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Development of a methodology for production of dehydrated tomato powder and study the acceptability of the product

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Tomato is one of the most popular and widely grown vegetable crops in Sri Lanka. A wide variety of tomato products are prepared by concentrated juice or pulp, which needs high cost technology for good quality products. This study was conducted to develop a suitable drying method for production of dehydrated tomato powder and to study the application of that in food preparations. Optimum processing conditions to develop dehydrated tomato powder were determined based on product color and water activity. The acceptability of the product was tested through physico-chemical and microbiological analysis of the powder. Organoleptic properties of the powder were tested using a sensory evaluation test after serving tomao sauce and leather, produced using dried tomato powder. Suitable packaging material for storage of the tomato powder was selected based on the changes in moisture content, water activity and rehydration ratio of the product. Results revealed that blanching at 60 ^{o}C hot water for one minute followed by dehydration at 55 ^{o}C for 48 hours was successful to preserve color and obtain a shelf-stable product with good physico-chemical properties. Dried tomato powder packaged in pouches made out of triple laminated Aluminium foil could be stored at 31±2 ^{o}C and 65±5% relative humidity for six months without quality deterioration.

Key words: Tomato, dehydration, packaging, sauce, leather

Introduction

Tomato is one of the most popular and widely grown vegetable crops in Sri Lanka and it is easily grown in all agro-ecological zones of the country with average yield of 9.8 metric tons per hectare (www.agridept.gov.lk). Tomato is consumed throughout the year with different forms. It is very appetizing,

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refreshing and has a pleasing taste. Fruits are eaten as raw or cooked. It can be cooked alone or mixed with other vegetables. Even though the ripe tomato contains about 94 % moisture, it is an excellent source of minerals and vitamins. Tomato contains large amounts of vitamin C, and A, providing 40 % and 15 % of the daily value, respectively. Moreover, the lycopene, red pigment contains in tomatoes act as an antioxidant, neutralizing free radicals that can damage cells in the body inhibiting the lung, breast, and endometrial cancer cells and cut down the risk of developing prostate cancer by 45% (www.philippineherbalmedicine.org).

However, marketing of fresh tomato during the season is a great problem because of its short postharvest life, which leads to high postharvest losses. The postharvest losses reported for tomatoes are around 54% (www.agridept.gov.lk). Short shelflife coupled with inadequate processing facilities results in heavy revenue loss to the country. Therefore development of preservation methods is beneficial to farmers who produce large quantities of tomatoes. A wide variety of tomato products are prepared using concentrated juice or pulp, which needs high cost technology for good quality products. Therefore development of low cost processing and packaging methodologies to produce shelf-stable and convenience products are the prime requirements of present competitive market. Therefore drying is the most suitable method to full fill the above requirements.

Hence this study was carried out to establish processing variables to develop dehydrated tomato powder. The physico-chemical properties of the fresh and the dehydrated products were analysed. The sensory quality of the dehydrated product was tested by preparing sauce and leather from dehydrated powder. A suitable packaging material for the dehydrated product was also identified.

Materials and methods

The experiment was conducted at the Research and Development Center of Institute of Post Harvest Technology, Anuradhapura, Sri Lanka.

Sample collection

Ripe tomatoes (Variety : Roma) were purchased from a commercial farm and transported to the laboratory. Diseased and damaged fruits were discarded to minimize biological variability.

Development of processing parameters

Ripe tomatoes were subjected to two different blanching temperatures, namely 60 ^{o}C and 100 ^{o}C hot water blanching for 1 minute. Blanched tomatoes were sliced to 5-8 mm thickness and dried at 50, 55 and 60 ^{o}C, using a cross flow air dryer until the water activity of the product reduced to below 0.60. The dried slices were ground using a laboratory grinder. The best blanching and drying temperature were established based on the organoleptic properties of the dried and reconstituted product and drying time.

Construction of a drying curve and drying rate curve

The drying curve was obtained by plotting the residual moisture content (dry basis) against corresponding time. The residual moisture content was determined at 3 hours intervals. The drying rate curve was obtained using the drying curve.

