Effects of blanching on the dehydration characteristics of unripe banana slices dried at different temperature

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Abstract: A study was undertaken to examine the effect of blanching on the dehydration characteristics of unripe banana slices blanched and dried at different temperatures. The effects of pretreatments such as blanching, dehydration and combination treatments on the quality of unripe bananas (Musa acuminata) were investigated. The banana fruits were dehydrated at 50 ℃, 60 ℃ and 80 ℃ in a tray dryer at the air velocity of 2-2.50 m/s. The percentage of dry matter loss of unripe banana slice sample A1, A2 and A3 was higher at blanching temperatures 80 ℃than the blanching temperatures 50 ℃ and 60 ℃.The drying rates for all treatments were high at drying temperature 50 ℃when the moisture content was highest then decreased rapidly. Shrinkage of banana slices is also played an important role in the banana products. Greater shrinkage, lesser good quality banana product (i.e. flour).The moisture content, ash, protein and pH is very important chemical parameters for banana flour were significantly higher in the blanching process followed by the combined blanching and dehydration. Therefore, combined blanching and dehydration could be used as a pre-treatment to produce high quality dried banana slices where the banana fruits are produced in surplus annually.

Keywords: Blanching; banana slices; dehydration; temperature and weight loss

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1 Introduction

India is the second largest producer of fruit in the world. Banana (*Musa acuminata)* is the second most important fruit crop in India after mango. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes (National Horticulture Board, 2013), which contributes 31% of the total food production in India. Maharashtra state is the largest banana producing state in India followed by Tamil Nadu, Gujarat, Assam and Andhra Pradesh.

Banana fruit is a delicate highly perishable fruit, whose production is subjected to serious postharvest problems including premature ripening, losses due to diseases, mechanical damages such as bruising, poor quality due to inappropriate ripening environments and losses in different markets due to its limited shelf life (Deka and Choudhury, 2006).In India, the postharvest losses of banana account about 35%-40%. Postharvest losses of banana could be substantially reduced if suitable processing methods are available to local small-scale processors to undertake onsite processing of banana. Considerable losses occur during natural sun drying; lowering the qualitative and quantitative value of the dried products. The slices of unripe fruit are normally spread out on bamboo frameworks or on bare patches of earth, roofs, stone outcrops or on sheets of corrugated iron (FAO, 1995). Small-scale processors using simple technology and equipment could produce dehydrated banana in the form of dried banana slices. Unmarketable small-sized and surface-blemished banana fruits could be

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utilized to produce dried slices. There is a potential to use banana slices in the form of powder as drinks, desserts, baby foods, sweets and other products (Deka and Choudhury, 2006). Processing of banana into various products with longer shelf life such as slices/chips, powder, puree and beverages has been proposed as a way of absorbing seasonal surpluses (Balasooriyaet al.,2006).

Processing of green sliced bananas into flour is of interest in the view of the surplus fruits often available year round in the production areas (Suntharalingam, 1993). Traditionally banana slices are dried as sun drying but conventionally dried as dehydration leads to undesirable changes in quality of the dried product (dark color, leathery texture and poor flavor with a loss of nutritive values) (Maskan, 2000 ; Adeboyeet al.,2014).Most banana flour produced from the green unripe sliced banana fruits is sun dried or dried in crude ovens with variable quality (Wilson, 1975). A novel way of utilizing these green banana slices is transforming them into flour that extends shelf life and provides easy storage of banana products (Thompson and Nair,1995).Amin and Hossain (2013) designed and developed a hot water treatment plant for blanching or treating banana fruits. Blanching increased the pH value of the flour of FHIA-21 but decreased that of French and False Horn and though insignificantly increased moisture uptake in all three plantain varieties (Konuklar, 2004).Hot water blanching increased the drying rate of products such as sugar beet, carrot, mangoes and chillies (Motaand Eipeson,2000). The processes of blanching and freezing combinely used them as a pre-treatment to produce high quality dried banana (Mahendran and Prasannath, 2008).The present study was undertaken with the objective of investigating the effects of blanching on the dehydration characteristics of unripe banana slices dried at different temperatures.

