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Effect of Microwave Blanching on Slice Thickness and Quality Analysis of Star Fruit

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Abstract

Star fruit (*Averrhoa carambola* L.) is one of the underutilized tropical fruits and is a good source of vitamins and minerals. Peroxidase (POD) is the most heat stable enzyme which is used as an indicator for adequacy of blanching process. Blanching is a prerequisite for the preservation of fruits and vegetables. Hot water blanching is having disadvantages like wastewater production and loss of valuable nutrients by leaching. Microwave blanching is one of the emerging and clean technology which seems to provide a better nutrient retention due to shorter heating time and zero wastewater production. Therefore, the present investigation was carried outto identify a suitable blanching method (hot water blanching and microwave blanching)for different slice thickness (5, 10 and 15 mm) of star fruit that ensures enzyme inactivation and maximum retention of therapeutic value (ascorbic acid and oxalic acid). It was observed that blanching at 600, 480, 240 and 120 W power level for aslice thickness of 5, 10 and 15 mm required blanching time of 30-60s, 40-70s, 60-80s, 80-150s and 300-720s respectively. For a given slice thickness, the moisture content of samples decreased with increase in power level. The moisture content was reduced to 84-88 % w.b. from an initial value of 90 % w.b. depending on power level and blanching time combinations. At the same time, the oxalic acid decreased significantly with increase in slice thickness and adecrease in power level. The change in ascorbic acid also showed a similar trend but the influence of slice thickness was not significant (p>0.05).

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Introduction

Star fruit (*Averrhoa carambola* L.) is one of the underutilized tropical fruits that belong to Oxalidaceae family[1]. The fruit is cultivated extensively in India and China and is a good source of vitamins and minerals[2,3]. It contains a high level of antioxidantas those of papaya, guava,and banana[4]. The fruit provides a considerable market potential due to its unique star shape and rich golden color. In addition, it can alsobe used as a fresh fruit and in jelly making[5,1]. This fruit contains high moisture (> 90% w.b.) at the time of harvest and causes a lot of post-harvest losses. Polyphenol oxidase and peroxidase are the main enzymes responsible for the development of browning, off flavours and nutritional damage in fruits and vegetables. Among these two, peroxidase (POD) is the most heat stable enzyme which is used as an indicator for adequacy of blanching process[6]. If this enzyme will be destroyed, the other significant enzymes would also be inactivated[7]. Blanching is a pretreatment technique for inactivating enzyme activity, preserving colour and associated changes in further processing like osmo dehydration, drying, freezing and canning. Steam and hot water blanching are the most commonly used blanching techniques in the food industry[8]. However, this blanching method produces wastewater, reduces the nutritional value of the product due to leaching of soluble compounds, and subsequently increase the pollutant charge[9].

The demand for high quality and minimally processed food is increasing which stimulated the development of new technologies that will not adverselyaffect the nutritional value of vegetables[10]. Recently, theuse of electromagnetic energy is important as a new method of food processing having advantages like lower processing time, water usage and energy with the improvement of product quality[11]. Among these, microwave blanching of vegetables offers better nutrient retention due to shorter heating time than other conventional methods[12,13,14]. This microwave blanching as dry techniques can produce less volume of wastewater and therefore, losses of water-soluble nutrients could be minimized.Therefore, the present investigation wascarried out to optimize the microwave blanching conditions for star fruitsthat ensure enzymeinactivation.

Materials and Methods

Sample Preparation and Pretreatment

The Proper maturity of star fruits of golden star variety (mature but not ripe, light yellow colour)[15] that were used throughout the experiment were procured from the Orissa University of Agriculture and Technology premises, Bhubaneswar.The collected fresh fruits were properly washed in the running water to remove dirt and foreign particles andwiped with a clean towel. The fruits were sliced crosswise using a hand-operated slicer and separated from the waste and stalk. The slices were of uniform thickness of 5, 10 and 15 mm, a common size used by the consumers. Initial moisture content was determined according to the procedure of AOAC[16]. A digital balance, (Contech, Ca224) with an accuracy of 1±0.0001 g were used for the purpose.The average moisturecontent of three replications was taken into consideration.

