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Development of process technology for the preparation of yam (*Amorphophallus* spp.) chips

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■ **ABSTRACT :** Yam (*Amorphophallus* spp.) known as *Ole, Balukand, Suran or Zamikand* in India represents an important food crop rich in starch. It is utilized as fresh vegetable after boiling or cooking the peeled and sliced tubers. Many value added products like chips, dehydrated slices, flour, pickles etc. can be made out of available elephant foot yam tubers.The process technology for producing chips was developed and process parameters were optimized. The prepared yam chips after pre-treatments of blanching in water and KMS (0.5%) were subjected for drying at temperatures *viz.*, 60, 70 and 80°C. The fried chips samples were subjected to organoleptic evaluation using 9-point hedonic scale and based on maximum average scores for different quality attributes, the best sample found was chips prepared with (T_{C2}) *i.e.* blanched with 0.5 per cent KMS and dried at 70°C drying temperature. The maximum average scores for colour, texture, taste, appearance and overall acceptability were found as 7.6, 7.2, 6.9, 7.2 and 7.2 for yam chips. The crispiness of the best sample of fried yam chips was found comparable with branded potato chips available in market. Thus, it could be recommended that the prepared dehydrated yam slices as well as yam chips were of very good quality and could be stored for 4 months in polythelene pack (200 gauge). Value added products could very well be prepared without much extra investment at home scale level like potato chips.

■ **KEY WORDS :** Yam, Pre-treatment, Dehydrated chips, Rehydration, Sensory evaluation, Storage

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Root and tuber crops are the third most important food crops after cereals and grain legumes. They constitute important and cheap source of food and energy especially for the weaker section of the population. Tuber crops find an important place in the dietary habits of small and marginal farmers especially in the food security of ever increasing population.Yams (*Amorphophallus* spp.) known as *Ole, Balukand*, *Suran* or *Zamikand* in India represents an important tropical food crop rich in starch. It is a highly potential tropical tuber crop (Nedunchezhiyan *et al*., 2006). The elephant foot yam (*Amorphophallus* spp.) production in India was 677.38x10^3 (MT) and that in Bihar 36.16x10^3 (MT) (NHB Database 2014-15). In India, they are grown in all the states but the major yam producing state are West Bengal, Kerala, Andhra Pradesh, Tamil Nadu, Bihar, Karnataka, Pondicherry and Tripura. The varieties of elephant foot yam are recommended for Bihar and other states, *Gajendra*, *Sree padma* (M-15), *Bidhan Kusum*. Generally yam is consumed as fresh vegetables after boiling or cooking the peeled and sliced tubers in water or by extracting its starch. In the era of ready to

eat food products there is a need to go for processing of yam so that it could be available round the year for consumption and that it could be converted to value added products when it is available in surplus. Practically, yam may be used as a substitute of potato. Any processed food product which can be made from potato can also be made from yam. Various processed value added products are known like pickles, yam flake chips, and sauce, fried yam balls etc but no defined processing methods are there which could describe the preparation procedures. A study on the effects of tuber storage and cultivar on the quality of vacuum microwave-dried potato chips (Lefort *et al.*, 2003) was also carried out. The products are being manufactured at home scale processing and sold in local markets. However, standardized methods for preparing various values added products from yam is still lacking and the products have very short shelf -life. Almost no scientific work has been done to develop the value added quality products to extend the shelf-life of the yam tubers in India. Thus, this study has been taken up to optimize various processes for preparation of quality chips using elephant foot yam. This will not only extend the shelf-life but also can be used to generate income at rural level and thus will also help the growers to fetch good price for their produce.

METHODOLOGY

Samples preparation:

Fresh and good quality yam was procured from local market of Pusa. It was properly washed in running water and gently blotted with absorbent paper. Average weight of yam was measured with the help of digital electronic balance machine.For the preparation of chips the yam was cut into slices of size 25 x 5 x 2 mm approximately.

