Dehydration of Concentrated Tomato Juice: Nutrient Composition and Organoleptic Qualities

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ABSTRACT

Tomato is a most popular and demanding vegetable grown in the tropics. The postharvest loss of tomato is estimated to 40-60%, which eventually contributes to high market prices. There is a great potential to use instant tomato powder in formulated drinks, baby foods, soups and other products. Therefore, a study was conducted to produce tomato powders using foam mat drying, spray drying and vacuum drying and to evaluate the quality characteristics of the tomato powder. A consumer preference test was conducted to determine the sensory attributes of the reconstituted tomato juice and to compare the final product with the commercial products. The moisture content of tomato powder ranged from 1.73 to3.57% on dry weight basis. The moisture content of the spray dried powder was lower than that of foam mat dried powder. During drying, a significant reduction ($p<0.05$) in titratable acidity of 23% and increase in pH of 0.62units after vacuum drying of tomato juice indicated that some acids were lost due to evaporation during drying. The oxidative loss of ascorbic acid following vacuum drying was 22.7% which was higher than following foam mat drying (11.6%) and spray drying (8.26%) with 70% Tomato solids + 30% Maltodextrin. Ready-to-serve (RTS) tomato nectars were prepared from fruit powders and were compared with those prepared from fresh juice. Maltodextrin proved to be the effective additive, reducing the wall deposition markedly and producing a product of acceptable flavour and with good free-flowing properties. The foam mat drying is an expensive method to apply commercially, therefore, spray drying may be the best alternative for producing tomato powder with good stability. Keywords: Physico-chemical qualities, maltodextrin, sensory analysis, spray drying, tomato powder.

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1.INTRODUCTION

Tomato (*Lycopersicon esculentum*)is a major vegetable crop that has achieves tremendous popularity over the last few decades. It is grown in practically every country of the world - in outdoor fields, greenhouses and net houses. Tomatoes, aside from being tasty, are very healthy as they are a good source of vitamins A and C. Tomatoes are not properly utilized especially during the peak production time due to lack of knowledge in using appropriate technologies. It is estimated that 40 - 60% of the harvested tomatoes go waste annually [1].

Postharvest management determines food quality and safety, competitiveness in the market, and the profits earned by producers. The major constraints in postharvest management of tomatoes include inefficient handling and transportation; poor technologies for storage, processing and packaging and poor infrastructure facilities. Thus, in the productive seasons, farmers do not get a good price for their produce because of the glut and some of it is spoilt resulting in complete loss. In light of the incidence of the huge postharvest losses in Sri Lanka and new challenges faced under trade liberalization and globalization, serious efforts are needed to reduce postharvest losses of tomatoes. Another approach for solving this problem is to process the tomatoes into various products which could be preserved for a long time and add value to the product.

Dehydration is one of the techniques most utilized in the food industry and under optimal processing conditions it has proved to be an effective method to obtain several products. Drying is the major food processing operation to increase the shelf life of tomatoes. The purpose of drying of tomato juices is to produce a stable and easily handled form of the juice, which re-constitutes rapidly to a quality product resembling the original juice. Dried juice products are used mainly as convenience foods and have long storage life at ordinary temperatures [2].

Tomato pulp and juice drying has great economic potential. Dehydration of tomatoes into powdered particles gives a considerable reduction in volume and is an effective method of prolonging the shelf life of tomatoes and tomato products. There is a potential use of powders in drinks, baby foods, soups and other products. Currently polysaccharides are widely used additive to obtain fruit and vegetable powders since it satisfies the demand and is reasonably cheap.

Dried tomato powder is one of the most flavored powder masala which is being used in various recipes. This aromatic tomato masala powder is available at every grocery store and is marketed from several brand names. Therefore, the objectives of this study were to produce tomato powders using vacuum drying, spray drying and foam mat drying methods and to evaluate the effects of drying on the quality characteristics of the tomato powders. A consumer preference test was conducted to determine the sensory attributes of the reconstituted tomato juice and to compare the final product with the commercial products available in the market.

