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Studies on Development of Fruit Powder from Muskmelon (*Cucumis Melo L.*) by Using Spray Drier

G. Pandidurai*[1] and P. Vennila[2]
[1]Department of Food Science and Nutrition, CSC & RI, Madurai.
[2]Post Harvest Technology Centre,
Tamil Nadu Agricultural University, Coimbatore - 641 003.

Muskmelon (*cucumis melo l.*) besides its value as table fruit may be processed into value added products. Fresh, ripened and fully matured muskmelon fruit was analyzed by its physico - chemical constituents. Muskmelon fruit contained moisture content - 91.08 per cent, β - carotene - 1215µg 100 g^{-1}, vitamin C - 33.32 mg100 g^{-1} and the total antioxidant activity - 68.36 mg 100g^{-1}. The fruit pulp was taken and the required concentration level (15º brix, 20º brix and 25º brix) of TSS was adjusted by using maltodextrin. The spray driers inlet air temperature (170 ºC, 180 ºC and 190 ºC) and the outlet air temperature (100 ºC) and the feed rate (25ml min^{-1}) were set as required. Among the treatments the TSS 25 ^{0}brix and temperature of 180^{0} C showed maximum drying characteristics and also better retention of nutrients.

Key words: Muskmelon, Physico - chemical characteristics, Spray drying, Fruit powder.

Muskmelon (*Cucumis melo L.)* commonly called as cantaloupe is a member of Cucurbitaceae family. Consumer preference for this fruit is determined largely by its rich source of phytonutrients, sweetness, flavor or aroma and texture. Muskmelon is commercially important fruit cultivated throughout the world, in tropical and sub - tropical countries. In India, muskmelon occupies an area of about 36.70 thousand hectares with an annual production of about 760.81 thousand metric tonnes (Indian Horticulture Database, 2015). The fruit crop is cultivated widely by farmers in our country particularly during the summer season. The important varieties grown in India are 'Pusa Sarbati', 'Hara Madhu', 'Pusa Madhuras', 'Arka Rajhans', 'Arka Jeet', 'Durgapur Madhu', and 'Narendra Muskmelon-15'. Muskmelon is commonly cultivated in Punjab, Tamil Nadu, Lucknow, Safeda, Uttar Pradesh, Maharashtra, and Andhra Pradesh. In Tamilnadu, muskmelon is mostly grown in Tindivanam, Kanchipuram, Dharmapuri, Villupuram, Pudukottai and Theni districts. Muskmelon flesh contains 3.5 g carbohydrates, 0.3 g protein, 0.2 g fat, 3420 IU vitamin A, 26 mg ascorbic acid, 23 mg calcium, 1.4 mg iron, 14 mg, phophorus and 341 mg potassium. Muskmelon is relished as a desert fruit, low in calories and fats or cholesterol and is an excellent source of vitamin A and C and minerals. In melons there are many phytochemicals that may have a vast array of potential health benefits.

The most important genera of melon, *cucumuis* (muskmelon) and *citrullus* (water melon), are also known as sweet melons or dessert. Melon is one of the most widely used fruits and stands at 4th in ranking of mostly consumed fruits in the world as source of food. Muskmelon has a high commercial value and is appreciated because of its peculiar sensory and nutritional characteristics. However, it has a very short postharvest shelf-life exhibiting a sign of quality degradation by excessive softening, flavor deterioration, a decline in sugar content and therefore increased vulnerability to pathogens. Hence transport of the matured fruit to long distance markets increases the risk of quantity and quality loss leading to enormous wastage. Due to look of appropriate storage and trade expertise, producers are enforced to dispose their harvest at minimal rate leading to diminishing returns during the glut season. It is reported that in developing countries producers lose more than 35 % or 32 - 40 billion annually, after the crop is ready to harvest and before it is consumed (Parveen *et al.*, 2014).

