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Comparative study of effect of frying temperature and hydrocolloid treatment on color and sensory characteristics of banana chips

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Abstract
The present investigation for screening of banana (*Musa paradisica*) cultivars for preparation of banana chips and snacks was carried out to standardized the process for preparation of banana chips and selection of good cultivars for production of Banana chips. Three cultivars *VIZ*. Ardhapuri, Grand naine and Mahalakshmi were selected for screening for preparation of banana chips and snacks. Further, these samples were evaluated for their physico-chemical, textural characterstics and sensory qualities.
Banana slices were fried at different temperature ie. 145 ºC, 160 ºC and 175 ºC for the period of 6 min., 4 min. and 3 min. respectively. The best result was obtained at temperature 160 ºC for the period of 4 minutes. At this temperature banana slices were yellowish in colour. Hence this temperature time combination was used for further process.
Three hydrocolloids were used for hydrocolloid treatments *VIZ*. Sodium alginate, CMC (Carboxy methyl cellulose) and Pectin were used for three different banana cultivar. Each cultivar was treated with these hydrocolloids. From each cultivar there was one sample selected for further studies. Sample C which treated with CMC from Ardhapuri cultivar, sample D which treated with pectin from Grand naine cultivar and sample C which treated with CMC from Mahalakshmi cultivar were selected. Again these three samples were evaluated for sensory characteristics.

Keywords: frying temperature, sensory characteristics, colour, hydrocolloids, banana chips etc.

Introduction
Fried products are popular as snack foods. These are prepared from a variety of raw materials and vary in size, shape and composition, but all are prepared by deep fat frying in vegetable oils and have relatively large proportions of fat/oil. They have a very low moisture content and can therefore be stored under ambient conditions. Off-flavour and rancidity resulting from fat peroxidation is the major cause of spoilage in these products. Because of their high volatility, incorporation of antioxidants in oils has not proved very effective, but sprinkling of antioxygenic salts after frying and use of antioxidant-treated packaging materials have given encouraging results (Sharma *et al*., 1992) [9]. Chips are the most popular snack item in many fast food outlets. Fried banana chips may be one of the important potential banana products in India. Banana chips may be also easily salable snack food in the markets. For longer shelf life, crispiness and chips quality moisture content is the most important factor as far as storage stability is concerned. Bacteria and other microorganism cannot grow easily in lower percentage of moisture content in chips. Visual colour is the major quality criterion for determining the commercial quality with respect to consumers' preferences and cost of the chips (Anand et al., 1982) [1].

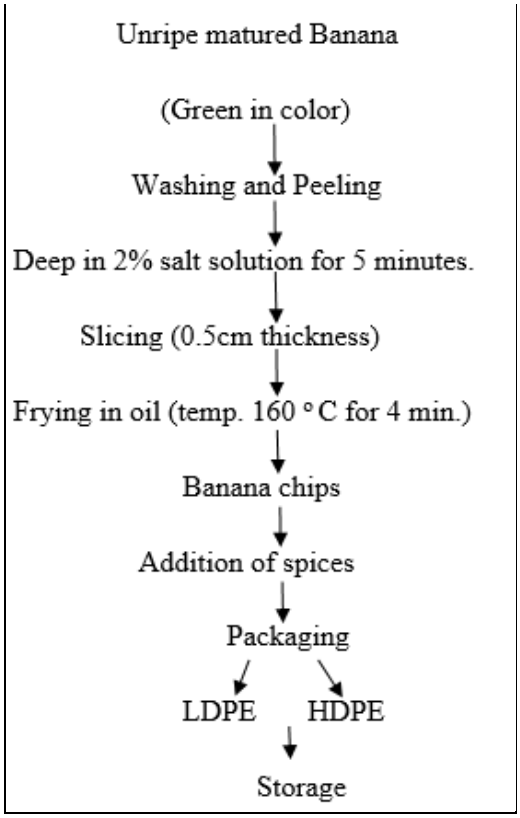
Materials and Methods
Material
Collection of banana varieties
Banana varities was procured from local market and farmers fields. Raw materials for preparation of banana chips were procured from a local market.

Ingredient
Refined sunflower oil, red chilli powder, salt, packaging material and spices mix were purchased from Parbhani local market.

