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Effect of molasses, honey, and sugar on osmotic dehydration of muskmelon (*Cucumis melo* L.)

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Abstract
The present investigation was undertaken to assess the effect of honey, molasses and sugar on osmotic dehydration of muskmelon cubes with the objectives to find out the possibility of using honey and molasses alternative to sugar in osmotic dehydration. Muskmelon cubes without (T_1) and with (T_2, T_3, T_4, and T_5) osmotic treatments were dehydrated in cabinet drier at 60 ^{0}C. Osmotic solutions of sugar T_2 and T_3 (50% and 60% respectively), honey solution T_4 (60%), and molasses solution T_5 (60%) were prepared using water. Results revealed that moisture content of T_3 (6.650%) were lesser than other treatments. Ash content in were T_2, T_3, T_4 and T_5 higher and T_5 (2.480%) treatment was highest. Fat, protein, and titrable acidity of dehydrated cubes without and with osmotic treatments were same. TSS of T_4 (58%) and T_5 (57%) solution treatment were T_3 (57%). Reducing (3.101 g/100g) and total sugars (5.618 g/100g) in T_4 was higher. β-carotene and ascorbic acid content in dehydrated cubes with osmotic treatment (1.8 µg/100 g of β-carotene and 23 mg/100g of ascorbic acid) was lesser than T_1 (2.050 µg/100 g of β-carotene and 30.140 mg/100g of ascorbic acid). Per cent shrinkage of T_2, T_3, T_4, and T_5 was lesser than T_1. Density of T_2, T_3, T_4, and $T_{5\ was}$ higher than T_1. Rehydration factor of T_2, T_3, T_4, and T_5 was lesser than T_1. Sensory panel adjudged T_4, and T_5 was on par with T_2 and T_3. The correlation and regression analysis of sensory data shows that over all acceptability of dehydrated cubes were largely dependent on texture, taste, and flavour. Hence, the study revealed that honey and molasses can be used as alternatives to sugar as osmotic agents in osmotic dehydration of muskmelon.

Keywords: Muskmelon, osmotic dehydration, honey, molasses, sugar

1. Introduction
Muskmelon (*Cucumis melo*), a type of melon in *Cucurbitaceae* family derived its name from Persian word Musk means perfume and French word Melon from the Latin melopepo meaning apple-shaped melon. It is native to Persia (Iran) and surrounding areas in the west and east. The netted rind with creamy, light yellow-orange flesh, tasting bland, with musky flavoured melon relished as table fruit. Muskmelon is nutritious and is good source of ascorbic acid (36 mg / 100 g), carotenoids (1800 µg / 100 g), and potassium (250 mg / 100 g). It also contains good amount of B-vitamins, vitamin K, Copper, magnesium, and fibre. Total horticulture production in 2019-20 is 3.12% higher than 2018-19, fruits production is 102.03 million tonnes, and Muskmelon's production is 1.368 MT (https://pib.gov.in/PressReleasePage.aspx?PRID=1703196). Muskmelon is perishable in nature and can be stored up to 15-20 days in ambient conditions. This results in large losses of the crop and value (Ismail *et al*., 2010; Solval *et al*., 2012) [8, 16]. Processed muskmelon in frozen, canned, desserts and/or in beverages form is available in market. However, dehydration is oldest technique to preserve food, because of its higher moisture content it is not economical. Thus, osmotic treatment where water content in which the process of removal of water in cells by immersing in hypertonic solutions is becoming popular. The osmotic dehydrated products are intermediate moisture products and processed easily with lesser cost. Previous studies on development of muskmelon chunks by osmotic dehydrating the cubes using sugar and glycerol (Ahmad Din *et al*., 2018) [4]. The authors indicated that developed muskmelon chunks were having good physicochemical and organoleptic properties.
Commonly used osmotic agent in osmotic dehydration is sugar that is sucrose made of equal parts of glucose and fructose derived from sugar cane (80%) or sugar beets (20%). Earlier studies revealed it as bittersweet due to its high glycemic index with proven ill effects. Corn syrup, honey, maple syrup, date syrup and molasses, etc. are replacing or alternatives to sugar in diets. This study intends the use of honey and molasses as better alternatives to sugars in