Hot water blanching (HWB)

About 200 ml of water wasput in a beaker and placed in a water bath at 80 °C (RSB-12, REMI, India). About 100 g of samples in the form of slices weredipped in boiling water and the time was recorded using a timer. The ratioof water to fruit slices was 4:1(v/w). After every 10 s, 5 g of samplewas removed from the beaker and immediately put in coldwater. This sample was then homogenized in a mortar pestle, filtered through muslin cloth for test on the presence of peroxidase enzyme[17]. The process was repeated for each sample blanched at the prefixed interval and the optimum blanching time was determined.

Microwave Blanching (MWB)

A programmable domestic microwave oven (Samsung, Model-CE73JD) with amaximum output of 600 W at 2450 MHz was used for this purpose. The dimensions of the microwave cavity were 215 mm x 350 mmx 330 mm. The oven was fitted with a fan for cooling of the magnetrons and to circulate the air flow inside the drying chamber. The moisture from drying chamber was removed withthe fan by passing it through the openings on the top of the oven wall to the outer atmosphere. The oven was fitted with a glass turntable (30 cm diameter) and had a digital control facility to adjust the microwave output power by the 20 % decrements and the time of processing to the lowest value of 10s.

Initially, the microwave was standardized for its efficiency. The amount of heat absorbed by a known amount of water sample due to the temperature difference was equated to input energy and the efficiency of the system was calculated.The procedure was repeated at adifferent power level and the average efficiency was determined for the microwave system to be used for the blanching operation.

For blanching treatment,about 100 g of sample in theform of slices were uniformly spread on the tissue paper and kept on the rotatable turntable to ensure the uniformity of absorption of microwave energyfor every sample. The microwave oven was allowed to operate at 600 W power level. After every 10 seconds, the system was switched to pause mode and immediately about 5 g of samples were taken out followed by cold water dipping in order to avoid the residual heating effect. Then, the peroxidase test was carried out and thus the optimum blanching time was determined. At adequate blanching stage, the samples were collected and stored ina sealed polyethylene packs in therefrigerator at 4 °C for further quality analysis of moisture content, ascorbic acid, and oxalic acid. Similar experiments were carried out at other power levels (i.e. 480 W, 360 W, 240 W, 120 W) and with adifferent slice thickness of 5, 10 and 15 mm.

Chemical Test for Adequacy of Blanching

Adequacy of blanching was tested by Guaicol peroxidase method[17]. One gram of guaicol was dissolved in about 50 ml of 50 % ethyl alcohol and the volume was made up to 100 ml with the same solvent. Peroxide solution of 5ml (0.3 %)was marked up to 150 ml with distilled water. One milliliter of hydrogen peroxide (H_2O_2) was added to a test tube containing the homogenized sample, and 0.5 ml of guaicol solution was added. The tube was kept aside for sometime for development of colour. The appearance of red colourconfirmed the presence of peroxidase. The process wasrepeated untilthe red colour disappeared. The time period of microwave heating required for the disappearance of red colour was called the blanching time for the sample under this study.

Quality Analysis of Star Fruit

Estimation of Ascorbic Acid

Ascorbic acid content of star fruit was estimated using thestandard method of Ranganna[18] based on the reduction of 2,6-diclorophenol indophenols dye by ascorbic acid. 10 g of sample was weighed andground in a mortar pestle by adding 10 ml of 3 % metaphosphoric acid. Then,40 ml of metaphosphoric acid was added and filtered through a filter paper. The mixture was centrifuged and thesupernatant was taken and transferred to a volumetric flask. This was rapidly titrated with 2, 6-diclorophenol indophenol solution until a distinct light rose pink colour persisted for more than 5 seconds. The standard solution of ascorbic acid was also treated against the dye. The ascorbic acid was determined using the standard formula.