2 Materials and methods

2.1 Sample preparation

Experiment was conducted at Agricultural Process and Food Engineering (APFE) Laboratory, Vaugh School of Agricultural Engineering and Technology (VSAET), Sam Higginbottom Institute of Agriculture Technology and Sciences-Deemed To be University (SHIATS). Culled green banana (*Musa acuminata*) bunches were obtained from the market as raw materials. The banana was blanched in hot water blancher and peeled manually and then cut into slices using a knife. Samples had an average diameter of 25 $\pm$0.05 mm and thickness of 6 $\pm$0.05 mm. At least ten measurements of the thickness were made at different points and only slices that fell within a 5% range of the average thickness were used. Unripe samples had an average moisture content of 75.3 $\pm$ 1.2% while ripe samples had an average moisture content of 78 $\pm$0.5%. To account for variability in the moisture content of the pulp, the initial moisture content was measured before the slices were pre-treated. The Precision Universal Penetrometer was used to determine the force needed to cut through the banana samples stored for up to three days. The penetrometer depth (10th mm/m) for unripe samples averaged 12.3 $\pm$1.0. In order to study the effects of blanching on the dehydration characteristics of unripe banana slices dried at different temperatures (50 ℃, 60 ℃ and 80 ℃).

2.2 Equipment used

There were various equipment used from the initial to the final operation i.e., cleaning of unripe banana fruits to storage of banana products. Slicer for cutting of banana into slices of desired shapes-Blender/Mixer for mixing of the food products or pulp or slurry; Tray dryer for removal of moisture from blanched banana slices; Screen for separation of banana fiber and pulp from banana starch solution were used.

2.3 Quality of banana

Weight, color and firmness of treated and untreated banana fruits were measured immediately before and after immersion in hot water blancher.

2.4 Blanching

Sliced samples were blanched by direct immersing in water at 60℃ for 10 min to avoid loss of product firmness. The samples were withdrawn from hot water blancher gently with a blotting paper to remove adhering surface water and weighed (Borges and Cal-Vidal, 1994).Sample weight, thickness and diameter were taken before and after pre-treatment. Untreated samples were used as the control.

2.5 Dehydration

After blanching, samples were spread thinly in the air drier at 50℃, 60℃ or 80℃ on a stainless steel tray. The weight, thickness and diameter of each sample had been monitored at 1h interval for 4 h then left to complete dryness. Drying curves of moisture versus time were be constructed and from these drying rate curves were obtained by method of tangents.

2.6 Moisture loss

After blanching of banana fruits, the dry matter loss was measures at different drying temperatures(50℃, 60℃ and 80℃) and time interval of 10 min. Dry matter loss indicates the loss of moisture from the banana slices that improves the quality of products.

2.7 Combined blanched and dehydration

In a tray dryer many shallow trays about 10-12 in number were kept one above the other with a gap in between in drying chamber. Treated banana slices from each of the treatments were placed in stainless steel trays and dried in a try dryer at a different temperaturesof 50℃, 60℃ and 80℃ using an air velocity of 2-2.50 m/s. Weight of the trays and the product were recorded every hour during drying of products using an electronic balance. Initial moisture content of all the blanched samples was determined using the electric balance. Drying rates were calculated based on the weight of water removed per unit time per kg throughout the drying process. Overall drying rate was calculated and defined as the ratio of total mass to water removed (kg) per unit mass of banana divided by total drying time (hr). The powder was obtained by grinding the dried sliced banana in a blender for 3 min and stored in HDPE polyethylene. Three replicates were carried out for each parameter. The chemical parameters (moisture content, ash content, protein and pH) of powder was obtained by using standard method for effect of blanching on the dehydration characteristics of unripe banana. The chemical parameters of banana powder was tested for 0 days of extraction.