Chemicals
Chemicals of analytical grade were obtained from department of Food Chemistry and Nutrition, College of Food Technology, V.N. M.K.V. Parbhani, Maharashtra, India.

Instruments
All the instruments were used from laboratories of niche area and Dept. of FCN, College of Food Technology, V.N.M.K.V., Parbhani, Maharashtra, India.

Preparation of Banana Chips



Standardized process for preparation of banana chips as follow

Hydrocolloid treatment
The bananas are washed, hand-peeled and cut into chips (0.3 cm thickness) and washed with water. The chips were blanched in an aqueous solution of calcium chloride ($CaCl_2$) at concentrations 0.5 g/100 ml distilled water at 85 ºC for 30 s. After blanching, the banana chips were immediately immersed in 1.0 g hydrocolloids (sodium alginate, CMC and pectin) /100 ml distilled water at 37 ºC for 2 min. Then, all chips were drained and dried at 135 ºC for 3 min to reduce the surface moisture. The frying process was carried out in fryer having a capacity of 4 l of oil. All chips were fried at 160 ºC for 5 min in Sunflower oil with a constant product weight/ oil volume ratio of 1:32. The volume of oil level was checked and replenished after each frying. All fried samples were drained and cooled to room temperature before analysis.
Banana chip sample is coded in following ways for sensory analysis and further work
Sample A - Control
Sample B - Sodium Alginate
Sample C - Carboxy Methyl Cellulose (CMC)
Sample D - Pectin

The experiment comprised three parts. Firstly, the only one best treatment from each group of studied hydrocolloids (sodium alginate, CMC and pectin), considered by the highest sensory scores in all traits, was selected. Secondly, properties of all selected three chip samples treated with, possibly, different concentration of $CaCl_2$ and three different hydrocolloids and the control sample (banana strips blanched in water at 85 ºC for 30 s and fried as previously described) were analyzed (Norizzah, A. R2016) [3]. Then, the best banana chip sample with the least oil uptake and the highest sensory scores in all traits was selected.
Above all the treatment is treated to three banana cultivar *VIZ.* Ardhapuri, Grand naine and Mahalakshmi. Twelve samples were prepared from banana cultivar including control sample from each banana cultvar. Among each cultivar one sample was selected on the basis of sensory scored from the sensory panel. It means final three samples were selected. Again the sensory evalution was done to select best variety among all three varities of banana cultivar.
There was a optimization of various treatments on the banana cultivar *VIZ.* Ardhapuri, Grand naine and Mahalakshmi for the selection of best cultivar for production of banana chips and snacks. The treatments include effect of frying temperature on the colour of banana chips, effect of hydrocolloid treatments on the sensory characteristics of banana chips and snacks, textural characteristics of banana chips.
Banana slices were fried at different temperature ie. 145 ºC, 160 ºC and 175 ºC for the period of 6 min., 4 min. and 3 min. respectively. The best result was obtained at temperature 160 ºC for the period of 4 minutes. At this temperature banana slices were yellowish in colour. Hence this temperature time combination was used for further process.
Three hydrocolloids were used for hydrocolloid treatments *VIZ.* Sodium alginate, CMC (Carboxy methyl cellulose) and Pectin were used for three different banana cultivar. Each cultivar was treated with these hydrocolloids. From each cultivar there was one sample selected for further studies. Sample C which treated with CMC from Ardhapuri cultivar, sample D which treated with pectin from Grand naine cultivar and sample C which treated with CMC from Mahalakshmi cultivar were selected. Again these three samples were evaluated for sensory characteristics.

Results and Discussion
Effect of frying temperature on colour of banana chips
Banana chips were fried at different temperature 145 ºC, 160 ºC and 170 ºC. for 6, 4 and 3 min. respectively. time to obtain final moisture content was in the range of 3 to 4 per cent. Effect of frying temperature on colour of banana chips prepared from cultivar Ardhapuri, Grand naine and Mahalakshmi were studied. Result obtained was depicted in tables 3, 4 and 5.

Effect on Ardhapuri cultivar
When chips of Ardhapuri cultivar was fried at different temperature 145 ºC, 160 ºC and 170 ºC. for 6, 4 and 3 min. respectivaly, change of colour was indicated in Table 3. When banana chips of Ardhapuri cultivar was fried at temperature of 145 ºC for 6 min., then colour of banana chips was light yellow. When temperature was increased to 160 ºC and time reduced to 4 min., then colour obtained was dark yellow.