Dehydration is one of the feasible methods of preservation. The dehydrated product can be easily converted in to fresh - like form by rehydrating it and can be used throughout the year. Fruit powders are more convenient to use, easy to handle and can be used in the preparation of several products such as beverages, health foods, bakery goods and pastes. The distinctive flavors, colors and water binding properties of fruit powders make them an ideal ingredient in instant fruit juices, extruded cereal products, snacks, cakes, sauces and baby foods. The quality of the dehydrated product in terms of rehydration ratio, colour and flavor retention depends on the pretreatments applied and method of drying. Research needs to be done to explore the possibility of employing dehydration techniques for processing of muskmelon to minimize the losses and to make them available for consumption in the off - season. Therefore, the present research work is undertaken to process the muskmelon fruit into powder different

*[1]Corresponding author's email: nanalpandi@gmail.com

drying methods and also to study their stability during storage.

Material and Methods

Physico - chemical characteristics of musk melon fruit

Fresh and fully ripe muskmelon fruits procured from the local market (Madurai) were used in the study. The fruits were mashed in a blender and analysed for chemical constituents. The physico - chemical characteristics of the selected fresh musk melon fruit namely fruit weight, fruit length, fruit width, pulp weight, pulp yield and color values were recorded.

The chemical characteristics of muskmelon fruit namely moisture, acidity, β - carotene (Ranganna, 1995), pH (Hart and Fischer, 1971), total soluble solids (TSS) (Saini *et al*., 2001), reducing and total sugars (McDonald and Foley, 1960), ascorbic acid (Mahadevan and Sridhar, 1982), total antioxidant activity (Lim *et al*., 2007) , total flavonoids (Meda *et al.,* 2005), total phenols (Quettier-deleu *et al.,* 2000), calcium (Clark and Collip, 1925), iron (Wong , 1928) and phosphorous (Fiske and Subba Rao, 1925) were analyzed.

Processing of musk melon fruit powder

The selected musk melon fruits were washed in running water and the inedible portion was peeled off by using a stainless steel knife. The peeled fruit was halved into two portions and its seeds were scooped out. The fruit was cut into small pieces and pulped in the mixie. The pulp was filtered through a sterilized nylon net.

To optimize the drying process for the production of fruit powder from the muskmelon pulp the process parameters such as total soluble solids of pulp (TSS), inlet hot air drying temperature, outlet air temperature and feed rate in spray drying were selected the range is given in Table - 1.

The musk melon fruit pulp concentration level (15º brix, 20º brix and 25º brix) of TSS was adjusted by using maltodextrin. The spray drier was switched on as per the operating procedure *i.e.,* inlet air temperature (170ºC, 180ºC and 190 ºC), exhaust air temperature (100 ºC) and feed rate (25ml/min.). After setting the parameters, the feed mixture was fed into the drying chamber and finally the product was collected and packed. The flow chart for the production of muskmelon fruit powder using spray drying process is given in Fig -1.

Table 1. Parameters for the production of musk melon fruit powder in spray drying process

Parameters	Levels
Total soluble solids (TSS)	15, 20, and 25º brix,
Inlet temperature	170, 180 and 190ºC
Outlet temperature	100ºC
Feed rate	25 ml min^{-1}

The muskmelon fruit powder prepared from spray drying process was analyzed for its physico - chemical characteristics namely powder recovery, water solubility index (Grabowski *et al.,* 2006), flowability (Tze *et al.,* 2012), bulk and tap density (Chegini and Ghobadian, 2005), hausner ratio (Hayes, 1987), carr index (Carr, 1965), hygroscopicity (Cai and Corke, 2000), colour values, vitamin C and β - carotene content.