2. MATERIALS AND METHODS

Raw Materials

Mature green tomatoes of (cv. *Thilina*) were ripened 30°C. The ripe fruits were washed thoroughly and trimmed to remove the stem and blossom ends. Immature, rotten and damaged fruits were discarded. The ripe fruits were cut into quarters and passed through an Apex mill pulper (HC 721-6) using a 250 μm mesh sieve.The pressed juice was concentrated by reverse osmosis in a plate and frame model (HR-98, Spain) of 0.72m^2 filtration surface composed polyethylene composite layer membranes (95% NaCl rejection).

Drying Methods

Foam-Mat Drying: Concentrated tomato juice of 300 ml was agitated using hand blender (Ovanda - HHB10 E, India) at 10,000 rpm. Tricalcium phosphate at 1.0% was added to develop the foam that increased the surface area because of air incorporation. Carboxy methyl cellulose (CMC) at 0.25% was also added as foam-stabilising agent. Foamed juice was poured in food grade stainless steel trays and dried in tray dryer (MSW-210, Macro Scientific Work, India) at drying air temperature of 70ºC. The dried product was scraped and pulverized in domestic grinder and stored in dark glass airtight bottles at 20$\pm$1ºC for further studies.

Vacuum Drying: The vacuum drier (Model 21009, Wisconsin) was a batch type and the drying temperature was maintained by passing the hot air into the system. An approximately 2 cm thick layer of concentrated tomato juice was spread on cheese cloth and placed over a wire mesh tray which was placed in the tunnel drier for drying. The air temperature was set to 70°C for the first 3 h and then reduced to 50°C. The total drying time was 12 h as judged by the appearance of the dried product. The powder was obtained by grinding the dried material in a grinder (VIK-1017, UK) for 3 min and stored in dark glass airtight bottles at 20 $\pm$ 1ºC.

Spray Drying: A laboratory scale counter-current spray drier (Nano-Anhydro LAB 209, Italy) with vaned centrifugal atomizer driven by an air turbine at speeds upto 40,000 rpm was used. The inlet temperature of the feed material was 140°C and the outlet (product) temperature was set to 70°C by regulating the feed pump speed. Corn maltodextrin DE-10 was added to the tomato juice before spray drying. The feed stock was atomized uniformly but difficulties were encountered owing to the slow flow rate through the gravity feed systems of the spray drier. Powder was separated from hot air by a cyclone and stored in dark glass airtight containers at 20ºC.

Based on the formula developed for spray drying of fruit juices by [3], the following combinations were selected for spray drying:

Tomato concentrates 70% + Maltodextrin 30%

Tomato concentrates 60% + Maltodextrin 40%

Tomato concentrates 50% + Maltodextrin 50%

Tomato concentrates 40% + Maltodextrin 60%

Analytical Methods

Moisture content was determined using a vacuum oven operated at 70°C at 100 kPa for 24 hr. Results are expressed as % on dry matter basis. The pH was measured using a digital pH meter (EIL 7045, UK) with a glass electrode. The reducing and total sugars were determined by standard AOAC [4] methods. Total ascorbic acid content was estimated using the sodium salt of 2, 6-dichloro-phenol-indophenol dye solution. Measurement of titratable acidity was conducted using a standard 1% phenolphthalein solution, titrated against 0.1N NaOH and the result was expressed as grams of anhydrous citric acid per 100g of sample. Total Soluble Solids (TSS) were measured using a RFM Refractometer (ATC-79) and expressed as °Brix.

Sensory Analysis

Sensory analysis was carried out by 20 panelists (11 females and 9 males; aged 21 to 46 years) to evaluate the colour, sweetness, aroma, flavour, consistency and overall acceptability of the reconstituted tomato juice using a descriptive analysis with scaling. A 50ml of juice at 7°C was presented to each panelist.