Table 1: Effect of frying temperature on colour of banana chips
Cultivar – Ardhapuri

Sr. No.	Oil Temp.(ºC)	Time(Min.)	Colour
1	145	6	Light Yellowish
2	160	4	Dark spot yellowish
3	175	3	Yellowish

When temperature again increased to the 175 ºC for time period of 3 min., then colour obtained was yellowish but dark spot formed on the surface of banana slices due to increase in temperature of oil.

Effect on Grand naine cultivar

When chips of Grand naine cultivar was fried at different temperature 145 ºC, 160 ºC and 170 ºC. for 6, 4 and 3 min. respectivaly, change of colour was indicated in Table 4. Temperature was increased in same way as that of Ardhapuri cultivar ie. 145 ºC, 160 ºC and 175 ºC for time period of 6, 4 and 3 min. respectively.

Table 4: Effect of frying temperature on colour of banana chips Cultivar- Grand naine

Sr. No.	Oil Temp. (ºC)	Time (Min.)	Colour
1	145	6	Spot and yellowish
2	160	4	Yellowish
3	175	3	Deep yellow

When banana chips were fried at temperature of 145 ºC for 6 min., then the colour obtained was Yellowish but spot was obtained due to change in cultivar. As the temperature was increased to 160 ºC for 4 min., then colour was improve to yellowish which was generally accepted. Again the temperature was extended to the 175 ºC for 3 min., then colour was deep yellow with some spot on it.

2.4 Effect on Mahalakshmi cultivar

When chips of Mahalakshmi cultivar was fried at different temperature 145 ºC, 160 ºC and 170 ºC. for 6, 4 and 3 min. respectivaly, change of colour was indicated in Table 4. Temperature was increased in same way as that of Ardhapuri cultivar ie. 145 ºC, 160 ºC and 175 ºC for time period of 6,4 and 3 min. respectively.

Table 2: Effect of frying temperature on colour of banana chips Cultivar- Mahalakshmi

Sr. No.	Oil Temp. (ºC)	Time (Min.)	Colour
1	145	6	Light Yellow
2	160	4	Yellowish
3	175	3	Spot and yellowish

When banana chips were fried at temperature of 145 ºC for 6 min., then the colour obtained was Light Yellow. As the temperature was increased to 160 ºC for 4 min., then colour was improve to yellowish which was generally accepted. Again, the temperature was extended to the 175 ºC for 3 min., then colour was deep yellow with some spot on it.

Banana chips fried at temperature 160 ºC for 4 min. were good in colour and this temperature and time was selected for further studies.

Similar results were reported by Mitra et *al* (2007) for different cultivars of Banana in which Banana chips were fried in hot oil to the desired moisture content (2-3%) and oil content (40%) in chips at 3 different temperatures and impact of different pretreatments were compared by sensory assessments.

Effect of hydrocolloid treatment on sensory characteristics of banana chips

It is known that hydrocolloids alter the water holding capacity and consequently affect oil absorption x. Thus, the ability of alginate, CMC and pectin to reduce oil absorption could be due to an increase in water holding capacity by entrapping the food moisture inside and preventing moisture replacement with oil. Besides, hydrocolloids and $CaCl_2$, as gel-forming agents and cross-linking agents, form a fine net structure which prevents oil migration into banana tissue during the frying process. (Norizzah, A. R.2016) [6].

Thus, the ability of alginate, CMC and pectin to reduce oil absorption could be due to an increase in water holding capacity by entrapping the food moisture inside and preventing moisture replacement with oil. Besides, hydrocolloids and $CaCl_2$, as gel-forming agents and cross-linking agents, form a fine net structure which prevents oil migration into banana tissue during the frying process.

The qualities of banana chips influenced by 2-step coating with $CaCl_2$ at concentrations 0.5 g/100 ml distilled water) and 1.0 g hydrocolloids (alginate, CMC and pectin)/100 ml distilled water were studied (table 6-8). Only one chip sample from each group of hydrocolloids which contained the least oil content and accepted the highest scores in all attributes was considered as the best treatment for further study.

