RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 10 | Issue 2 | October, 2017 | 416-422
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/10.2/416-422**

Characterization of quality parameters during drying and frying of banana chips

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Received : 16.05.2017; **Revised :** 09.08.2017; **Accepted :** 23.08.2017

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■ **ABSTRACT :** Fully mature hard green banana fruits of six varieties *viz.*, Grand Naine (V_1), Poyo (V_2), Kalyani Local (V_3), Nendran (V_4), Cooking I (V_5) and Champa (V_6) were harvested and chips were prepared by two methods i) Frying (M_1) and ii) Drying and frying (M_2). Physical parameters of fruits were recorded and sensory quality of chips was evaluated. Sensory score of colour of Nendran (8.4) was significantly higher than V_1, V_2 and V_6 while it was at par with V_3 and V_5. The sensory score for taste, crispness and overall acceptability of V_4 *i.e.* Nendran though not significant was higher than other varieties. The interaction effect for colour, taste, crispness and overall acceptability were non-significant. However, M_1V_4 *i.e.* Nendran with frying recorded high sensory score for colour (8.6), taste (8.8), crispness (8.8) and overall acceptability (8.7) indicating that the product was very much desirable with good quality of chips. Other interactions *i.e.* Nendran with drying and frying (M_2V_4), Kalyani Local with frying (M_1V_3), Cooking I with frying (M_1V_5) also recorded high sensory score of 8.2, 8.3 and 8.1 for overall acceptability, respectively, showing that these treatments were much desirable. High pulp: peel ratio, thin peel, comparatively thicker pulp, high dry matter content and golden yellow colour pulp are some of the important physical characteristic features of Nendran which are associated in producing superior quality chips.

■ **KEY WORDS :** Banana, Drying, Frying, Sensory quality, Varieties

■ **HOW TO CITE THIS PAPER :** Kuchi, Venkata Satish, Kabir, J., Bouri, F.K., Gupta, Rajesh and Dhua, R.S. (2017). Characterization of quality parameters during drying and frying of banana chips. *Internat. J. Agric. Engg.*, **10**(2) : 416-422, **DOI: 10.15740/HAS/IJAE/10.2/416-422.**

Banana is one of the oldest fruits known to mankind. It is one of the widely grown and consumed fruits due to their distinct aroma and taste, in all parts of the world. It is highly nutritive and every part of the plant is useful. For these reasons it is often referred as 'Apple of Paradise' and 'Tree of paradise'. It is a good source of vitamin A, C and B_2. Fruits are rich source of minerals like magnesium, sodium, potassium, phosphorus, calcium and iron. The ripe fruits are delicious and are used for table purpose. Many products are made from banana such as banana chips, fig, soft drink, flour and jam. Banana flour is prepared from unripe fruits and banana powder from ripe fruits.

India is the largest producer of banana in the world. In West Bengal, banana is cultivated in an area of 45,500 ha with a production of 1.09 million tonnes for the year 2013-14 (Anonymous, 2015). Moreover, with increasing population and urbanization leading to conversion of agricultural land in to industrial areas it is hardly possible to make an increase in area under cultivation. Instead, if we minimize the post harvest losses, automatically there will be increase in production. However, this high

production will have significance only when it reaches consumers in good condition. Faulty handling practices coupled with underdeveloped and exploitive marketing systems results in postharvest losses to the extent of about 30% and value deterioration, leaving little quality surpluses for export and processing (Anonymous, 2002).

Banana chips are very popular value added snack foods which are generally consumed in all parts of India. Different types of unexploited cultivars grown in this region are not evaluated to access suitability for preparation of chips. The crispness is one of the quality criteria of the chips which determine the consumers' preference and acceptability. Therefore, keeping these points in view a research programme on "Suitability of varieties for making chips" was planned.

METHODOLOGY

The present study was carried out in the department of Postharvest Technology of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya Mohanpur, Nadia, West Bengal during 2012-2015.