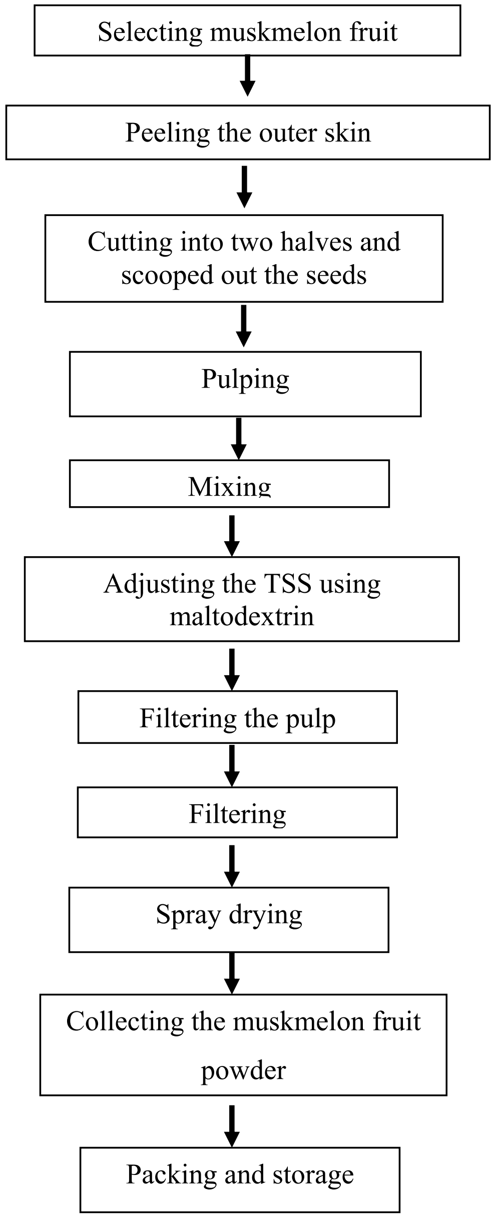

Fig.1. Process for the production of musk melon fruit powder

Results and discussion

Physico - chemical characteristics of muskmelon fruit

The physico - chemical characteristics of fresh muskmelon fruit was analyzed. The selected fruit was oblong in shape and its outer skin was creamish yellow in colour. The edible inner portion was yellowish orange in colour with pleasant natural muskmelon fruit flavour and highly acceptable in taste. The physical characteristics of muskmelon fruit weight, length and width were 1106 g, 10.40 cm and 16.20 cm respectively. The pulp weight and pulp yield was 649.0 g and 55.96 % respectively.

The chemical characteristics of muskmelon fruit was moisture - 91.08 %, pH - 5.60, acidity - 0.128 %, TSS - 6.0 ^{o}brix, total sugar - 5.58 %, reducing sugar - 4.0 %, β - carotene - 1215 µg 100g^{-1} and ascorbic acid - 33.32 mg100g^{-1} respectively.

The muskmelon fruits are much valued for their nutraceutical properties wherein the total antioxidant activity, total flavonoids and total phenols were 68.36 mg 100g^{-1}, 2.17 µg REg^{-1} extract and 3.14 mg GAEg^{-1} extract respectively and with a mineral content of calcium - 19.50, iron - 0.34, phosphorous - 310.0 and potassium - 28.40 mg 100g^{-1}. The colour values were L*- 105.78, a*- 3.94 and b*- 24.19.

Teotia *et al.,* (1997) analyzed the physico - chemical characteristics of muskmelon fruit and pulp. The average weight of fruit, length and breadth of the fruit were 695.0 g, 9.10 cm and 11.0 cm respectively. The fruit contained moisture (93.0 %), pH (6.06 %), acidity (0.06 mg 100g$^{-1)}$, reducing sugar (3.30 %), total sugar (6.30 %) and vitamin C (38.20 mg 100g^{-1}).

Sharma *et al.,* (2004) studied the physico - chemical characteristics for ten varieties of muskmelon. The average fruit weight ranged from 322 to 856 g and the fruit shape varied from oval round to globular round. The rind colour was light yellow and flesh colour was orange. The average dry mater content ranged from 6.63 to 11.17 %, TSS -7.77 to 11.20 % and vitamin C content ranged from 11.46 to 23.12 mg 100g^{-1}.

