Impact of packaging materials and storage temperatures on the quality of sugarcane molasses (black honey)

Abstract

Sugarcane molasses is defined as a product obtained from the concentration of sugarcane juice. This product is accepted in the Egyptian market and can be used as a sweetener instead of refined sugar. The packaging materials and storage temperature affect the quality properties of the sugarcane molasses. In this study, the sugarcane molasses was packed in four different packaging materials (glass jars, pottery pitchers, plastic jars, and tin containers) and stored at two different temperatures (20 and 40^{o}C) to study the quality properties. The changes in the physicochemical, antioxidant activity and sensory properties were estimated at periodic intervals of 60 days during the period of storage study (12 months). The results showed that, pH, total soluble solids, moisture, total sugars, antioxidant activity, flavor and overall acceptability score of stored sugarcane molasses were reduced significantly ($p \leq 0.05$) with the progression of the storage period. The stability of packed samples stored at 20°C was better, as the highest values of all studied quality traits were recorded compared to their counterparts at 40°C. Among the studied packaging materials, sugarcane molasses filed in glass jars with metallic covers, and pottery pitchers with sterilized tampons had the best quality properties. Final of storage period, the glass jars recorded the highest values of total soluble solids, moisture and total sugars. While pottery pitchers were better for pH, antioxidant activity, flavor and overall acceptability score. These results may come from the physiochemical properties of the raw materials of the pottery pitchers.

Key words: Sugarcane molasses, Packaging materials, Physicochemical properties, Storage stability.

1. INTRODUCTION

In Egypt sugarcane molasses is produced in various governorates in Upper Egypt, particularly in El Minia, Sohag, Kena, and Aswan, where the climate and soil are suitable for sugarcane cultivation. This crop's primary function is to produce sugar. In addition, it is used to make fresh cane juice as a beverage and molasses. A few studies have been undertaken in Egypt to examine sugarcane molasses production, manufacturing processes, and the various factors impacting and defining the major features of high-quality sugarcane molasses [1].

Sugar cane honey quality should be addressed in both product and process design for its long-term ramifications, which are linked to product acceptance and process feasibility, two interdependent components. This should be given the same weight as economic, technical, and environmental considerations. [2].

Sugarcane molasses is a syrupy liquid made from sugarcane juice that has been concentrated until it has a solid content of 65 to 75 % [3]. Sugarcane molasses is liquid syrup prepared by boiling sugar cane juice and evaporating it. Sugars such as sucrose, glucose, and fructose are abundant, and they may crystallize during storage, especially at low temperatures. The biggest challenge faced by treacle makers in the Egyptian traditional food business was crystallization, which had a detrimental impact on quality and market acceptance. [4] & [5] reported that sugarcane-derived foods are good for your health because they are high in nutrients and include natural antioxidants (flavonoids). Within the primary chemicals identified, there was a lot of variety. This meant that determining the quality of treacle solely based on the chemical composition of the primary components was impossible [6].

[7] Studied physicochemical and sensory properties of sugarcane syrups. They reported that there is a broad fluctuation in the physicochemical parameters of sugarcane syrup, which does not necessarily signal a problem with technological quality, and it is suggested that the range of values specified in the legislation be revised.

2. Materials and methods

2.1 Sugarcane molasses

Sugarcane molasses was purchased from the main sugarcane squeezer in Upper Egypt. This squeezer is located in the main sugarcane molasses producing governorate, Kena (Nag Hammady).

2.2 Packaging materials

The glass jars (13×8 cm), pottery pitchers (15×4cm), plastic jars (PET 14×8 cm), and tin containers (16×9 cm) were purchased from local shop. The sugarcane molasses was filtered from impurities with the first observations recorded and then packed under normal conditions in four clean, dried containers and then tightly closed (i.e., glass jars closed with metallic covers, pottery pitchers closed with sterilized tampons, plastic jars closed with plastic covers, and tin containers with tin covers), at a rate of 500 ml per package for (12 months) at 20°C in an electric incubator and in the same way, four other packages were filled, and then placed in the incubator at 40°C. During the storage period the physiochemical properties, antioxidant activity and sensory evaluation of sugarcane molasses were estimated at regular intervals of 60 days.