osmotic dehydration considering availability and therapeutic properties of honey and molasses. Honey is sweetener from ancient times and is natural product rich in phenolic compounds, enzymes, and sugars with antioxidant, anti-carcinogenic, anti-inflammatory, and antimicrobial potential. This contains proteins, antioxidants, and minerals. The major portion of honey is carbohydrates, fructose (~38.2%), glucose (~31%), sucrose, maltose, isomaltose, maltulose, turanose and kojibioseIt (~9%). Honey's glycemic index is lower than sugar and regarded for its therapeutic properties. Molasses, thick viscous product derived from the third boiling of cane syrup contains 20% of the daily value for calcium, magnesium, potassium, and iron. Molasses contain sucrose (30-40%), glucose (4-9%), fructose (5-12%), and total reducing substance (10-25%). Molasses is cheaper than honey and sugar, used as colourant. Molasses can also be obtained from sugar beets. Keeping the above in facts view, the laboratory study to assess the effect of honey and molasses on osmotic dehydration of muskmelon in comparison with sugar solution was undertaken.

2. Materials and Methods

The study was conducted in Department of Food Engineering, College of Community Science, University of Agricultural Sciences, Dharwad during 2018-19 under laboratory conditions. Muskmelon, sugar, and honey were from local market Dharwad. Molasses was obtained from Mudhol, Belgavi. There were six treatments *viz.*, T_0: Fresh muskmelon, T_1: Dehydration of muskmelon without osmotic treatment, T_2: Dehydration of muskmelon with osmotic treatment in 50% sugar solution, T_3: Dehydration of muskmelon with osmotic treatment in 60% sugar solution, T_4: Dehydration of muskmelon with osmotic treatment in 60% Honey solution, and T_5: Dehydration of muskmelon with osmotic treatment in 60% molasses solution, replicated thrice.

2.1 Preparation of muskmelon cubes dehydrated with and without osmotic treatments

Washed, peeled, and sliced 2 cm cubes of mature unripe muskmelon were steam blanched and immersed in sugar solution, honey, and molasses overnight at an ambient temperature. The cubes in solution were drained and dried in cabinet drier at 60 ^{0}C. Dehydrated chunks were used for further analysis.

2.2 Physico-chemical Analysis of muskmelon cube dehydrated with and without osmotic treatments

Osmotic dehydrated muskmelons were analysed for moisture by adapting AOAC 930.15 method, fat with AOAC method 920.39C, ash with muffle furnace, and protein with Kjeldhal method. Total soluble solids of dehydrated cubes were determined using Erma hand refractometer, and the values expressed as% TSS. Acidity by method of Nielsen (2010) [10], ascorbic acid by the method of A.O.A.C. (2005) [1], total carotenoids by method of Rodriguez-Amaya, D.B. (1999), sugars by the method of Hulme and Narain (1931) [6].

Dimensions of the cubes were measured using vernier callipers. Volume (equation 1), density (equation 2), and per cent shrinkage (equation 3) were calculated mathematically from the dimensions. Dehydrated cubes were rehydrated using warm water in 1:4 cubes to water ratio and rehydration factor (equation 4) was calculated.

$$Volume = Length\ X\ Breadth\ X\ Height \quad (1)$$

$$Density = \frac{Mass}{Volume} \quad (2)$$

$$\%\ Shrinakge = \frac{(V\ of\ cube\ before\ osmotic\ treatment - V\ of\ cube\ after\ osmotic\ treatment)}{V\ of\ cube\ before\ osmotic\ treatment\ (after\ slicing)}\ X\ 100 \quad (3)$$

$$Rehydration\ factor = \frac{Weight\ of\ rehydrated\ cubes}{Weight\ of\ dehydrated\ cubes} \quad (4)$$

Sensory evaluation of muskmelon cubes dehydrated with and without osmotic treatments Semi-trained panel of twenty panellists adjudged sensory parameters of osmotic dehydrated muskmelon cubes incorporated in bread using 9-point hedonic scale as described by Ranganna, S. (2003) [13]. The characters (Colour, appearance, flavour, taste, overall acceptability) with mean scores of six or above out of nine were considered acceptable.

