The mean values of crude fat in NDA-5 and NDA-9 elephant foot yam flour were 0.50 and 0.65 per cent, respectively. The mean crude fat values of blanched and unblanched elephant foot yam flour were 0.58 and 0.57 per cent, respectively. The mean crude fibre content of elephant foot yam flour of NDA-5 and NDA-9 were 2.69 and 3.20 per cent, respectively. The mean value of ash content of elephant foot yam flour of NDA-5 and

NDA-9 were 4.97 and 4.87 per cent, respectively. The mean values of carbohydrate content of flour of NDA-5 and NDA-9 were 73.42 and 73.79 per cent respectively. The mean values of energy content of flour of NDA-5 and NDA-9 were 328 kcal and 327 Kcal, respectively.

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