The results showed that the concerted activity of the combinations of 0.5 g $CaCl_2$/100 ml distilled water and 1 g CMC/100 ml distilled water for Ardhapuri cultivar and 0.5 g CaCl2/100 ml distilled water and 1 g pectin/100 ml distilled water for Grand naine cultivar and 0.5 g CaCl2/100 ml distilled water and 1 g CMC /100 ml distilled for Mahalakshmi cultivar were the most efficient in reducing oil uptake and promoting sensory attributes.

Effect on Ardhapuri cultivar

The Organoleptic evaluation for banana chips prepared from Adhapuri cultivar was carried out by a panel of 10 members using a 9 point hedonic scale to assess the parameters like Colour, apperance, Taste, Texture and Overall acceptability. The average score recorded by judges was presented in table 6.

Table 3: Effect of hydrocolloid treatment on sensory characteristics of banana chips. Cultivar – Ardhapuri

Sr. No	Treatment	Sensory characteristics				
		Colour	Appearance	Texture	Taste	Overall acceptability
1	A	8.0	8.0	8.0	6.5	7.0
2	B	7.0	7.0	7.0	6.0	7.0
3	C	8.0	8.0	8.0	7.5	8.0
4	D	8.0	8.0	7.0	7.0	8.0
	Mean	7.75	7.75	7.5	6.75	7.5
	SE+	0.32	0.29	0.23	0.18	0.3
	CD at 5%	0.90	0.81	0.67	0.58	0.91

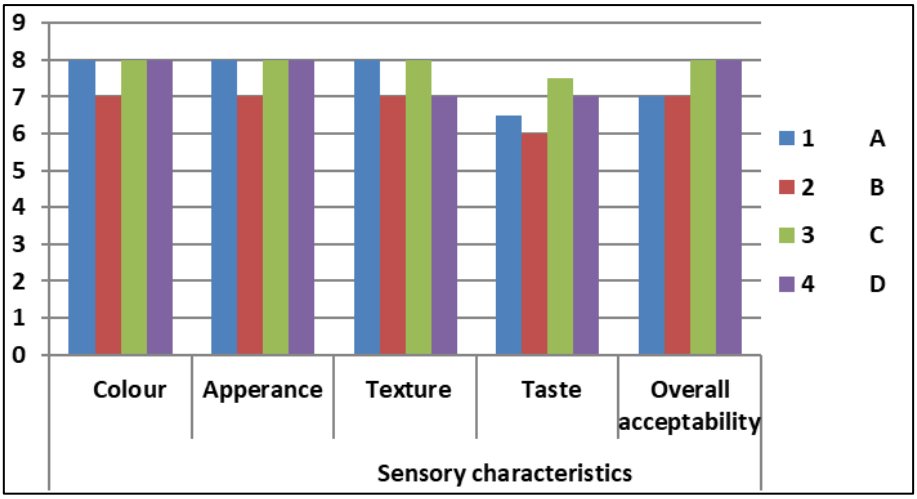


Fig 1: Effect of hydrocolloid treatment on sensory characteristics of banana chips. Cultivar – Ardhapuri.

It was observed from table 6 that the highest score for each sensory attribute was recorded for sample C (0.5% $Cacl_2$ + 1 gm CMC) banana chips whereas minimum for sample B (0.5% $Cacl_2$ + 1 gm Sodium alginate). The other samples i.e. sample A and D were recorded more or less similar values for each sensory attributes.

Effect on Grand naine cultivar: The Organoleptic evaluation for banana chips prepared from Grand naine cultivar was carried out by a panel of 10 members using a 9 point hedonic scale to assess the parameters like Colour, apperance, Taste, Texture and Overall acceptability. The average score recorded by judges was presented in table 7.

Table 4: Effect of hydrocolloid treatment on sensory characteristics of banana chips Cultivar -Grand naine

Sr. No.	Treatment	Sensory characteristics				
		Colour	Appearance	Texture	Taste	Overall acceptablity
1	A	8.0	6.0	5.5	5.0	6.0
2	B	6.0	7.0	5.0	5.0	5.0
3	C	6.0	5.0	6.0	6.0	6.0
4	D	7.0	7.0	7.0	8.0	8.0
	Mean	6.75	6.25	5.87	6.0	6.25
	SE±	0.31	0.29	0.23	0.31	0.24
	CD at 5%	0.92	0.86	0.67	0.91	0.76

It was observed from table 7 that the highest score for each sensory attributes was recorded for sample D (0.5% $Cacl_2$ + 1 gm Pectin) banana chips where as minimum for sample C (0.5% $Cacl_2$ + 1 gm Sodium alginate). The other samples i.e. sample A and B were recorded more or less similar values for each sensory attributes.