2.4 Analysis of data

The recorded data were analysed for analysis of variance (ANOVA) using Microsoft Excel. The values were analyzed with Duncan Multiple Range Test using OPSTAT developed by O. P. Sheoran., C.C.S. HAU, Hisar. The recorded observations of sensory evaluation were analyzed using regression and correlation test in Microsoft Excel. The critical difference of 5% level value was used for comparison among different treatments. Interpretations of results were based on the guidelines suggested by Kothari C R and Gaurav Garg (2019) [8].

3. Results and Discussion

3.1 Physico-chemical properties of muskmelon

The data presented in table 1 on physico-chemical properties of muskmelon. The data revealed that fresh cubes contains 93.630% moisture content, 0.310 g/100g fat content, 1.990 g/100 g protein, 6.00% total soluble solids, 0.026g/100 g titrable acidity, 2.028 g/100 g of reducing sugars, 3.352 g/100 g of total sugars, 8.730 µg/100g β-carotene and 32.250 mg/100g of ascorbic acid. The physico-chemical values were comparable with findings of Balaswamy K *et al.*, 2016 in muskmelon.

3.2 Physico-chemical properties of cubes dehydrated with and without osmotic treatments

Moisture content of cubes dehydrated with 60% sugar solution (6.650%) treatment was lesser than 50% sugar solution (9.980%), honey (8.820%) and molasses (9.900%) solutions (Table 1). This variation in moisture content may be due to relatively higher rate of diffusion of sugar molecules than honey and molasses. Moisture content of cubes dehydrated without osmotic treatment (12.620%) was higher. Pavkov, I *et al.*, 2021 also reported increased hypertonic solution's concentration induces water loss in osmotic dehydration, as the data recorded in table 1. This may be due to water diffusion in to hypertonic solution during osmosis. Fat, protein, and titrable acidity of cubes before and after dehydration with and without osmotic treatments were similar and statistically non-significant. Teresa Delgado *et al.*, 2017 [15] also reported similar findings in osmotic dehydration of chestnut slices. This may be due to oxidation of fat, denaturation of proteins during drying, leaching of protein, acids and other solutes into hypertonic solutions. Ash content of cubes dehydrated after osmotic treatment in molasses solution (2.480%) was higher and cubes dehydrated without osmotic treatment (0.590%) was lesser. This may be due to absorption of minerals from sugar, honey, or molasses solution into cubes (Table 1).

Total soluble solids of cubes dehydrated with osmotic treatment (50% sugar solution: 43% TSS, 60% sugar solution: 57%, Honey solution: 58%, Molasses solution: 57%) is higher than cubes dehydrated without osmotic treatment (8%). Ashmita Dhungana *et al*., 2017 [3] also reported higher water loss during osmotic dehydration yacon (*Smallanthus sonchifolia*) slices using honey. Reducing sugars and total sugars of cubes dehydrated after osmotic treatment with honey (3.010% and 5.618% respectively) were higher and cubes dehydrated without osmotic treatment (1.987% and 2.073% respectively) were lower. Ashmita Dhungana *et al*., 2017 [3] also reported similar findings in osmotic dehydration of yacon slices. β-carotene and ascorbic acid content of cubes dehydrated with osmotic treatment (~1.8 µg / 100 g and ~25 mg / 100 g respectively) was lesser than cubes dehydrated without osmotic treatments (2.050 µg/100 g and 30.140 mg/100 g respectively). Teresa Delgado *et al*., 2017 [15] reported similar findings in osmotic dehydration of chestnut slices. The losses in β-carotene and ascorbic acid content may be due to drying temperature and leaching of solutes into hypertonic solutions.