Estimation of Oxalic Acid

The procedure of calcium oxalate[19] has been standardized and modified for star fruit and used in the present investigation. 60 ml of distilled water was added to 3 g sample and was boiled followed by addition of 0.3 g of calcium chloride and the mixture was allowed to stand for 16 h at room temperature. The precipitated calcium oxalate is separated by centrifuging, the supernatant fluid was decanted,and the precipitate was washed with dilute ammonia (20 %, 20 ml per each sample)solution for twice. The washed precipitate was dissolved in 1N sulfuric acid and the solution was titrated with0.1N $KMnO_4$ at 60-70 °C. (1ml of 0.1N$KMnO_4$ was equivalent to 4.5 mg of anhydrousoxalic acid).

Statistical Analysis

Analysis of variance (Microsoft Excel, version 2010) was applied to test the differences inquality characteristics[final moisture content (FMC), ascorbic acid (AA) and oxalic acid (OA)] of samples with different conditions of blanching.

Results and Discussion

Effect of Hot Water Blanching on Quality Characteristics

In order to study the effect of theadequacy of blanching onquality characteristics of the slices, a comparison was made with those of fresh slices. The initial value of moisture content, ascorbic acid, and oxalic acid was 909.14 % d.b., 743.67 mg / 100 g dry matter and 28.04 mg / g dry matter, respectively (Table 1). After blanching with hot water, the final moisture content, ascorbic acid, and oxalic acid were found to be in arange between 909.79 to 911.12 % d.b., 432.12 to 589.32 mg/100g dry matter, 14.23 to 19.86 mg/g dry matter, respectively. The final moisture content increased slightly after the hot water blanching. The percentage reduction inascorbic and oxalic acid content was found to be in the range of 20.75 %-41.89 % and 29.17 %-49.25 %, respectively. The losses of ascorbic acid and oxalic acid were more in the case of hot water blanching compared to microwave blanching (Table 2)[7]. Ruiz-Ojeda *et al.,* [9] reported the losses of ascorbic acid of green beans to half of the original value in hot water blanching (92 °C for 200s). Therefore, further statistical analysis has not made for hot water blanching.

Table 1: Hot water Blanching and its effect on quality characteristics

Description	Thickness (mm)	Blanching time (sec)	Final moisture content (% d.b.)	Ascorbic acid (mg / 100 g DM)	Oxalic acid(mg / g DM)
Fresh (unblanched)	-	-	909.14	743.67	28.04
Hot water blanching	5	80	909.79	589.32	19.86
(80°C)	10	130	910.56	487.56	17.38
	15	320	911.12	432.12	14.23

*DM is dry matter

Table 2: Effect of power level and slice thickness on blanching time and quality characteristics of star fruit slices

Power level (W)	Thickness (mm)	Blanching time (sec)	Final moisture content (% d.b.)	Ascorbic acid (mg / 100 g DM)	Oxalic acid (mg / g DM)
600	5	30	538.57	660.34	25.86
	10	50	652.45	649.54	23.38
	15	60	678.21	616.34	21.23
480	5	40	556.17	614.21	25.54
	10	50	676.40	605.00	22.48
	15	70	688.64	593.00	19.54
360	5	60	591.56	612.12	25.38
	10	70	713.67	598.16	21.07
	15	80	703.21	592.17	16.47
240	5	80	620.46	582.21	24.87
	10	90	694.28	532.73	20.31
	15	150	750.34	582.31	15.76
120	5	300	_	-	_
	10	450	_	-	_
	15	720	_	-	_

Standardization of Microwave Blanching

Peroxidase is the most thermally stable enzyme present in the plant system for which it is used as an index for the effectiveness of blanching treatments. If this enzyme is inactivated, other enzymatic systems (like polyphenol oxidase and polygalacturonase) responsible for tissue degradation is also inactivated. As explained earlier, the microwave system used for this experiment was tested and the average efficiency was found to be 77 % as far as heat transfer was concerned.