Testing was conducted twice for each panelist in individual boots equipped with white florescent lights.

Judges were given distilled water and crackers to cleanse their palates between samples.

Statistical Analysis

Data were statistically examined by analysis of variance and means separated by Duncan's multiple range tests. All statistical analysis was conducted using SAS version 6.0 (SAS Inst. Cary, N.C., USA).Descriptive statistics was done on sensory attributes and the means were compared using the Friedman test.

3. RESULTS AND DISCUSSION

The effect of different drying methods on the Chemical characteristics of dehydrated tomato juice is shown in the Table 1. The moisture content of tomato powder ranged from 1.73–3.57% on dry weight basis. The moisture content of the spray dried powder was lower than that of foam mat dried powder. Similar results were reported for mango [5], pineapple [6] and citrus[7] in the dried fruit powders. Increasing the maltodextrin concentration during spray drying resulted in decrease in moisture content of dried tomato powder, probably due to an increase in solids in the feed and reduced amount of free water. All the successful experiments in spray drying lead to moisture content lower than 3% with good free-flowing properties. The inlet and outlet air temperatures are usually the main variables controlling moisture content in the powder.

Table 1: Effect of Different Drying Methods on the Nutritional Quality of Tomato Powder

Treatments	Moisture (% Dry basis)	pH	Titratable acidity (% citric acid)	Total sugars (%)
Fresh Tomato concentrate	96.4±1.21	3.68±0.12	1.02±0.006	3.89±0.11
Foam mat-dried	3.57±0.04^{d}	3.79±0.13^{a}	0.92±0.004^{c}	2.84±0.15^{b}
Vacuum-dried	1.73±0.03^{a}	4.30±0.10^{d}	0.79±0.008^{a}	2.04±0.12^{a}
Spray- dried				
Tomato concentrate 70% + Maltodextrin 30%	2.87±0.04^{c}	3.89±0.11^{ab}	0.88±0.004^{bc}	3.32±0.09^{c}
Tomato concentrate 60% + Maltodextrin 40%	2.76±0.02^{c}	3.98±0.09^{b}	0.86±0.007^{b}	3.11±0.10^{c}
Tomato concentrate 50% + Maltodextrin 50%	2.53±0.03^{bc}	4.12±0.10^{b}	0.85±0.005^{b}	2.89±0.13^{bc}
Tomato concentrate 40% + Maltodextrin 60%	2.46±0.04^{b}	4.24±0.13^{c}	0.80±0.008^{a}	2.72±0.11^{b}

Values are the means of triplicates± standard error.

Values in the same column bearing different letters are significantly different at 5% level.

The fruit juice to maltodextrin ratio could be increased by decreasing the inlet air temperature and/or by using maltodextrin with low dextrose equivalent [8]. During drying, a significant reduction (p<0.05) in titratable acidity of 23% and increase in pH of 0.62 after vacuum oven drying of tomato juice indicated that some acids were lost due to evaporation during drying. [9]stated a noticeable loss in the titratable acidity after drying of fruits and vegetable juice.

The oxidative loss of ascorbic acid following vacuum drying was 22.7% which was higher than following foam mat drying (11.6%) and spray drying (8.26%) with 70% Tomato solids + 30% Maltodextrin. Ascorbic acid was lost during drying as a result of high temperature and oxidation(Figure: 1). [11] reported a 15% loss of ascorbic acid in foam mat dried tomato pulp. [12] also found that foam mat dried tomato powder had a higher level of ascorbic acid than spray dried powder. There was a reduction in total sugars in the tomato powder, which may be due to non-enzymic browning reactions during drying of tomato juice (Table 1). There was an increase in °Brix following drying which may be the result of concentration accompanied by the hydrolysis of maltodextrin during drying process.