Pre-treatment of yam chips:

The yam chips were blanched in water at 90°C for 4 minutes before drying. The pre-treatment with 0.5 per cent KMS (potassium metabisulphite) was also done to chips samples during blanching to see the effect over raw (U_{CT}) and blanched (T_{C1}) samples. The pre-treatments were selected as recommended in published research (Young *et al*., 2007; Singh *et al*., 1999 and Ranganna, 1986). Potassium metabisulphite as added at 0.5 per cent by mass to increase storage life of product under adverse temperature conditions (Ruiz *et al*., 2005). After blanching, the yam chips were taken away from the boiling pan and left for cooling (15 to 20 minutes) before draining the water. Besides, the yam pieces were wiped with a cotton cloth to remove the surface moisture. Afterwards, the yam chips were spread uniformly on drying trays of the cabinet dryer.

Moisture content:

The moisture content of fresh raw and dried yam chips was determined with the help of standard hot air oven method. The samples (20 g) were kept in a hot air oven at 102°C ± 1°C for 24 hours. The total dry materials or the initial moisture content of raw yam was determined in accordance with AOAC method no. 934.06 (AOAC, 1990) and moisture content was calculated using formulae.

Moisture content was determined on wet weight basis as:

$$m = \frac{W_m}{W_m + W_d} x100 \quad ....(1)$$

Moisture content was determined on dry weight basis as:

$$M = \frac{W_m}{W_d} x100 \quad ....(2)$$

where,

W_d= Bone dry weight

W_m= Moisture evaporated.

Rehydration characteristics:

The rehydration quality of dehydrated product was determined by rehydration test (Ranganna, 1986). Dehydrated samples of 10 g each were placed in glass beakers containing 200 ml of water and heated at 40–45^{0}C for 60 minutes. The excess water was drained off through filter paper (Whatmann number 4). The drained samples were weighed. Rehydration ratio (R_r) and co-efficient of rehydration (C_r), in the dehydrated samples were computed by using following eq.:

$$R_r = \frac{C}{D} \quad ....(3)$$

$$C_r = \frac{C_x (100 - A)}{(D - B) x 100} x 100 \quad ....(4)$$

where,

A = Moisture content of samples before dehydration, per cent (w.b)

B = Moisture content of dehydrated sample, per cent (w.b)

C = Drained weight of rehydrated sample, g

D= Weight of dehydrated samples taken for rehydration test, g.

Organoleptic evaluation:

Approximately 250 ml of oil was heated up and the dried yam chips were fried for 20-30 seconds in it. The fried yam chips were tested for organoleptic attributes. A proforma consisting of basic organoleptic characteristic was prepared and evaluated on a 9-point hedonic scale.

Storage:

Dehydrated chips were stored in a polyethylene packages (200 guage) at room temperature for 3 months and were used to evaluate the quality of the dehydrated as well as fried chips.

Statistical analysis:

A computer programme (STPR programme, DOS Based) was used to evaluate the co-efficient and analyze the statistical data. To analyze the ANOVA further, the critical difference (CD) between the various means of treatment combinations was also calculated at 1 per cent and 5 per cent level of significant.

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Drying characteristics:

Raw, treated and KMS pretreated samples of yam chips were dried in the dryer at three drying temperatures

Table 1: Reduction in moisture content (w.b.) of yam chips during drying at different temperatures as affected by treatment

Treatments	Time (h)	Moisture content (w.b.) Temperature (°C)		
		60	70	80
Raw (U_{CT})	1	72.29	70.17	69.10
	2	65.76	60.92	57.31
	3	56.75	52.81	46.68
	4	44.17	29.62	17.49
	5	35.27	17.27	12.11
	6	26.25	15.09	
	7	16.69	11.58	
	8	14.62		
	9	12.56		
	10	11.98		
Blanched (T_{C1})	1	70.85	70.91	65.46
	2	62.68	61.96	56.12
	3	51.52	50.97	43.34
	4	32.94	30.63	15.25
	5	23.52	19.86	10.80
	6	17.28	13.31	
	7	15.43	10.25	
	8	13.42		
	9	11.60		
	10	10.90		
KMS treated (T_{C2})	1	70.65	70.53	65.37
	2	53.70	59.54	55.70
	3	42.31	43.59	42.65
	4	21.49	25.57	14.50
	5	17.46	17.45	9.57
	6	14.40	12.35	
	7	12.34	9.33	
	8	11.42		
	9	10.50		
	10	9.54		