Blanching Time for Adequacy of Blanching at Different Slice Thickness

Results of standardization of adequacy of blanching for microwave are shown in Table 2. It was observed that microwave blanching time at 600, 480, 240 and 120 W power level for aslice thickness of 5, 10 and 15 mm was ina rangeof 30-60s, 40-70s, 60-80s, 80-150s and 300-720s, respectively. Since the blanching time at 120 W was exceptionally high and some of the colors were observed in isolated patches of the fruit slices;therefore, the samples obtained at this power level was discarded without further analysis. This is probably due to higher blanching time for which the product is subjected to heat energy for a relatively longer period.

According to Table 2, it was observed that the blanching time decreased with increase in power level but increased with increase in slice thickness. This may bedue to the low rate of heat transfer at lower power level leading to more time requirement for enzyme inactivation. However, for any power level, the blanching time variation was higher when the slice thickness was increased from 10 to 15 mm than that offrom 5 to 10 mm. Similarly, this variation was significantly higher at the lower power level. Two-way ANOVA without replication (Table 3) indicated ($p<0.05$ for both power level and slice thickness) change in blanching time with the change in both slice thickness and power level (Fig.1.). Ramesh *et al.,*[11] studied the microwave blanching of bell pepper, spinach, carrots and reported the decrease in blanching time with increase power level compared to conventional hot water blanching. Ruiz-Ojeda *et al.,*[9] also reported the decrease in enzyme activity with increase in processing time and power level.

Effect of Microwave Power Level and Slice Thickness on Biochemical Quality

The process of microwave blanching influenced the biochemical quality characteristics namely moisture content, ascorbic acid, and oxalic acid. Fig. 1, 2, 3 and Table 2 presents the post-blanching values of these parameters at adifferent power level and blanching time combinations. The moisture content of the sample decreased with increase in power level for a particular thickness. This may be due to the moisture evaporation due to volumetric heating by

Table 3: Two-way ANOVA summary table for blanching time and quality of microwave blanched sample

Source of Variation	df	SS	MS	F	P-value
Blanching time, min					
Power level	3	6491.667	2163.889	11.985	0.006
Slice thickness	2	2916.667	1458.333	8.077	0.019
Error	6	1083.333	180.556		
Total	11	10491.670			
Final Moisture content (% d.b.)					
Power level	3	7663.512	2554.504	10.708	0.008
Slice thickness	2	37979.170	18989.580	79.601	0.000
Error	6	1431.352	238.559		
Total	11	47074.030			
Ascorbic acid (mg / 100g DM)					
Power level	3	8760.221	2920.074	9.034	0.012
Slice thickness	2	1183.475	591.737	1.831	0.239
Error	6	1939.455	323.242		
Total	11	11883.150			
Oxalic acid (mg / g DM)					
Power level	3	18.810	6.270	5.123	0.043
Slice thickness	2	102.645	51.322	41.937	0.000
Error	6	7.343	1.224		
Total	11	128.79			

*Ftable - 4.75 to 5.14, where, d.b. is dry basis,DM is dry matter, SS is sum of square, MS is mean square

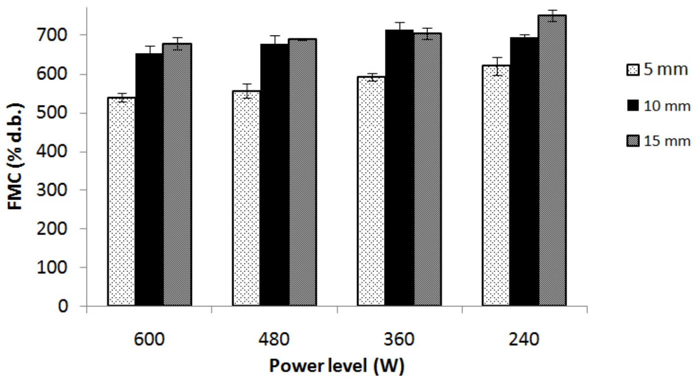

Fig.1: Effect of power level and blanching time combination on FMC for different slice thickness