2.3 Physicochemical properties

Moisture content was determined by drying sugarcane molasses samples for each treatment at 70 °C until the weight remains constant. Total soluble solids (TSS) were determined using a digital refractometer with a Brix scale of 0-100. The Lane and Eynone Volumetric method was used to determine total sugars. At 25°C, pH values were determined using a Systolic 324 combination glass electrode pH meter according to the AOAC [8]. Antioxidant activity was estimated by the DPPH method according to [9]. Briefly 2 gram of sugarcane molasses sample was extracted with 30 ml ethanol and water (1:1v/v). The mixture was stirred for 3 hours at room temperature and then centrifuged at 3000 rpm for 20 minutes. The supernatant was collected and filtered. Free radical scavenging activity was determined using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) method. A methanol solution (0.1 ml) containing crude extract was added to 3.9 ml of freshly prepared DPPH methanol solution (0.1 mM). An equal amount of methanol was used as a control. After incubation for 30 minutes at room temperature in the dark, the optical density (OD) was measured at 517 nm. The activity of scavenging (%) was calculated using the following equation:

$$\text{DPPH radical scavenging \%} = \frac{\text{OD control} - \text{OD sample}}{\text{OD control}} \times 100$$

Where, OD= optical density

2.4 Sensory evaluation

Sensory evaluations were conducted on the different treatments of samples. The quality attributes, including flavor and overall acceptability (10 points of each) were evaluated by panelists, comprised of 10 staff members and graduate students at Food Science and Technology Department, faculty of Agriculture Assiut Al- Azhar University. [10].

2.5 Statistical analysis:

Temperatures, storage periods, and packaging materials all had an impact on the sugarcane molasses quality during storage. Therefore, the nutritional values of sugarcane syrup were statistically analyzed. Completely Randomized Design (CRD) was employed for the analysis. Significant change levels are listed as p≤0.05. [11].

3 Results and Discussion

3.1 The physicochemical characteristics

3.1.1. Effect of packaging materials and storage temperatures on pH value

Results presented in Table (1) indicated a decrease in pH value of sugarcane molasses stored in all packaging materials along with increasing of storage period. The data observed that, the pH value of the packaging materials of glass jars, pottery pitchers, plastic jars and tin containers packaging decreased from 4.960 Initial month of storage to 4.00, 4.050, 3.980, 3.940, 4.190, 4.260, 4.010 and 4.110 after storage periods at 40°C and 20°C temperatures, respectively. The percentage of change of pH value for the packaging materials of glass jars, pottery pitchers, plastic jars and tin containers stored at 40°C were 19.35, 18.35, 19.76 and 20.56%, while they were 15.52, 14.11, 19.15 and 17.14% at 20°C temperatures, respectively.

Table (1): Effect of the packaging materials and storage temperatures on pH value

Tem.	Packaging materials	Storage periods (months)							Mean
		0	2	4	6	8	10	12	
Temperature 40 °C	Glass jars	4.960	4.660	4.340	4.320	4.300	4.280	4.000	**4.400**
	Pottery pitchers	4.960	4.860	4.600	4.310	4.280	4.250	4.050	**4.470**
	Plastic jars	4.960	4.330	4.210	4.010	3.990	3.980	3.980	**4.200**
	Tin containers	4.960	4.350	4.260	4.090	3.970	3.950	3.940	**4.210**
Mean		**4.960**	**4.550**	**4.350**	**4.180**	**4.130**	**4.110**	**3.990**	**4.320**
Temperature 20°C	Glass jars	4.960	4.750	4.670	4.560	4.430	4.210	4.190	**4.530**
	Pottery pitchers	4.960	4.910	4.750	4.470	4.360	4.290	4.260	**4.570**
	Plastic jars	4.960	4.770	4.680	4.370	4.230	4.160	4.010	**4.450**
	Tin containers	4.960	4.530	4.420	4.380	4.250	4.120	4.110	**4.390**
Mean		**4.960**	**4.740**	**4.630**	**4.440**	**4.310**	**4.190**	**4.140**	**4.490**
Mean effect		**4.960**	**4.640**	**4.490**	**4.310**	**4.220**	**4.150**	**4.060**	
F-test A=**		**L.S.D 0.05**	**B 0.04**	**C 0.06**	**AB 0.06**	**AC 0.08**	**BC 0.11.**	**ABC 0.16**	

F-test L.S.D 0.05
A= Temperatures *
B= Packaging materials 0.04
C= Storage periods 0.06
AB= interaction between temperatures x packaging materials 0.06
AC= interaction between temperatures x storage periods 0.08
BC= interaction between packaging materials x storage periods 0.11
ABC= interaction between temperatures x packaging materials x storage periods 0.16

These findings are consistent with previous findings that indicated that the mean pH value fell over the course of storage, which could be attributed to increased acidity or other chemical reactions [12]. From this data, it was clear that there were highly significant differences ($p \leq 0.05$) between all packaging materials in their pH values. After the storage period and at both storage temperatures (20 and 40°C), the syrup packaged in a pottery pitcher had the highest pH value (4.26 and 4.05) compared with the other packaging materials. The surfaces of the pottery pitcher, which is made from alkali clay, can react with the hydrogen ions produced from the decomposition of sucrose during the storage time. It can provide a suitable pH balance for sugarcane molasses during the storage period.