Preparation of chips :

Fully mature hard green banana fruits of selected varieties were harvested from farm maintained by AICRP on tropical fruits Mandoli, Nadia. The fruits were washed with clean water and peeled. After peeling, the fruits were cut into 2 mm thickness. The slices were then weighed out, blanched for 90 seconds in water at 85-90°C and immersed in 1000 ppm potassium metabisulphite (KMS) + 250 ppm ascorbic acid for 2-3 minutes using 2 litre of solution per 500g of slice. After sieving water, the slices were; (a) dried in a mechanical dryer at 65 °C for 30 minutes and in view for using less oil in subsequent frying, (b) dried for 5-6 hours in mechanical drier at 55-60 °C to minimum moisture level (water activity, $a_w < 0.6$) to prevent microbial load. Then the dried slices were fried in sunflower oil and stirred with narrow wooden stick. When the slices were turned to light yellow colour, the chips were put out from saucepan. The flow sheet for preparation of banana chips is shown in Fig. A and the details of the treatments are presented in Table A.

Table A : Details of the treatments

Method of preparation	Varieties	Treatment symbol
Frying (M_1)	Grand Naine (AAA) (V_1)	M_1V_1
	Poyo (AAA) (V_2)	M_1V_2
	Kalyani local (ABB) (V_3)	M_1V_3
	Nendran (AAB) (V_4)	M_1V_4
	Cooking I (ABB) (V_5)	M_1V_5
	Champa (AAB) (V_6)	M_1V_6
Drying and frying (M_2)	Grand Naine (AAA) (V_1)	M_2V_1
	Poyo (AAA) (V_2)	M_2V_2
	Kalyani local (ABB) (V_3)	M_2V_3
	Nendran (AAB) (V_4)	M_2V_4
	Cooking I (ABB) (V_5)	M_2V_5
	Champa (AAB) (V_6)	M_2V_6

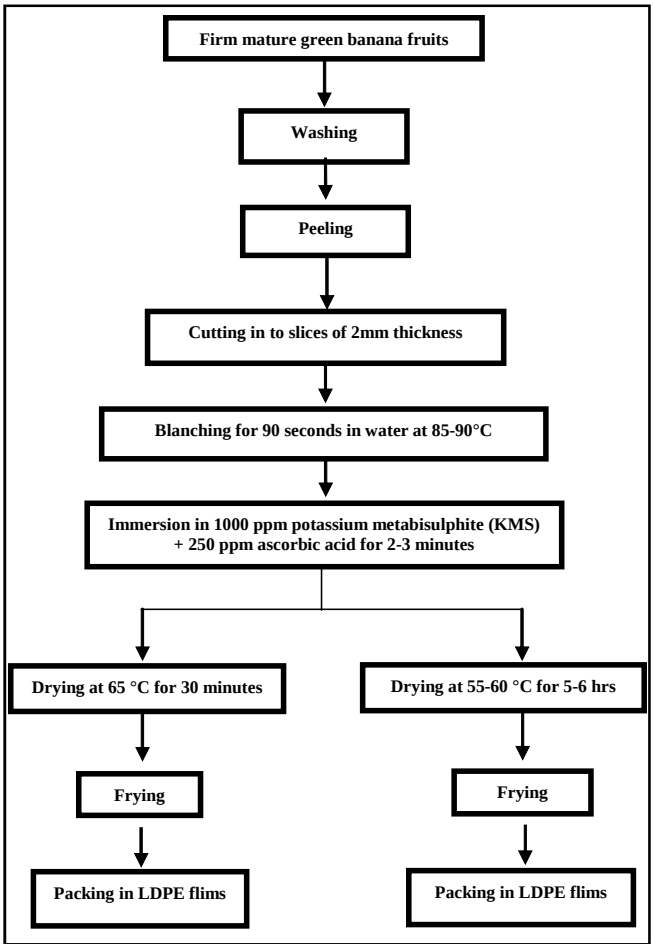

Fig. A : Flowchart for the preparation of banana chips

Observation :

Different physical parameters such as pulp peel ratio and ease of peeling were recorded during the experiment. Parameters such as total soluble solids (TSS), moisture content of fresh pulp, dried chips and fried chips and dry matter content were also analyzed.