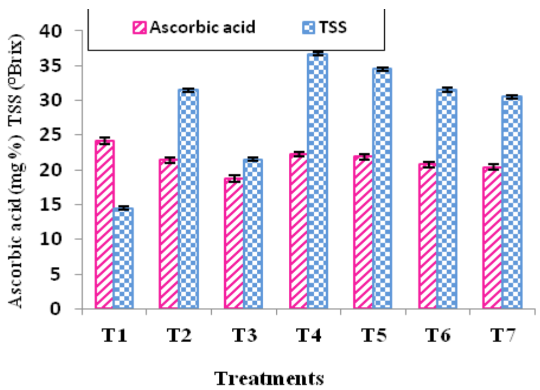

Fig 1: Ascorbic acid and TSS content of the Tomato powder produced by different drying methods

T_1-Fresh tomato concentrate; T_2- Foam mat-dried; T_3- Vacuum-dried; T_4 - Spray-dried (Tomato conc. 70% + Maltodextrin 30%); T_5 - Spray-dried (Tomato conc. 60% + Maltodextrin 40%); T_6 - Spray-dried (Tomato conc. 50% + Maltodextrin 50%) and T_7 - Spray-dried (Tomato conc. 40% + Maltodextrin 60%).

Wall deposition was not a serious problem with tomato juice; the product was fine, free-flowing powder of light yellow colour. However, most of the product remained in the lower part of the chamber instead of reaching the cyclone collector. This powder could readily be dislodged by knocking the chamber walls, suggesting that the air broom or vibrating hammer devices available on larger spray driers would overcome this problem.The additive maltodextrin formed a film around the solids in the feed that facilitated the production of non-hygroscopic and fine flowing powder. This behaviour occurs because the particles are better dispersed, while decreases cohesive force between them. Based on these results, it can be stated that the addition of maltodextrin to tomato juice caused changes in the microstructure of the dehydrated powder, influencing the functional characteristics of the powder. [9] stated that the addition of maltodextrin reduced the stickiness and prevented the caking of dried fruit powders during storage.

The spray dried tomato powders produced in this research were stable at room temperature of 20±1°C. Spray drying of heat sensitive food material containing a high proportion of hygroscopic sugars is often associated with problems of non-uniform atomization and wall deposition. It was observed that the stickiness decreased as a function of maltodextrin concentration for the spray drying of tomato juice. According to [13], the wall deposition problem encountered in the spray drying of orange juice concentrate and indicated that wall deposition is dependent on the thermoplasticity and hygroscopicity of the powders.

The fruit powders were reconstituted after blending with water at the ratio of 1:10 at the room temperature of 20±1°C. Solubility problems occur when foods are subjected to higher temperatures, especially in products with high concentration of solids. The foam mat dried powder could be reconstituted instantly with water at room temperature. In general, a reduction in maltodextrin concentration improved the solubility. When 30% maltodextrin was added to tomato juice, the solubility of powder was 95% whereas adding 60% maltodextrin decreased the solubility to 86%. These results are in agreement with [14], who reported that higher concentrations of drying carriers resulted in low solubility of the dried pineapple powder.

The reconstituted drink made from the fruit powder with 60% maltodextrin was not clear because the maltodextrin exceeded the solid limits suggested for making clear solutions. Maltodextrin as a carrier in juice dehydration by spray drying is one of the most utilized substances due to its physical properties such as solubility in water. With respect to the results obtained in a previous study under similar conditions by [15], the solubility was 95% with 60% Tomato solids + 40% Maltodextrin.

Change in its structure not only changes the physico-sensorial attributes but also it may have some quality deteriorating consequences such as increase in rate of chemical reactions, structural damage and changes in microbial quality. The properties of the powdered tomato particles change as a function of maltodextrin concentration; the higher concentrations leading to decreased solubility of the powder in water. To maintain the tomato powder quality during storage, the physico-chemical state of the dried product has to be maintained for as long as possible.

Ready-to-serve (RTS) tomato nectars were prepared from fruit powders and were compared with those prepared from fresh juice. The fruit powders were reconstituted at the ratio of 1:10 by

adding water to the final total soluble solid contents of 10.5°Brix.