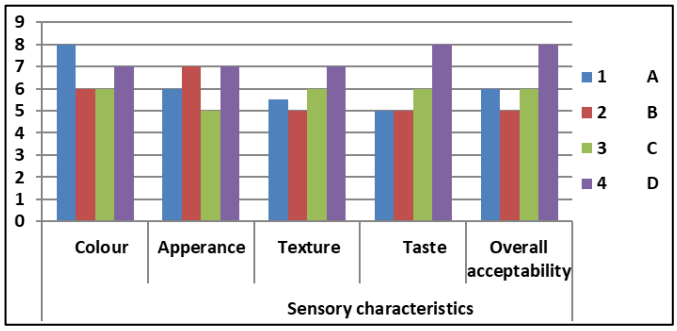


Fig 2: Effect of hydrocolloid treatment on sensory characteristics of banana chips Cultivar -Grand naine

Effect on Mahalakshmi cultivar

The Organoleptic evaluation for banana chips prepared was carried out by a panel of 10 members using a 9 point hedonic scale to assess the parameters like Colour, apperance, Taste, Texture and Overall acceptability. The average score recorded by judges was considered by presented in table 8.

Table 5: Effect of hydrocolloid treatment on sensory characteristics of banana chips. Cultivar- Mahalakshmi

Sr. No	Treatment	Sensory characteristics				
		Colour	Apperance	Texture	Taste	Overall acceptablity
1	A	6.0	6.0	7.0	7.0	7.0
2	B	6.0	5.0	7.0	6.0	7.0
3	C	6.0	7.0	7.5	8.0	8.0
4	D	5.0	6.0	7.0	7.0	6.0
	Mean	5.75	6.0	7.13	7.25	7.0
	SE±	0.34	0.29	0.14	0.21	0.41
	CD at 5%	1.01	0.76	0.49	0.64	1.29

It was observed from table 6 that the highest score for each sensory attributes was recorded for sample C (0.5% $Cacl_2$ + 1 gm CMC) banana chips where as minimum for sample B (0.5% $Cacl_2$ + 1 gm Sodium alginate). The other samples i.e. sample A and D were recorded more or less similar values for each sensory attributes. Statistically results were significant at 5 per cent CD.

Finally one treatment sample from each banana cultivar was selected ie. Sample C from cultivar Ardhapuri, sample D from cultivar Grand naine and sample C from Mahalakshmi. These selected samples from each varities were further studied for textural characteristics and storage studies.

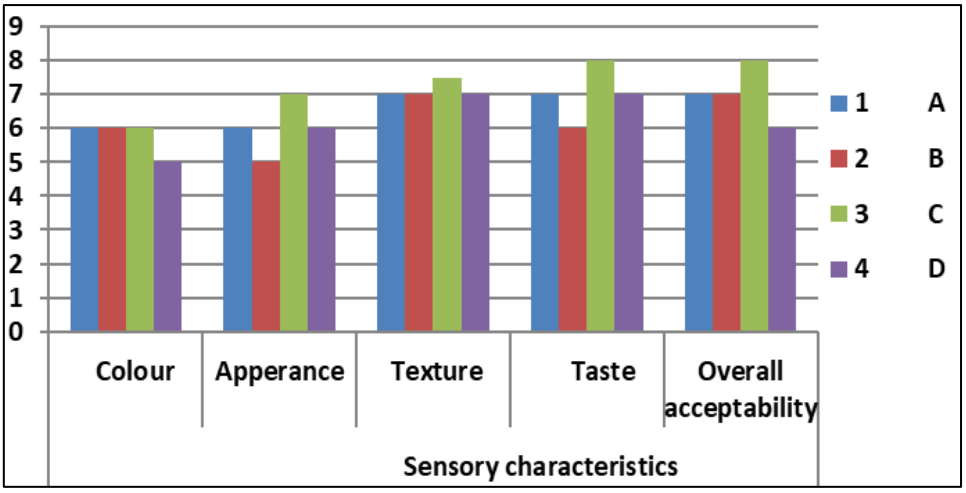


Fig 3: Effect of hydrocolloid treatment on sensory characteristics of banana chips. Cultivar- Mahalakshmi.