Colour of the pulp of selected varieties was also noted. Chips prepared by frying and drying with subsequent frying were analyzed for organoleptic studies.

Statistical design :

The data obtained from the three replications were subjected to the analysis of variance by 'F' test for Completely Randomized Design (CRD) for parameters of fresh fruits and Factorial Completely Randomized Design (FCRD) for chips preparation (Gomez and Gomez, 1984).

Details of observations :

Ten fruits were used for the analysis of physical parameters. All fruit physical quality evaluations were done according to Dadzie and Orchard (1997). To calculate pulp to peel ratio, the weight of pulp and peel was used and expressed as a ratio of pulp weight divided by the peel weight. The ease or difficulty to peel was ascertained subjectively on matured green cooking banana by peeling each fruit and scoring the ease or difficulty to peel on a 5- point hedonic scale given by Belayneh *et al.* (2013) from very difficult to peel (1-2), difficult to peel (2-3) and ease to peel (3-5). In addition to the calculated pulp to peel ratio from the measured values, the pulp thickness was used as easy to peel indices.

Among the chemical properties, total soluble solids (TSS), dry matter and moisture content were measured according to INIBAP technical guidelines (Dadzie and Orchard, 1997; Tigist *et al.*, 2013 and Kundan *et al.*, 2011). TSS was measured by blending 30 g of pulp tissue that was taken from the transverse section of the fruit in 90 ml distilled water for 2 min in a blender and the slurry was filtered through filter paper. A single drop of a the filtrate was placed on a prism of calibrated hand held refractometer (Misco®, USA) with a degree brix range of 0–32 % and resolutions of 0.2 °Brix at 20 °C with distilled water. Dry matter content and moisture content were measured by methods suggested by Ranganna (2000).

■ RESULTS AND DISCUSSION

Fruit characters of six varieties (*i.e.* V_1: Grand Naine, V_2:Poyo, V_3:Kalyani Local, V_4:Nendran, V_5:Cooking I and V_6:Champa) has been presented in Table 1. There were significant differences for fruit and pulp characters among the varieties studied for chips making. Pulp to peel ratio was observed to be significantly higher in V_4 *i.e.* 'Nendran' than V_2, V_3, V_5 and V_6. However, it was at par with V_1. Peel thickness in V_4 *i.e.* Nendran was noted to be significantly ($P \leq 0.05$) lower than V_1, V_3, V_5 and V_6 but it was at par with V_2.

Ease of peeling which was assessed subjectively indicated that the score of V_2 *i.e.* Poyo was highest (3.43) (Easy peeling), while the score of V_4 *i.e.* Nendran was least (1.08) (very difficult to peel). The data revealed that except Poyo *i.e.* V_2, all the other varieties were difficult to peel (scores between 1- 3). TSS was estimated to be maximum in V_2 (4.27 °Brix) followed by V_1 (2.53 °Brix), V_6 (2.33 °Brix) V_4 (2.00 °Brix) V_3 (1.93 °Brix) and V_5 (1.87 °Brix) in that decreasing order.

Moisture content, dry matter and pulp colour has been depicted in Table 1. Dry matter content of V_4 (Nendran) was estimated maximum (29.49%) followed by V_5 (27.16%), V_3 (26.63%), V_6 (23.74%), V_1 (23.23%) and V_2 (22.41%) in that decreasing order. Moisture content of pulp varied from maximum 77.62% in V_2 (*i.e.* Poyo) to minimum 70.54% in V_4 (*i.e.* Nendran). Consequently maximum moisture content of