Physico-chemical analysis of the product

Water activity

Water activity of the fresh and dehydrated products was determined in triplicate according to the method of Karel (1975) by measuring the equilibrium relative humidity using a hygrometer (Model : Testo 635, accuracy $\pm$ 0.03).

Rehydration ratio

Rehydration ratio of the product was measured using the method of Ranganna (1986).

Proximate analysis

Moisture, total ash, crude protein, crude fat and crude fiber content of the dehydrated and fresh tomato were determined in triplicates according to the standard methods of AOAC (1990).

Microbiological study

Total plate count of the dried product was evaluated using the methods of SLS :516 part 1 (1991).

Sensory evaluation of the developed products

Tomato sauce and tomato leather were prepared using reconstituted tomato powder and control samples were prepared using fresh tomatoes. The prepared sauce and leather were tested for colour, taste, consistency/texture, and overall acceptability by using a sensory evaluation panel consisting of 30 panelists and a Five-point Hedonic scale (1-extremely dislike, 5-extremely like). The results were analysed by the Friedman test of the MINITAB statistical package.

Storage study

Dehydrated tomato powder was packaged in polystyrene cups, polyvinylchloride (PVC) trays, pouches made from polypropylene and triple laminated aluminum bags (PE/Al/PET) and stored under ambient conditions for 6 months period. Samples were withdrawn in two month interval in triplicates and moisture content, water activity, rehydration ratio and microbiological analysis were conducted.

Data analysis

The data of physico-chemical analysis and microbiological analysis were subjected to analysis of variance (ANOVA). General Linear Model Procedure developed by Statistical Analysis System was used to perform ANOVA. Treatment means were compared at $p<0.05$ according to the Duncan's New Multiple Range Test (DNMRT) and Least Significant Difference (LSD).

Results and discussions

Development of processing parameters

Pre-treatment condition of blanching, affected the colour of the dehydrated product (Table 1). Blanching at 60 ^{o}C hot water resulted bright red coloured product which was acceptable while blanching at 100 ^{o}C hot water resulted a brownish red colored product which was not acceptable. Therefore hot water blanching at 60 ^{o}C for 1 min. was found to be the most effective pre-treatment in preservation of red color of the dehydrated product. Toor and Savage (2006) also have reported that, color of dehydrated tomatoes could be improved by low temperature treatments. Drying at 50 ^{0}C temperature took a long time period (72 hours) for drying and drying at 60 ^{0}C temperature required 39 hours for drying, however, the product colour was not acceptable at this temperature due to brownish red colour. Among different drying temperatures tried out in this study, drying at 55 ^{o}C was found to be the best that produced the acceptable color with lower drying time.

Table 1. Effect of blanching and drying temperature and blanching temperature on product quality

Treatment condition	Observations
Blanching temperature	
60 ^{0}C	Colour was acceptable (Bright red colour)
100 ^{0}C	Colour was not in acceptable level (brownish red colour).
Drying temperature	
50 ^{0}C	Drying time was too long (72 hours) colour of the product was acceptable.
55 ^{0}C	Drying time 48 hours. Colour of the product was acceptable (Bright red colour)
60 ^{0}C	Drying time was law (39 hours) but colour was not acceptable (brownish red colour).

Note: Three samples from each treatment were observed.

Drying and drying rate curves

Change of moisture content during drying and drying rate of tomato slices is shown in Fig. 1. Initially the moisture decreased rapidly and afterwards slowed down and reached to the equilibrium moisture content of 7.4 %, after 48 hr of drying. During drying, a slow rate of drying was observed up to 12 hr followed by a rapid rate of drying period for 6 hr and thereafter a falling rate period. The falling rate of drying was observed with out any constant rate period. This corresponds to the findings of Hussian *et al* (1972) who stated that high moisture foods usually have falling rate period drying only. This may be attributed to low diffusion of moisture within the tomato slices than that of evaporation of moisture from the surface. It can be observed in Fig. 1 that the drying rate increased rapidly during the first 21 hr of the drying (when the moisture content was quite high) and then slowed down later when the moisture content of the samples declined. In the early stages of drying, food material behaves as though the surface is saturated with water and the drying rate was high.