Rashid and Mahmood (2004) evaluated the chemical characteristics of musk melon fruit. Fruit pulp contained 92.9 % water, 5.0 % carbohydrates, 1.0 % protein, 3420 IU of vitamin A and 33.0 mg vitamin C. Muskmelon quality was largely determined by its sugar content which varied from 8 - 13 % (TSS) with sucrose as the principal sugar, total titratable acidity of 0.15 % and pH of 5.2 (Pandin *et al.,* 2012). Similarly Praveen *et al.,* (2012) also reported that muskmelon quality was determined by its sugar content which varied from 8 to 13 % (TSS) with a total acidity of 0.13 to 0.21 %.

Optimization of drying process for the production of fruit powder

The physico - chemical characteristics of the muskmelon fruit powder prepared from spray drier was carried out and the results of the same are presented in Table - 2.

The musk melon fruit pulp with 25 ^{0}brix and spray dried at 180 ^{0}C had the powder recovery of 96.86 g kg^{-1} of fruit pulp. Increasing temperatures (170 ^{0}C - 190 ^{0}C) led to a higher process yield, which can be attributed to the higher efficiency of heat and mass transfer processes occurring when higher inlet temperatures were used. The lower process yield was obtained the fruit pulp with higher TSS (20 - 25 ^{0}brix) and dried at 190 ^{0}C in spray drier due to the higher amount of solids were contact with the drying chamber and makes the solids as paste.

Table 2. Physico - chemical characteristics of spray dried muskmelon fruit powder

Parameters		15 º bx			20º bx			25º bx		
170 °C		180 °C	190°C	170°C	180°C	190°C	170°C	180°C	190°C	
Powder recovery per kg of pulp (g)		32.09	36.34	50.88	65.06	83.44	53.68	68.55	96.86	39.15
Water solubility (%)		98.17	98.55	98.91	98.28	99.07	69.18	98.35	99.54	50.18
Bulk density (g cm^{-3})		0.788	0.752	0.718	0.793	0.762	0.725	0.797	0.780	0.743
Tap density (g cm^{-3})		0.823	0.815	0.812	0.840	0.838	0.828	0.865	0.863	0.859
Hausner's ratio		1.04	1.09	1.13	1.06	1.10	1.14	1.08	1.11	1.16
Carr index (%)		4.49	7.75	11.5	5.59	9.06	13.28	8.52	10.64	15.60
Flowability		Excellent	Excellent	Good	Excellent	Excellent	Good	Excellent	Excellent	Good
Hygroscopicity (%)		12.48	13.68	15.10	13.34	13.83	15.17	13.62	14.09	15.42
Vitamin C (mg 100g^{-1})		151.21	120.98	100.23	148.55	118.34	99.02	143.86	115.07	97.63
β - carotene (µg 100g^{-1})		1031.62	1016.4	1007.1	1025.8	1013.0	998.41	1012.3	1009.6	988.99
Color values	L*	91.34	92.63	94.95	92.01	94.12	96.09	93.33	95.92	98.20
	a *	5.12	4.76	3.35	5.03	4.49	3.11	4.96	4.17	2.90
	b *	23.49	22.73	22.27	23.17	22.48	22.07	22.99	22.12	21.98

Fruit powders are intended for rehydration, therefore, the ideal powder would wet quickly and thoroughly, sink rather than float and disperse / dissolve without formation of lumps. The water solubility index of the musk melon fruit powder increased with increasing drying temperature and also the concentration of food additives. The water solubility index was nearly 100 per cent when the fruit pulp spray dried at 180^{0}C having the TSS of 25 ^{0}brix. The bulk density and tap density of the spray dried fruit powder varied from 0.718 - 0.797 and 0.499 - 0.569 g cm^{-3} respectively. The reduction in density of the powder was attributed to the rapid moisture removal at higher drying temperature (180 ^{0}C and 190 ^{0}C).

The hauser's ratio and carr index measures the flow properties of powders. From the experiments, it was found that the flowability increased with increase in drying temperature. The hauser's values of spray dried powder was found to be in the range of 1.04 - 1.16 and the carr index was in the range of 4.49 - 15.60 %. Based upon the hauser's ratio and carr index values, it was clearly indicated that the spray dried fruit powder posses excellent flowability characteristics when the sample dried between the temperature 170 ^{0}C and 180 ^{0}C and good flowability at 190 ^{0}C.