namely 60°C, 70°C and 80°C. From the Table 1 it is clear that as the drying temperature increases, the reduction in moisture or weight loss also increases for all the treatments. Higher temperature of drying helps in increasing the drying rate and thus the time required to dry the chips upto equilibrium moisture was also reduced. It took about 10 h, 7 h and 5 h time for drying untreated yam chips at drying temperatures of 60°C, 70°C and 80°C, respectively. It was also evident for blanched and KMS treated chips. The effect of treatment on drying characteristics *i.e.* drying time and final moisture content of the product could be seen from Table 1. At the end of 5 hours of drying at 80°C drying temperature, the untreated (U_{CT}), blanched (T_{C1}) and KMS treated (T_{C2}) chips attained a moisture content of 12.11, 10.80 and 9.57 per cent (w.b.). The blanching and KMS treatment to yam chips helped in drying and the time required to reach a final safe moisture content was also reduced.

Rehydration characteristics :

The rehydration characteristics *i.e.* rehydration ratio (RR), co-efficient of rehydration, moisture content of rehydrated samples of yam slices are shown in Table 2.

The values of RR and co-efficient of rehydration were higher in yam slices samples with KMS treated (T_{S2}) over that of blanched (T_{S1}) and untreated (U_{ST})

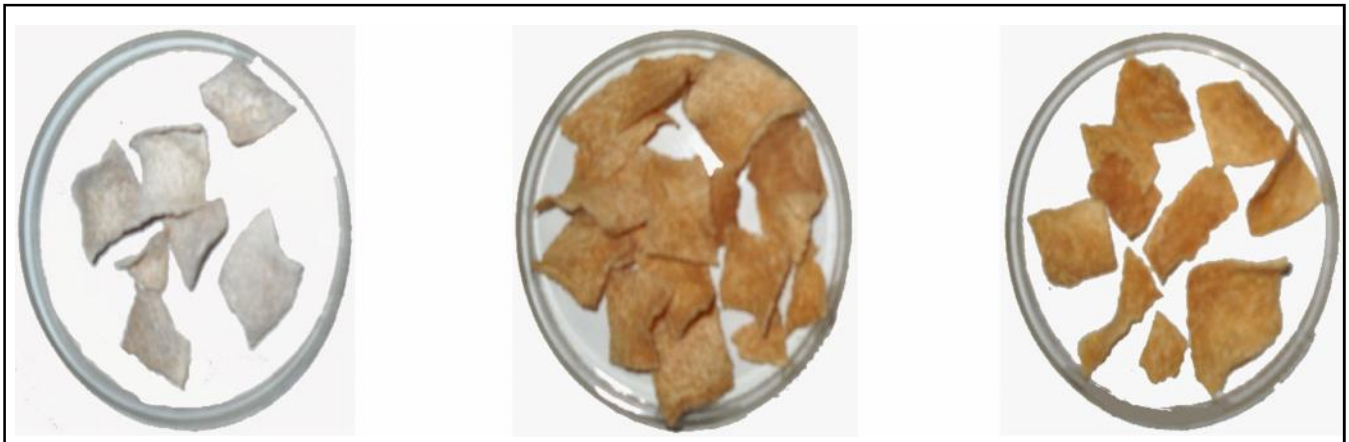
Table 2 : Rehydration characteristics of yam slices dried at different temperatures

Treatments	Drying temp. °C	Moisture content of D.S. (w.b.)	Moisture content of R.S. (w.b.)	R.R.	Co-efficient of rehydration
U_{ST}	60	10.80	69.0	2.63	0.601
T_{S1}	60	9.80	69.8	2.95	0.629
T_{S2}	60	9.10	70.5	3.00	0.790
U_{ST}	70	10.05	69.2	2.84	0.626
T_{S1}	70	9.50	70.5	3.60	0.681
T_{S2}	70	9.20	72.0	4.50	0.893
U_{ST}	80	9.90	69.7	2.72	0.652
T_{S1}	80	9.50	70.0	2.96	0.753
T_{S2}	80	9.30	71.5	3.50	0.805