Table 1 : Physical characteristics and TSS of selected banana varieties

Treatments	Pulp peel ratio	Ease of peeling	TSS (°Brix)	Dry matter content (%)	MC of fresh pulp (%)	MC of dried chips (%)	MC of directly fried chips	Colour of the pulp
V_1	1.59	2.16	2.53	23.23	76.80	5.77	2.74	White
V_2	1.33	3.43	4.27	22.41	77.62	5.88	2.54	White
V_3	1.34	1.13	1.93	26.63	73.40	4.63	2.10	White
V_4	1.67	1.08	2.00	29.49	70.54	4.34	1.97	GY
V_5	1.54	2.38	1.87	27.16	72.87	4.65	2.10	White
V_6	1.18	2.50	2.33	23.74	76.29	4.72	2.96	White
S.E. $\pm$	0.03	0.41	0.17	0.416	0.222	0.173	0.019	
CD (P=0.05)	0.09	1.28	0.54	1.296	0.693	0.540	0.058	

V_1 (Grand Naine); V_2 (Poyo); V_3 (Kalyani local); V_4 (Nendran); V_5 (Cooking I); V_6 (Champa), GY (Golden Yellow)

dried chips was recorded 5.88% in V_2 (*i.e.* Poyo) and minimum 4.34% in V_4 (*i.e.* Nendran). Moisture content of directly fried chips varied from 1.97% in V_4 (*i.e.* Nendran) to 2.96% in V_6 (*i.e.* Champa). Colour of pulp of all the varieties was white except V_4 *i.e.* Nendran which was golden yellow (Fig. 1).

Quality of chips as influenced by method of preparation and varieties has been presented in Table 2. Among the method of preparation M_1 *i.e.* frying method was observed to be superior over M_2 *i.e.* drying and frying method irrespective of the effect of varieties as revealed from the higher sensory score of colour (7.4), taste (8.2), crispness (8.3) and overall acceptability (8.0). Significant difference among the methods for crispness and overall acceptability was noted but for colour and taste there was no significant difference among the methods.

Regarding the effect of variety on chips preparation, it was found that except colour none of the sensory quality parameters were significant ($P \leq 0.05$). Sensory score of colour of Nendran (8.4) was significantly higher than V_1, V_2 and V_6 while it was at par with V_3 and V_5. The sensory score for taste, crispness and overall acceptability for V_4 *i.e.* Nendran though not significant was higher than other varieties.

The interaction effect for colour, taste, crispness and overall acceptability was non-significant. However, M_1V_4 *i.e.* Nendran with frying recorded high sensory score for colour (8.6), taste (8.8), crispness (8.8) and overall acceptability (8.7) indicating that the product was very much desirable with good quality of chips. Other interactions *i.e.* Nendran with drying and frying (M_2V_4) (Fig. 2), Kalyani Local with frying (M_1V_3), Cooking I with frying (M_1V_5) also recorded high sensory score of

Table 2 : Influence of varieties and methods of chips making on sensory quality of banana chips

Treatments	Colour	Taste	Crispness	Overall acceptability
M_1	7.4	8.2	8.3	8.0
M_2	7.2	7.8	6.9	7.3
S.E.±	0.22	0.17	0.17	0.18
C.D. (P=0.05)	NS	NS	0.50	0.54
V_1	6.7	7.5	7.6	7.3
V_2	6.5	7.5	7.6	7.2
V_3	7.4	8.0	7.4	7.6
V_4	8.4	8.7	8.2	8.5
V_5	7.7	8.1	7.4	7.8
V_6	7.0	8.0	7.4	7.5
S.E.±	0.39	0.29	0.30	0.32
C.D. (P=0.05)	1.14	NS	NS	NS
M_1V_1	6.9	7.8	8.1	7.6
M_1V_2	6.7	7.6	8.1	7.5
M_1V_3	7.5	8.2	8.5	8.1
M_1V_4	8.6	8.8	8.8	8.7
M_1V_5	7.8	8.2	8.3	8.1
M_1V_6	7.1	8.1	8.2	7.8
M_2V_1	6.5	7.1	7.0	6.9
M_2V_2	6.4	7.3	7.1	6.9
M_2V_3	7.3	7.7	6.3	7.2
M_2V_4	8.3	8.5	7.6	8.2
M_2V_5	7.6	8.0	6.4	7.4
M_2V_6	6.9	7.9	6.5	7.2
S.E.±	0.55	0.41	0.42	0.45
C.D. (P=0.05)	NS	NS	NS	NS

M_1 (Frying); M_2 (Drying and frying): V_1 (Grand Naine); V_2 (Poyo); V_3 (Kalyani local); V_4 (Nendran); V_5 (Cooking I); V_6 (Champa)
NS=Non-significant

8.2, 8.3 and 8.1 for overall acceptability, respectively, showing that these treatments were much desirable.