3 Results and discussion

Results showed the effect of blanching on the moisture content of dehydrated unripe banana slices. The treatment conditions are consistent with those obtained for moisture content by Pacheco-Delahayeet al.,(2008)(2.36% and 41.75%) and are indicative of flours with a stable shelf life at moisture content less than 14%, and increased the pH value of the flour of unripe banana slices. Taiwo and Adeyemi (2009) observed that blanching facilitate greater moisture loss, greater product shrinkage, higher rehydration capacity and increased dry matter loss of unripe as well as ripe banana slices. Furthermore comparative study of the moisture content of the flour of the banana varieties indicated a significantly higher at blanching temperature 50^{o}C.Muyonga(2000)found that blanching significantly increased the solubility of unripe banana flour that is easily digestible**.** Pacheco-Delahayeet al., (2008); Dadzie and Jayaraman (1998) reported that the pH value range 4.6-6.5is desirable when banana flours were produced from dehydration procedures at different temperatures 50℃, 60℃ and 80℃. Deviations from reported values could be attributed to variations in temperature.

Table 1 Moisture loss at different blanching temperatures and time

Blanching temperature,	Time duration, min	Sample	Weight,		Loss of weight,
			Before	After	
50	10	A_1	293.33	286.33	7.00
		A_2	293.33	286.42	6.91
		A_3	293.33	287.47	6.86
60	10	A_1	286.66	281.66	5.00
		A_2	286.66	281.74	4.92
		A_3	286.66	281.78	4.88
80	10	A_1	263.33	260.00	3.33
		A_2	263.33	260.09	3.24
		A_3	263.33	260.12	3.21

Table 1 shows that as the blanching temperature increases the percentage of dry matter loss decreases. For 50℃ blanching temperature having time duration of 10 min the dry matter loss of samples A_1, A_2 and A_3 was 7.00, 6.91 and 6.86 gram and the percentage loss in weight was 2.38%, 2.28% and 2.24%, respectively. When the blanching temperature was 60℃ having time duration of 10 minutes the dry matter loss of sample A_1, A_2 and A_3 was 5.00, 4.92 and 4.88 gram and the percentage loss in weight was 1.75%, 1.68% and 1.65%, respectively. Similarly, when the blanching temperature was 80℃ having time duration of 10 minutes the dry matter loss of sample A_1, A_2 and A_3 was 3.33, 3.24 and 3.21 gram and the percentage loss in weight was 1.26, 1.24 and 1.22%. These experimental data shows that when the blanching temperature was increased there was a significant change in the percentage weight loss of samples A_1, A_2 and A_3. This is also depicted in Figure 1.