U_{ST}= Untreated, T_{S1} = Blanched, T_{S2} = KMS treated slices, R.R. = Rehydration ratio, D.S. = Dehydrated yam slices, R.S. = Rehydrated yam slices

Table 3 : Average sensory evaluation scores for different quality attributes of fried yam chips samples

Quality	Pre-treatment	Drying temperature, °C		
		60	70	80
Colour	U_{CT}	3.50	4.35	4.35
	T_{C1}	6.35	7.25	4.85
	T_{C2}	6.75	7.65	5.65
Texture	U_{CT}	4.55	5.90	5.10
	T_{C1}	6.50	5.95	4.55
	T_{C2}	6.30	7.25	5.45
Taste	U_{CT}	3.82	4.08	5.06
	T_{C1}	5.34	5.27	5.22
	T_{C2}	6.82	6.92	5.77
Appearance	U_{CT}	3.95	5.60	4.85
	T_{C1}	5.70	6.30	5.35
	T_{C2}	6.45	7.20	5.10
Overall acceptability	U_{CT}	4.00	5.12	4.66
	T_{C1}	6.03	6.25	5.03
	T_{C2}	6.63	7.28	5.31



Dehydrated yam chips at drying temperature of 70°C

Plate 1: Raw/untreated | Plate 2: Blanched sample | Plate 3: KMS treated sample

samples at all drying temperatures. The maximum values of RR and co-efficient of rehydration were 4.5 and 0.893 were found for yam slices dried at 70°C drying temperature and with KMS treatment. The moisture content of rehydrated yam slices samples also followed the same trend. However, the reconstitutional properties of all samples were reasonably good. The moisture contents of all the rehydrated samples were between 69 to 72 per cent (w.b.), which depict that the rehydrated product could very well be utilized for substituting the fresh product in off-season. These findings are in conformity with those of Singh *et al.* (1999) and Mudgal and Pandey (2008).

Quality evaluation and storage:

The fried yam chips were tested for organoleptic attributes. A performa consisting of basic organoleptic characteristics was prepared and evaluated using 9-point hedonic scale. As it is evident from Table 3 that the fried chips with pre-treatment of KMS scored maximum marks (7.28) followed by blanched chips (6.25) and untreated chips (5.12) for OA when dried at 70°C. The best fried chips sample with maximum scores for colour, texture taste, appearance and O.A. was (T_{C2}) sample. Blanched yam chips when fried were also found good or acceptable by all the panelists. Some of the panelists also liked the taste and texture of yam chips prepared without (U_{CT}) pre-treatment. On the basis of overall acceptability scores for the fried yam chips sample of raw, blanched and KMS pre-treated samples (0.5%, potassium bi-sulphite), it was found that scores were maximum for KMS treated fried yam chips in compassion to raw and blanched chips samples. Thus, the KMS treated samples produced the best result which is in compliance with previous researches made by Datrtatreya *et al*. (2006); Goyal and Mathew (1990) and Sharma *et al*. (2000) and other researchers made in this field. Similar results were found for potato chips quality by Das *et al*. (2004) and for good quality yam chips by Kumar (2009). The prepared yam chips after dehydration can be stored safely without any appreciable change in quality for about 3-4 months in a polyethylene pack (200 g).

Conclusion:

The drying temperatures and pre-treatments of yam chips had affected the sensory quality attributes of the prepared chips. The KMS treated (T_{C2}) dehydrated chips were found to be the best in colour, appearance and overall acceptability followed by blanched (T_{C1}) and untreated (U_{CT}) chips samples.The best quality was found for dehydrated yam chips prepared with 0.5 per cent KMS treatment and dried at 70°C, the scores given by different panelists for colour, the best sample, with maximum average scores for different quality attributes *viz.*, colour (7.6), texture (7.2), taste (6.9), appearance (7.2) and overall acceptability (7.28), was 0.5 per cent KMS treated dried chips. However, the samples dried at 60°C without any treatment (U_{CT}) were also liked by some of the panelists.

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