Results indicate that the variety Grand Naine, Kalyani Local, Nendran, Cooking I and Champa have thick pulp when compared with the mean pulp thickness of Poyo. Among these varieties Nendran had the thinnest peel and high pulp: peel ratio than the other four varieties. Consumers often prefer thicker and bulker pulp (Dadzie and Orchard, 1997; Forster *et al.*, 2003 and Muchui *et al.*, 2010). This confirms the potentiality of Nendran to produce larger sized slices for processing into various products such as chips.

Considering the method and different variety, Nendran was found to be most suitable because of bright colour, taste, crispness and overall quality. The brightness of colour might depend on pulp quality specially the porosity of pulp texture of different banana varieties. The golden yellow pulp colour of Nendran might be the reason for bright colour and high sensory score for colour (photograph of pulp of Nendran, Fig. 1). The higher score for crispness in Nendran is due to porosity (Molla *et al.*, 2009).

The pulp thickness of Nendran was, however, lesser than Grand Naine, Kalyani Local, Cooking I and Champa. Moreover, these varieties were superior to Nendran for most of the physical properties like fruit weight, fruit length, pulp weight etc. However, chips of these varieties (Grand Naine, Kalyani Local, Cooking I and Champa) have been rated inferior to Nendran. This might be due to the slice sticking problem observed in these varieties during frying because of larger pulp resulting very larger slices (Belayneh *et al.*, 2013). According to Diaz *et al.* (1996) sticking of slices together during frying had a great influence on homogenous product processing efficiency. Thus, the lower chips colour acceptance score of Grand Naine, Kalyani Local, Cooking I and Champa by the panelist could be explained by the slice sticking problem that hinder uniform colour development upon frying and sometimes visible black core with hole at the centre of chips disc. The pulp size of cv. Poyo being least produces inferior quality chips.

Sensory evaluation of fried fruit of banana had shown earlier that the higher the dry matter content, the better the eating quality *i.e.* taste, crispness (Ferris *et al.*, 1996; Dadzie and Orchard, 1997). This is in agreement with the present findings where Nendran

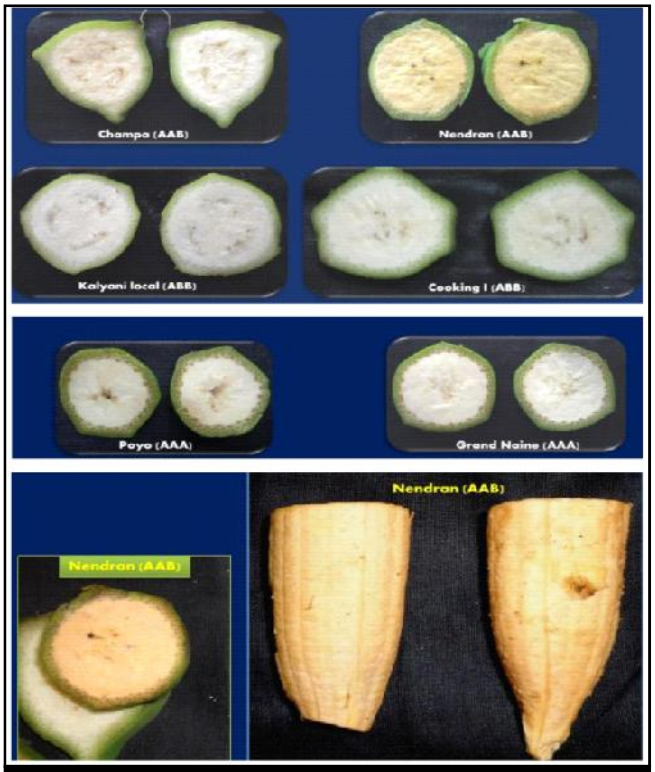

Fig. 1 : Pulp colour of varieties selected for chips preparation

A (Poyo); B (Grand Naine); C (Kalyani Local); D (Cooking I)