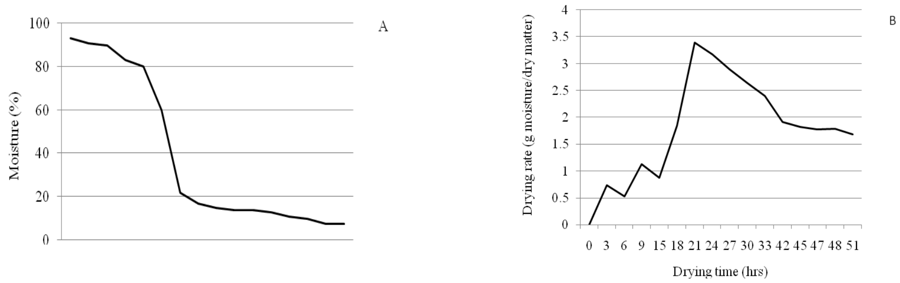

Fig. 1. Drying (A) and drying rate (B) curves for dehydration of tomato at 55 °C

Physico-chemical analysis

Water activity reduced from 0.84 to 0.61 when moisture content was reduced from 93.2 % to 7.4 % during drying at 55 °C for 48 hr. Dehydration has not significantly changed ($\alpha = 0.05$) on the crude fat, crude fiber and total ash content. However crude protein content has reduced significantly (Table 2).

Table 2. Physico-chemical properties of fresh tomato and dehydrated tomato powder

Property	Fresh tomato	Dehydrated tomato powder	$LSD_{0.05}$
Moisture	93.2^{a}	7.4^{b}	0.51
Water activity	0.84^{a}	0.61^{b}	0.01
Crude fat	6.9^{a}	6.9^{a}	0.08
Crude fiber	0.07^{a}	0.07^{a}	0.01
Crude protein	1.9^{a}	1.4^{b}	0.04
Total ash	7.5^{a}	7.5^{a}	0.06

Note: Each value represent mean of triplicate. Composition was given as on dry weight basis per 100g of edible portion.

Sensory evaluation of the developed products

The developed products of tomato sauce and tomato leather were tested for colour, taste, consistency/texture, and overall acceptability. The processing parameters were successfully established in this study to minimize changes in quality attributes. The same was reflected in the mean preference scores of thirty panelists. The estimated medians for odour, consistency/texture, taste, color and overall acceptability, of the two products were above the point "like very much" which corresponds to number 4 of the 5- point Hedonic scale (Fig. 2).

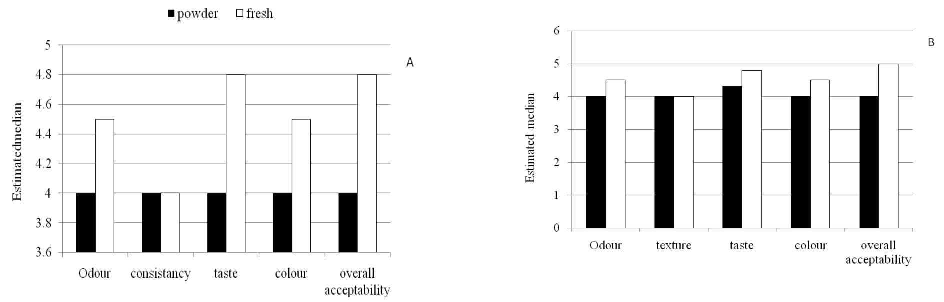

Fig. 2. Estimated means for sensory quality attributes of sauce (A) and leather (B) prepared using fresh tomato and dehydrated tomato powder

The two treatments were different in colour and odour at significance (α = 0.05) level. But as far as the taste was concerned, the difference was insignificant. This means that the blanching or the drying method used had no effect on taste of the tomato powder. The average overall acceptability score was 4, which implies that the dried tomato powder was accepted by the panel.

When comparing colour of the sauce prepared using powder was in low level. It may be due to the reduction of lycopene content in the tomato fruits during dehydration process. Actually Tripathi and Nath (1989) stated that non-enzymatic browning in the dried tomato slices may be due to oxidation and polymerization of ascorbic acid, sugar caramalization and polymerization of lycopene.