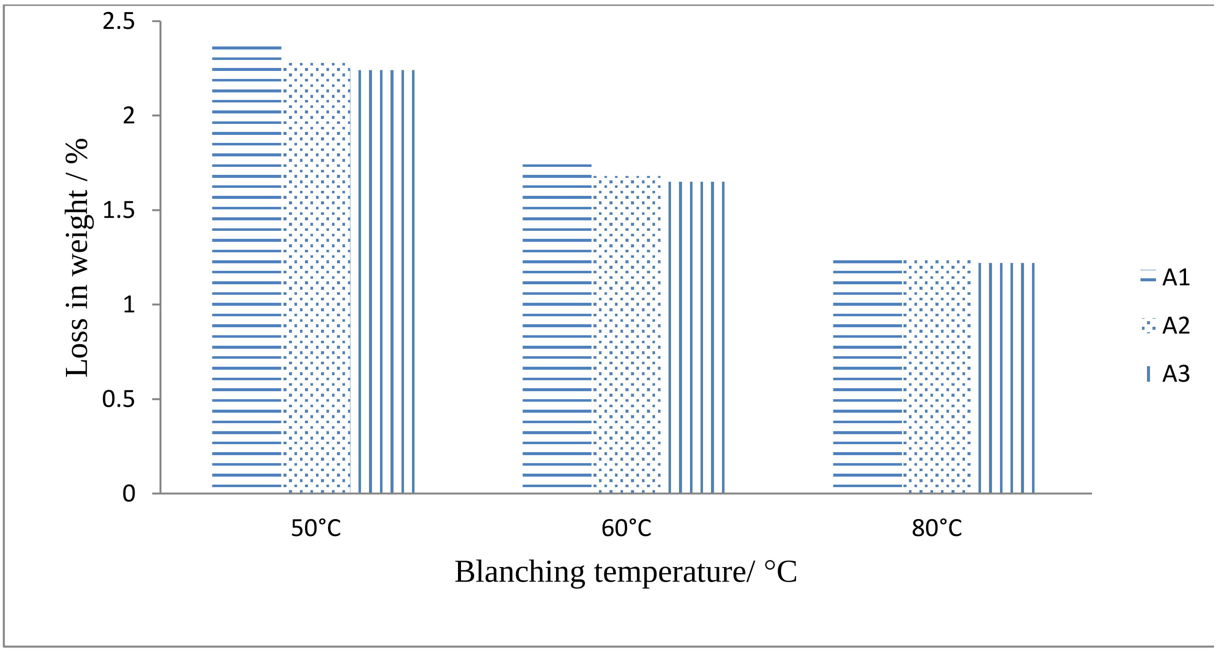

Figure 1Effect of blanching temperature on weight loss (%) of unripe banana slices

Figure1 shows that the maximum percentage of weight loss from blanched banana slices occurred at temperature 80℃ and the values of percentage of weight loss decreased with increased in temperature 50℃ and 60℃, respectively. This shows that the product banana slices at 80^{o}C were not of good quality than the blanching temperature 50 ℃ and 60 ℃.

Table 2 shows that the percentage of moisture loss from unripe banana slices at 0 day of extraction depended on tray drying temperature which was 50 ℃, 60 ℃ and

increases in the drying temperature that is not significantly viable because it is not liable for better product. Better banana flour were obtained at blanching temperature 50 ℃ as well as 60 ℃ than 80 ℃ because at higher temperature the flour texture and quality were changed and it is not suitable for easily digestible.

Table 2 Dry matter loss of samples obtained during drying at 50 ℃, 60 ℃ and 80 ℃

Samples	A_1	A_2	A_3	A_1	A_2	A_3	A_1	A_2	A_3
Tray drying temperature, ^{o}C	50	50	50	60	60	60	80	80	80
Dry matter loss, %	76.25	76.0	76.2	76.87	76.90	76.85	76.94	76.97	76.92

80 ℃. All the samples were kept under the different tray drying temperature. Dry matter loss increases with

The shrinkage/dimensional changes obtained are presented in Table 3, Table 4 and Table 5. It was evident that sample thickness reduced with time and drying temperature had a significant effect on percent change in thickness. The diameter and thickness of banana slices were measured before and after blanching and at the end of 4 hr of try drying, percent change in thickness at different temperatures were found 14% - 15.1%, 20% - 23% and 23% - 25% at 50 ℃,60 ℃ and 80 ℃ respectively. Samples dried at 60 ℃ shown an initial faster shrinkage rate in thickness but after 3hr of drying, samples dried at 80 ℃ exhibited greater shrinkage. This result suggests that the higher the temperature of drying, the greater the product shrinkage Johnsonet al.(1998) onplantains. Senadeeraet al. (2005); Taiwo and Adeyemi (2009)reported that both the rate of dimensional shrinkage and maximum dimensional shrinkage might be affected by drying temperatures. So this parameter is very important for making the product of any food materials and without these parameters we can’t observe the product quality and texture.