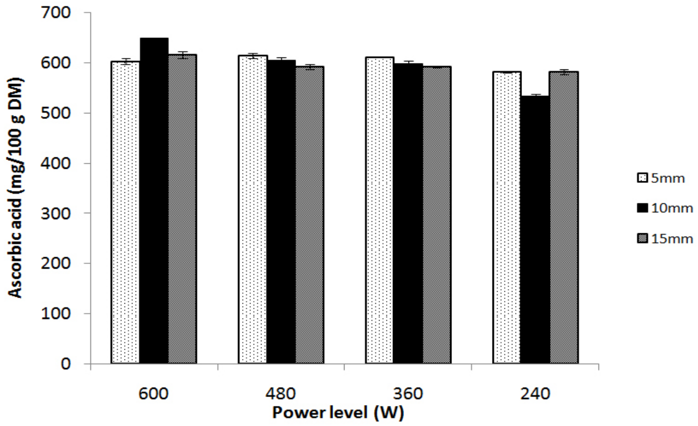

Fig. 2: Effect of power level and blanching time combination on AA for different slice thickness

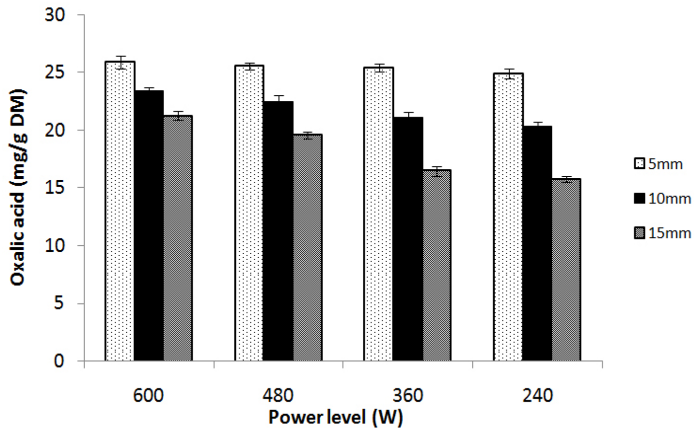

Fig. 3: Effect of power level and blanching time combination on OA for different slice thickness

the microwaves.The results are in accordance with Ramesh *et al.,* [11]. A significant increasing ($p<0.05$) trend (Table 3) was observed with increased slice thickness for each power level. This may be due to lower surface area availability per unit mass of samples with higher thickness.There was a reduction in moisture content in the range of 84-88 % depending on power level and blanching time combinations. On the contrary, the oxalic acid decreased significantly with increase in slice thickness(due to the higher blanching time for which the product is subjected to heat energy for a relatively longer period) and decrease in power level. The change in ascorbic acid also showed a similar trend but the influence of slice thickness was not significant ($p>0.05$). The AA decrease with increase in blanching time and slice thickness. Ruiz-Ojeda *et al.,*[9] reported the decrease of ascorbic acid with increases of power level and processing time for blanching of green beans.The decrease in vitamin C with increase in microwave power level and blanching time is also reported by Ramesh *et al.,*[11] for vegetables and Dwivedy and Rayaguru[7] for Indian borage leaves.

Conclusions

Hot water blanching is not suitable for star fruit slices due to ahugeloss of ascorbic and oxalic acids. Microwave blanching may be a better way as a pre-treatment for drying of the fruit slices. Overall analysis on microwave blanching indicated that blanching at lower power level required higher blanching time for which there was aloss of qualitative properties. The slice thickness of the fruit affects significantly the quality parameters. Therefore, the optimum blanching parameters selected were: power level 600 W with 30s blanching time for 15 mm slice thickness and power level 480 W with 50 and 60s blanching time for 5 and 10 mm slice thickness respectively.

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Conflict of interest

The authors have no conflict of interest.

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