The hygroscopicity of spray dried powder ranged from 12.48 to 15.10 % in 15 ^{0}brix, 13.34 to 15.17 % in 20 ^{0}brix and 13.62 to 15.42 % in 25 ^{0}brix. This might be due to the food additives variable has affected the fruit powder hygroscopicity. The lowest hygroscopicity values were obtained when the highest food additives concentrations were used. Similarly the lowest hygroscopicity values were also obtained with decrease in temperature.

The vitamin C and β - carotene contents of fruit powders ranged from 97.63 - 151.21 mg 100g^{-1} and 988.99 - 1031.62 µg 100g^{-1} respectively. Increasing inlet air temperature led to an increase on vitamin C and β - carotene loss, which was due to the high sensitivity of the nutrients to high temperatures. The reduced vitamin C and β - carotene contents were likely due to thermal degradation and oxidation.

The colorimetric analysis showed that L, a, b values changed with increase in inlet air temperature and also the concentration of food additives added to the muskmelon fruit pulp. Overall the lightness (L - values) of the powders increased and to a and b values were decreased. The L, a, b values of muskmelon fruit powder were from 91.34 - 98.20, 2.90 - 5.12 and 21.98 - 23.49 respectively.

Siew Young Quek *et al.,* (2006) reported that the spray dried watermelon powder at a temperature of 175 ºC and 5.0 % maltodextrin, showed the colour values L* - 66.91, a* - 18.94 and b* - 24.66. Similarly β - carotene content of spray dried powder had 23.05 ± 0.323 µg100g^{-1}. They also reported that when the inlet temperature increased, the L* - values decreased whereas a* and b* values increased.

Tonon *et al.,* (2008) studied the physico - chemical properties of acai powder produced by spray drier. They reported that the processed powder yield was 48.49 % and hygroscopicity was 13.55 g 100g^{-1}.

The fruit (Pitaya) powder was prepared by using spray drier (Tze *et al.,* 2012). The fruit powder spray dried at different temperature viz., 145 ºC, 155 ºC, 165 ºC and 175 ºC and 30 % maltodextrin had 340.302 - 344.817 kg m^{-3}, 574.232 - 565.682 kg m^{-3}, 40.738 - 39.044 % and 1.687 - 1.641 % for bulk density, tap density, carr index and hausner ratio respectively.

Patil *et al.,* (2014) estimated the vitamin C content of spray dried guava powder and the values were 996 g 100g^{-1} at 7.0 % maltodextrin, 170 ºC inlet temperature and 75 ºC outlet temperature. They also found that increasing the maltodextrin concentration and also the inlet temperature, which decreases the vitamin C content in the fruit powder.

Saifullah *et al.,* (2016) analyzed the physico - chemical and flow properties of pineapple fruit powder. The bulk density, tapped density, carr index and hausner ratio of the fruit powder was 579.68 ± 0.25 kg m^{-3}, 749.47 ± 0.42 kg m^{-3}, 22.65 ± 0.21 % and 1.29 ± 0.12 % respectively.

Diego Archaina *et al.,* (2017) reported that the spray dried fruit powder from black current contained solubility - 94.25 ± 4.24 per cent, bulk density - 0.39 ± 0.07 g ml^{-1}, tapped density - 0.41 ± 0.08 g ml^{-1} and hygroscopicity - 14.46 ± 0.13 g 100g^{-1}. In the present study, similar results were observed in the spray dried muskmelon fruit powder at varying TSS and at different temperatures.

Conclusion

From the study it was concluded that the prepared spray dried muskmelon fruit powder found to have the maximum (180 ^{0}C and TSS 25 ^{0}brix) drying characteristics and also retention of nutrients β - carotene and vitamin C. The muskmelon fruit powder can be utilized in the preparation of various products.

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