Storability of the tomato powder and selecting a suitable packaging material

Moisture content, the water activity and rehydration ratio did not changed significantly ($p<0.05$) during storage for 6 months at 31±2 ^{o}C and 65±5% RH in pouches made out of triple laminated pouches (Table 3). Shelf-life up to 3 months at 27 ^{o}C has been reported for dehydrated mushroom packaged in foil laminate pouches (Jayathunge and Illeperuma, 2001). PP, PS and PVC were found to be unsuitable for storage of dehydrated tomato powder as the moisture content and water activity increased and rehydration ratio decreased during storage (Table 4). Sagar and Maini (1997) have reported that there is a structural deterioration in products when stored in OPP/CPP leading to reduction in rehydration ratio, thus affecting consumer preference after some time. Jay (2000) has also reported that, when water activity of dehydrated foods increase, structural changes may occur leading inability of the dried product to rehydrate fully.

Table 3. Changes of moisture content, water activity and rehydration ratio during storage of tomato powder in different packaging materials under ambient conditions (31±2 ^{o}C and 65±5% RH)

Packaging material	**Storage period (Months)**	**Quality parameter**		
		Moisture	Water activity	Rehydration ratio
	Initial	7.4	0.61	6.3
Polypropylene (PP)	Two	7.5	0.61	6.3
	Four	7.9	0.62	5.3
	Six	12.3	0.65	2.2
Polystyrene (PS)	Two	8.0	0.63	5.3
	Four	9.8	0.69	2.3
	Six	16.5	0.71	2.2
Polyvinyl chloride (PVC)	Two	12.0	0.69	5.2
	Four	15.6	0.75	3.5
	Six	22.0	0.77	2.9
Triple laminated aluminium (PET/Al/PE)	Two	7.4	0.61	6.3
	Four	7.4	0.61	6.3
	Six	7.4	0.61	6.3

Note: Each value represent mean of triplicate. Composition was given as on dry weight basis per 100g of edible portion.

Table 4. Effect of packaging material on microbial count of dehydrated tomato powder during storage at ambient conditions (31±2 ^{o}C and 65±5% RH)

Storage period (months)	**Packaging material**	**Total plate count (TPC) CFU/g**
Initial		1.06 x 10^{2}
Polypropylene (PP)	Two	1.23 x 10^{2}
	Four	1.62 x 10^{2}
	Six	2.46 x 10^{2}
Polystyrene (PS)	Two	1.91 x 10^{2}
	Four	2.95 x 10^{2}
	Six	4.45 x 10^{2}
Polyvinyl chloride (PVC)	Two	1.20 x 10^{2}
	Four	1.55 x 10^{2}
	Six	2.36 x 10^{2}
Triple laminated aluminium (PET/Al/PE)	Two	1.06 x 10^{2}
	Four	1.06 x 10^{2}
	Six	1.06 x 10^{2}

Note: Each value represent mean of triplicate. Composition was given as on dry weight basis per 100 g of edible portion.

Microbiological quality

Microbiological quality is a common criterion used to determine the acceptability and shelflife of dehydrated plant based products. Although some microorganisms are destroyed in the process of drying, this process is not lethal to all microbes. Microbial count of the dehydrated foods depends on handling quality of utensils used during the processing period (Jay, 2000). All packaging materials were capable of maintaining the microbial load below 10^2 throughout the storage. That may be due to maintenance of water activity below 0.75 in samples packaged in all packaging materials (Table 3). Earlier researches have suggested that dried foods to be held for several years should be processed to reach the final water activity of 0.60 to 0.75 (Jay, 2000). Moreover all packaging materials except polyvinyl chloride were able to maintain the moisture content between 14-20 %, which the alarm water content suggested for storage stability of dehydrated foods (Jay, 2000).

Conclusions

Immersing tomatoes in 60 ^{0}C hot water for 1 min followed by cutting and drying at 55 ^{0}C for 48 hrs and powdering was sufficient to obtain a product with good physico-chemical and organoleptic properties. Pouches made from triple laminated aluminum foil were found to be suitable for storage of dehydrated tomato powder for 6 months at 31±2 ^{o}C and 65±5% RH.

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