The qualities of three treatment samples as mentioned above and control chips were determined. The crispiness (hardness), moisture and fat content of banana chips were significantly affected by hydrocolloid (alginate, CMC and pectin) treatments. It is known that the structure of banana depends on the presence of pectic substances, which are part of the intercellular material. On the other hand, an increase in the hardness value (less crispiness) of coated samples could be due to the combination effect of $CaCl_2$ and hydrocolloid. As gel-forming agents and cross linking agents, the coating substances formed a rigid network that increases middle lamella and cell wall rigidity, forming a resistant film on the surface of the banana to protect the structure during the frying process.

Moreover, the results showed that the treated samples appeared to be ignificantly lower in fat content than the control (6–43% reduction) These results indicated that the interaction of $CaCl_2$ and hydrocolloids formed thermal gelation or cross-linked network to help cement the cell wall and enclose the outer surface of the tissue, consequently preventing oil penetration into the banana tissue during frying process (*Akdeniz et al.*, 2006, Jittra S and chutima T 2009) [5, 4].

Comparison of sensory quality characteristics of different cultivars: After hydrocolloid treatment on different samples from Ardhapuri, Grand naine and Mahalakshmi cultivar. finally one sample was selected from each varities including control sample on the basis of sensory scores obtained by the panel. Again the sensory evalution done to screen out best cultivar for banana chips production and further study of textural evalution and storage studies. Sensory scores obtained by the expert panel was presented in table 9.

Table 6: Sensory characteristics of banana chips. Cultivar – Ardhapuri, Grand-naine and Mahalakshmi

Sr. No	Treatment	Sensory Evalution				
		Colour	Appearance	Texture	Taste	Overall acceptability
1	Control	8.0	7.0	7.0	7.0	8.0
2	A-C	8.0	9.0	8.0	8.0	8.0
3	G-D	7.0	7.0	7.0	8.0	8.0
4	M-C	7.0	6.0	7.0	7.0	7.0
	Mean	7.5	7.25	7.25	7.5	7.75
	SE+	0.29	0.29	0.24	0.25	0.25
	CD at 5%	0.91	0.76	0.76	0.74	0.78

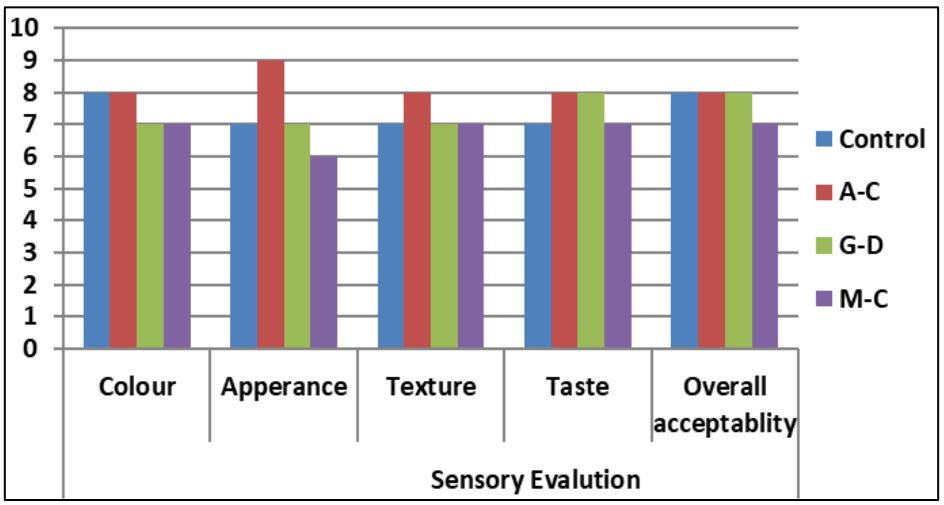


Fig 4: Sensory characteristics of banana chips. Cultivar- Ardhapuri, Grand naine and Mahalakshmi.

Sensory characteristics indicate that snacks prepared from Ardhapuri cultivar were good in terns of sensory characteristics as compared to snacks from Grand naine and Mahalakshmi cultivar.

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