Data in table 1 on physical properties shows that volume of cubes dehydrated with osmotic treatments (0.4 cm^3) was comparatively higher than volume of cubes dehydrated without osmotic treatment (0.2 cm^3). Cubes of 0.8 m^3 volume shrunken after dehydration and per cent shrinkage of cubes dehydrated after osmotic treatment was 95% and without osmotic treatment was 97%. Shrinkage may be due to loss of water during osmosis and dehydration. Density of cubes dehydrated after osmotic treatment (0.333 g/ml) was higher than cubes dehydrated without osmotic treatment (0.143 g/ml). This may be due to absorbed solutes from hypertonic solution while osmosis. Rehydration factor of cubes dehydrated with osmotic treatment (50, 40, 50and 60 for 50% sugar solution, 60% sugar solution, 60% honey solution and 60% molasses solution treatments respectively) was lesser than cubes dehydrated without osmotic treatment (360).

3.3 Sensory evaluation of cubes dehydrated with and without osmotic treatments

Data in table 2 on sensory parameters of cubes dehydrated with and without osmotic treatments revealed that cubes dehydrated after osmotic treatment in 50% sugar solution scored highest in appearance, flavour, taste, and overall acceptability (7.88, 7.77, 7.88, and 7.66 respectively). Colour score (8.00) of cubes dehydrated after osmotic treatment with 60% sugar solution was highest. Texture score (7.55) of cubes dehydrated after osmotic treatment with honey was highest followed by scores of cubes dehydrated with osmotic treatments of 50% sugar solution and molasses (7.44). Taste and texture score (7.88 and 7.55) of cubes dehydrated with osmotic treatment in honey was more. Overall acceptability of cubes dehydrated without osmotic treatment (7.22) was lesser than cubes dehydrated with osmotic treatment (7.44 to 7.66). Overall acceptability scores of cubes with sugar, honey, and molasses treatment were statistically non-significant.

Correlation data in table 3 portrays decent relation between flavour, taste, and texture with overall acceptability. The figures of correlations show that taste and texture scores (0.740 and 0.790 respectively) of cubes dehydrated with and without osmotic treatment influence to more extent for overall acceptability scores than colour and appearance scores (-0.032 and 0.260 respectively). Correlation between taste and texture (0.710), flavour and taste (0.690), and flavour and overall acceptability (0.620) was also relatively good. According to regression data in table 4 of sensory attributes, it was evident their exists linear relation between appearance and colour (0.897), texture and taste (0.710), flavour and taste (0.698), texture and overall acceptability (0.798), flavour and overall acceptability (0.622), and taste and overall acceptability (0.742).

Table 1: Physico-chemical parameters of fresh and dehydrated muskmelon

Treatments	T_0	T_1	T_2	T_3	T_4	T_5
Moisture (g / 100 g)	93.630^a	12.620^b	9.980^b	6.650^b	8.820^b	9.900^b
Fat (g / 100 g)	0.310^a	0.290^a	0.390^a	0.370^a	0.320^a	0.280^a
Ash (g / 100 g)	0.430^a	0.590^a	1.960^a	1.580^a	1.750^a	2.480^a
Protein (g / 100 g)	1.990^a	1.980^a	2.670^a	2.880^a	2.350^a	2.630^a
TSS (%)	6.000^b	8.000^b	43.000^a	57.000^a	58.000^a	57.000^a
Titrable Acidity (g / 100 g)	0.026^a	0.024^a	0.026^a	0.025^a	0.022^a	0.021^a
Reducing Sugar (g / 100 g)	2.028^a	1.987^a	2.704^a	2.814^a	3.010^a	2.891^a
Total Sugars (g / 100 g)	3.352^a	2.073^a	4.366^a	4.390^a	5.618^a	4.383^a
Beta Carotene (µg / 100 g)	8.730^a	2.050^a	1.940^a	1.860^a	1.830^a	1.760^a
Ascorbic acid (mg / 100 g)	32.250^a	30.140^a	24.190^a	23.310^a	22.310^a	20.830^a
Volume (cm^3)	8.00^a	0.200^a	0.400^a	0.400^a	0.400^a	0.400^a
Percent shrinkage	-	97.410^a	94.86^a	94.538^a	95.254^a	95.179^a
Density(g/ml^3)	-	0.143^a	0.333^b	0.333^b	0.333^b	0.357^b
Rehydration factor	-	360^a	50^b	40^b	50^b	60^b