Fig. 2 : Chips prepared by direct frying method (M_1)

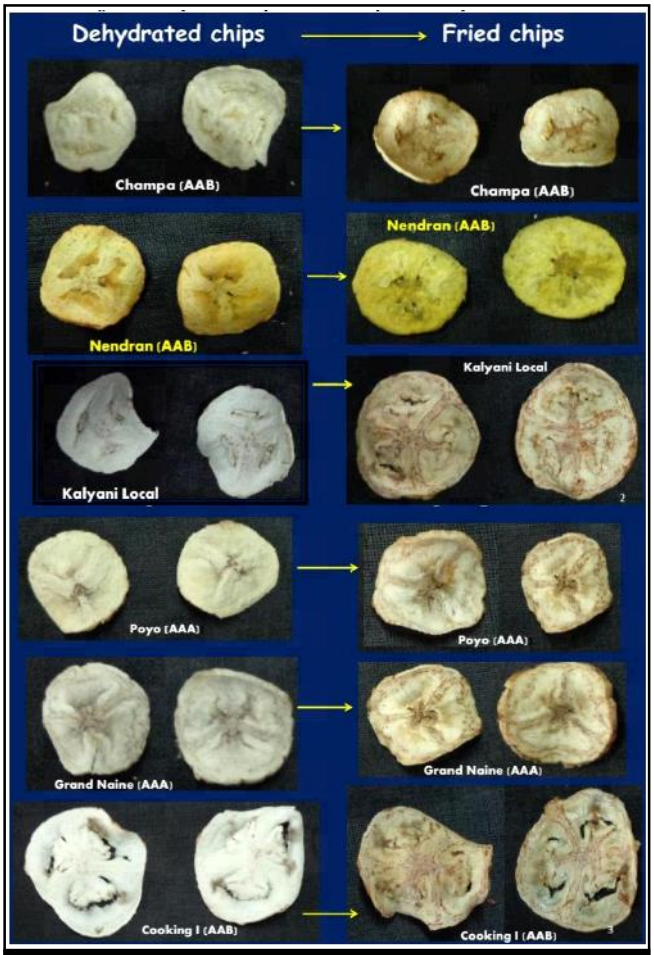

Fig. 3 : Dehydrated chips and fried chips after dehydration

which had higher dry matter content produced tastier and crispier chips as indicated by superior scores.

Direct removal of moisture quickly to a very low level through frying in M_1 (frying) was one of the main reason of reduced crispness in M_1 over sequential removal of moisture by drying followed by frying in M_2 (*i.e.* drying followed by frying) as reported by Belayneh *et al.* (2013). This information is, however, contrary to present findings because M_1 (frying) has been found to be effective method in quick removal of moisture and accordingly M_1V_4 (frying + Nendran) was best treatment combination for chip making. Other treatment combination with high crispness consequently high overall acceptability were M_1V_3 (frying x Kalyani Local), M_1V_5 (frying x Cooking I) and M_2V_4 (drying followed by frying x Nendran). Thus, high score of M_2V_4 *i.e.* Nendran with drying followed by frying in the present investigation is in accordance to report of Belayneh *et al.* (2013). The porosity of Nendran might be the reason of efficacy of the effect of direct frying in M_1V_4 (Molla *et al.*, 2009).

Conclusion :

Nendran with frying recorded high sensory score for colour (8.6), taste (8.8), crispness (8.8) and overall acceptability (8.7) indicating that the product was very much desirable with good quality of chips. High pulp: peel ratio, thin peel, comparatively thicker pulp, high dry matter content and golden yellow colour pulp are some of the important physical characteristic features of Nendran which are associated in producing superior quality chips.

Acknowledgement :

Authors convey gratitude to All India Co-ordinated Research Project on Tropical Fruits for providing necessary quantity of banana fruits and sincere support throughout the study.

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