Table 3Shrinkage of banana slices during tray drying at 50 ℃

Time duration, hr	**Diameter, cm**		**Thickness, mm**		**Shrinkage, %**
	Before	After	Before	After	
1^{st}	2.4-2.49	2.36-2.43	5.90-6.20	5.87-5.91	1.191-1.914
2^{nd}	2.36-2.43	2.33-2.39	5.88-5.91	5.76-5.85	4.424-4.426
3^{rd}	2.33-2.38	2.30-2.34	5.76-5.85	5.71-5.80	5.620-5.641
4^{th}	2.30-2.34	2.25-2.28	5.68-5.76	5.61-5.64	6.958-6.995

Table 4 Shrinkage of banana slices during tray drying at 60 ℃

Time duration, hr	**Diameter, cm**		**Thickness, mm**		**Shrinkage, %**
	Before	After	Before	After	
1^{st}	2.42-2.55	2.39-2.52	5.80-6.42	5.79-5.88	1.205-1.215
2^{nd}	2.42-2.52	2.35-2.44	5.79-5.88	5.79-5.87	4.667-4.670
3^{rd}	2.33-2.46	2.30-2.38	5.78-5.86	5.75-5.84	5.724-5.785
4^{th}	2.30-2.46	2.25-2.40	5.73-5.84	5.28-5.39	7.202-7.565

Table 5 Shrinkage of banana slices during tray drying at 80 ℃

Time duration, hr	Diameter, cm		Thickness, mm		Shrinkage, %
	Before	After	Before	After	
1st	2.45-2.62	2.41-2.57	5.77-6.40	5.75-5.90	1.352-1.467
2nd	2.41-2.57	2.35-2.44	5.75-5.90	5.72-5.86	4.875-5.475
3rd	2.31-2.44	2.20-2.30	5.72-5.86	5.64-5.74	6.152-6.745
4th	2.20-2.31	2.16-2.21	5.64-5.74	4.80-5.30	8.230-8.825

Table 6 Chemical composition of unripe banana slices flour dried at different temperatures

Drying Temperature, ℃	Sample or Replicate used	Moisture content, % w.b	Ash,%	Protein,%	pH
	A_1	5.9	0.84	0.72	7.4
	A_2	3.2	0.83	0.71	7.0
50	A_3	3.3	0.90	0.71	7.1
	A_1	5.7	0.84	0.72	7.4
	A_2	3.1	0.83	0.70	7.0
60	A_3	3.1	0.89	0.71	7.1
	A_1	5.4	0.84	0.72	7.0
80	A_2	3.0	0.83	0.71	7.4
	A_3	3.0	0.88	0.70	7.0

The blanched and dehydrated banana slice powder was tested for chemical variation in the banana product. The Moisture content, Protein, Ash content, and pH value of all the three samples slightly decreased with rise in temperature. Adeboyeet al., (2014) observed that the protein, fat and fiber content decreased with increase in temperature but the ash content increased with increase in temperature of pretreated mature green plantain (*Musa paradisiaca*).The Moisture content, Protein, Ash content, and pH value of banana powder were not found much variation in the quality of product. The product is significantly acceptable at 5 % level of significance. The All the data were analyzed using ANOVA which is shown in table 7.

Table 7 ANOVA for percentage of dry matter loss and chemical composition of the unripe banana slices

Source of variation	df	Sum of square	Mean sum of squares	Fcal	Ftab	significance
Treatment	11	58.18	5.28	2.23	3.30	significant
Replication	2	6.35	3.17	1.34	3.42	significant
Error	22	51.83	2.36			
Total	35					

Table 7 shows the statistical analysis and found that the Fcal value was greater than Ftab value which was found to be significant for both treatment and samples at 5 % level of significance.

4 Conclusions

This study examined the effect of blanching on the dehydration characteristics of unripe banana slices dried at different temperatures (50℃, 60℃ and 80℃). Increasing drying temperatures (50℃ - 80℃) facilitated greater moisture loss, greater product shrinkage, higher dehydration capacity and increased dry matter loss. Greater shrinkage was observed along the axes (thickness) than along the diameter or radial shrinkage. Although the impact of blanching was significant on most product attributes (shrinkage, dry matter loss, moisture loss, pH and ash content). It still improved mass and solid transfer through the samples. The drying rates of all treatments were high initially when the moisture content was highest then decreased rapidly. The blanched samples had the highest moisture content whereas the dehydrated banana samples resulted in the shortest drying time compared to other treatments. Therefore blanching could be used as a pre-treatment to produce high quality dried banana slices.

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