T_0: Fresh Muskmelon fruit
T_1: Dehydration of muskmelon without osmotic treatment
T_2: Dehydration of muskmelon with osmotic treatment in 50% sugar solution
T_3: Dehydration of muskmelon with osmotic treatment in 60% sugar solution
T_4: Dehydration of muskmelon with osmotic treatment in 60% Honey solution
T_5: Dehydration of muskmelon with osmotic treatment in 60% molasses solution

Table 2: Sensory parameters of dehydrated muskmelon without and with osmotic treatments

T	Appearance	Rank	T	Colour	Rank	T	Flavour	Rank	T	Taste	Rank	T	Texture	Rank	T	OAA	Rank
T_2	7.88 ^{a}	1	T_3	8.00 ^{a}	1	T_2	7.77 ^{a}	1	T_2	7.88 ^{a}	1	T_4	7.55 ^{a}	1	T_2	7.66 ^{a}	1
T_3	7.88 ^{a}	1	T_2	7.88^{a}	2	T_1	7.44 ^{a}	2	T_4	7.88 ^{a}	1	T_2	7.44 ^{a}	2	T_4	7.55 ^{a}	2
T_1	7.77 ^{ab}	3	T_1	7.55 ^{ab}	3	T_4	7.44 ^{a}	2	T_1	7.44 ^{a}	3	T_5	7.44 ^{a}	2	T_3	7.44 ^{a}	3
T_4	7.22 ^{bc}	4	T_4	7.55 ^{ab}	3	T_5	7.44 ^{a}	2	T_5	7.44 ^{a}	3	T_3	7.33 ^{a}	4	T_5	7.44 ^{a}	3
T_5	6.88 ^{c}	5	T_5	7.00 ^{b}	5	T_3	7.33 ^{a}	5	T_3	7.33 ^{a}	5	T_1	7.22 ^{a}	5	T_1	7.22 ^{a}	5

T: Treatment
T_1: Dehydration of muskmelon without osmotic treatment
T_2: Dehydration of muskmelon with osmotic treatment in 50% sugar solution
T_3: Dehydration of muskmelon with osmotic treatment in 60% sugar solution
T_4: Dehydration of muskmelon with osmotic treatment in 60% Honey solution
T_5: Dehydration of muskmelon with osmotic treatment in 60% molasses solution

Table 3: Correlation between sensory attributes of dehydrated muskmelon without and with osmotic treatments

	Appearance	Colour	Flavour	Taste	Texture	Overall Acceptability
Appearance	1					
Colour	0.890	1				
Flavour	0.260	0.190	1			
Taste	-0.037	0.150	0.690	1		
Texture	-0.550	-0.200	0.260	0.710	1	
Overall Acceptability	-0.032	0.260	0.620	0.740	0.790	1

Table 4: Regression between sensory attributes of dehydrated muskmelon without and with osmotic treatments

	Appearance and Colour	Texture and Taste	Flavour and Taste	Texture and Overall Acceptability	Flavour and Overall Acceptability	Taste and Overall Acceptability
Multiple R	0.897	0.710	0.698	0.798	0.622	0.742
R Square	0.805	0.504	0.487	0.637	0.387	0.550
Significance: p (0.05)						
T_1	NS	NS	NS	NS	NS	NS
T_2	NS	NS	NS	NS	NS	NS
T_3	NS	NS	NS	NS	NS	NS
T_4	NS	NS	NS	NS	NS	NS
T_5	0.039	NS	NS	NS	NS	NS

T_1: Dehydration of muskmelon without osmotic treatment
T_2: Dehydration of muskmelon with osmotic treatment in 50% sugar solution
T_3: Dehydration of muskmelon with osmotic treatment in 60% sugar solution
T_4: Dehydration of muskmelon with osmotic treatment in 60% Honey solution
T_5: Dehydration of muskmelon with osmotic treatment in 60% molasses solution

4. Conclusion

Cubes dehydrated with osmotic treatment were better in physico-chemical properties and scored higher in sensory evaluation than cubes without osmotic treatments. This study concludes that honey and molasses are better alternatives to sugar and can be osmotic agent in osmotic dehydration of muskmelon.

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