All the sensory panelists had tasted tomato fruit or drink before and all of them gave higher scores for its taste. (Table: 2).Ready-to-serve drink made from the foam mat dried powder contained the highest ascorbic acid content of 22.7 mg/100ml primarily due to greater proportion of tomato powder used in the final drink whereas the commercial juice contained low level of ascorbic acid (12.9 mg/100ml).

There was no significant difference ($p>0.05$) between the acceptability of the fresh juice and the reconstituted foam mat dried powder. This indicated minimal flavour loss during foam mat drying. Most of the panelists preferred the flavour and sweetness of the foam mat dried nectar and gave scores accordingly. Spray dried powder produced from 40% tomato juice was unacceptable to 78% of the panelists because of the thick consistency and off-flavour. This may be due to the addition of maltodextrin at higher concentration than the desirable level from the sensory standard point.

Overall, 88% of the panelists were either very satisfied or satisfied with reconstituted tomato nectar and only 5% disliked it. The remainder of the panelists expressed neutral opinion. Our results are in contrast to the finding of [11]. They reported a significant loss in quality in tomato powder which was unacceptable by most of the consumers.

Table 2: Effect of Different Drying Methods on the Sensory Characteristics of the Reconstituted Tomato Drink

Treatments	Colour	Sweetness	Aroma	Flavour	Consistency	Overall Acceptability
Concentrated Fresh Tomato juice	6.9[c]	6.8[c]	6.9[c]	6.9[c]	6.5[c]	6.8c
Foam mat-dried	6.5[bc]	6.7c	6.9[c]	6.7[c]	5.9[b]	6.4[bc]
Vacuum-dried	5.8[a]	5.8[a]	5.7[a]	5.4[a]	5.6[a]	5.6[a]
Spray- dried						
Tomato concentrate 70% + Maltodextrin 30%	6.4[bc]	6.6[bc]	6.7[c]	6.4[c]	6.7[c]	6.7[c]
Tomato concentrate 60% + Maltodextrin 40%	6.3[b]	6.6[bc]	6.7[c]	6.4[c]	6.6[c]	6.7[c]
Tomato concentrate 50% + Maltodextrin 50%	6.2[b]	6.4[b]	6.5[c]	6.3[bc]	6.4[bc]	6.2[b]
Tomato concentrate 40% + Maltodextrin 60%	5.9[a]	6.0[a]	6.1[b]	6.0[b]	6.1[b]	6.0[b]

Values are the means of two replications with sensory evaluation completed by 20 trained panelists.

Values in the same column bearing different letters are significantly different at 5% level by Friedman test.

This may be due to the difference in sensory method used by [16] and more diverse ethnicity of the consumers participated in the sensory analysis.

4. CONCLUSIONS

Foam mat drying produced the best quality tomato powder in terms of colour, flavour and ascorbic acid retention though it was quite hygroscopic in nature. Spray dried product had bright and attractive colour in comparison to the darker vacuum dried product. The latter was rated poorly in the taste panel assessments possessing a distinct off-flavour. Spray drying produced stable powders at room temperature of 20±1°C. Maltodextrin proved to be the effective additive, reducing the wall deposition markedly and producing a product of acceptable flavour and with good free-flowing properties. Concentrated tomato juice without additives cannot be satisfactorily spray dried because of the hygroscopic and thermoplastic nature of the product. The spray dried, reconstituted juice was slightly lacking in flavour compared to freshly prepared juice but was preferred to vacuum dried material. This assessment reflects the heat damage indicated by the chemical analyses, consequently the poor quality of the product does not recommend the application of tunnel drying. Because foam mat drying is an expensive method to apply commercially, spray drying may be the best alternative for producing tomato powder with good stability. In each case, a compromise must be found to the fruit juice to additive ratio, drying yield and cost of production. The development of an instant tomato juice powder not only reduces the shipping cost but also curtails wastage because tomato powder is more stable than its liquid counterpart.

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