3.1.2. Effect of packaging materials and storage temperatures on T.S.S value

The results in Table (2), total soluble solids of all packaging materials decreased from 73.90% initial month of storage to72.10, 72.20, 71.00, and 71.10% after storage at 40°C. Meanwhile, the loss in T.S.S of glass jar and other packaging materials stored at 20ºC was slightly lower than that of the same packaging material stored at 40ºC. The rate of loss in T.S.S of a glass jars were 2.44% at 40ºC and 1.49% at 20ºC temperature after storage.

These results are consistent with his mention [13]. They found that, total soluble solids of light and thick sugarcane molasses during storage period were 31.870% to 31.760 and 54.230 to 53.850%, respectively.

Table (2) Effect of packaging materials and storage temperatures on T.S.S value

Tem.	Packaging materials	Storage periods (months) 0	2	4	6	8	10	12	Mean
Temperature 40 °C	**Glass jars**	73.90	73.60	73.50	73.30	72.80	72.20	72.10	**73.06**
	Pottery pitchers	73.90	73.80	73.60	73.30	72.20	71.40	71.20	**72.77**
	Plastic jars	73.90	73.30	73.20	73.00	72.00	71.30	71.00	**72.53**
	Tin containers	73.90	73.30	73.20	73.00	72.10	71.50	71.10	**72.59**
Mean		**73.90**	**73.50**	**73.38**	**73.15**	**72.28**	**71.60**	**71.35**	**72.74**
Temperature 20°C	**Glass jars**	73.90	73.70	73.60	73.50	73.10	73.00	72.80	**73.37**
	Pottery pitchers	73.90	73.90	73.70	73.40	73.00	72.70	72.40	**73.29**
	Plastic jars	73.90	73.70	73.60	73.30	73.10	72.40	72.00	**73.14**
	Tin containers	73.90	73.50	73.40	73.30	73.20	72.20	72.00	**73.07**
Mean		**73.90**	**73.70**	**73.58**	**73.38**	**73.10**	**72.58**	**72.30**	73.22
Mean effect		**73.90**	**73.60**	**73.48**	**73.26**	**72.69**	**72.09**	**71.83**	
F-test A = *		**L.S.D**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**	

	0.05	**0.05**	**0.09**	**0.07**	**0.11**	**0.12**	**0.18**

F-test L.S.D 0.05
A= Temperatures *
B= Packaging materials 0.05
C= Storage periods 0.09
AB= interaction between temperatures x packaging materials 0.07
AC= interaction between temperatures x storage periods 0.11
BC= interaction between packaging materials x storage periods 0.12
ABC= interaction between temperatures x packaging materials x storage periods 0.18

3.1.3. Effect of packaging materials and storage temperatures on moisture content

According to the results in Table (3), the moisture content of all packaging materials decreased from 23.50% at Initial period to 20.80, 19.70, 19.50, and 19.00% after storage at 40^{o}C. Meanwhile, the loss in moisture content of glass jar and other packaging materials stored at 20ºC was slightly lower than that of the same packaging materials stored at 40ºC. The rate of loss in moisture content of a pottery pitcher was 16.17% at 40ºC and 6.08% at 20ºC after storage perhaps this is because pottery is heat insulating.

From the statistical analysis, there were significant differences (p≤0.05) between all packaging materials in their moisture content due to different storage temperatures, storage periods and interactions. The higher loss of moisture content was observed in packaged samples stored at high temperatures. The more rapid decrease in moisture content may be due to moisture evaporation for storage at high temperature [14].

Table (3): Effect of packaging materials and storage temperatures on moisture content

Tem.	Packaging materials	Storage periods (months)							Mean
		0	2	4	6	8	10	12	
Temperature 40 ºC	**Glass jars**	23.50	22.80	22.70	22.80	21.80	21.30	20.80	**22.24**
	Pottery pitchers	23.50	22.90	22.30	21.80	21.00	20.90	19.70	**21.73**
	Plastic jars	23.50	22.90	22.20	21.60	21.20	20.90	19.50	**21.69**
	Tin containers	23.50	22.20	21.80	21.10	20.00	19.50	19.00	**21.01**
Mean		**23.50**	**22.70**	**22.25**	**21.83**	**21.00**	**20.65**	**19.75**	**21.67**
Temperature 20ºC	**Glass jars**	23.50	23.40	23.40	23.30	22.90	22.30	22.20	**23.00**
	Pottery pitchers	23.50	23.40	23.30	23.20	23.00	22.80	22.10	**23.04**
	Plastic jars	23.50	22.90	22.80	22.70	22.00	21.80	21.50	**22.46**
	Tin containers	23.50	23.10	22.90	22.90	21.90	21.70	21.00	**22.43**
Mean		**23.50**	**23.20**	**23.10**	**23.03**	**22.45**	**22.15**	**21.70**	**22.73**
Mean effect		**23.50**	**22.95**	**22.68**	**22.43**	**21.73**	**21.40**	**20.73**	
F-test A=*		**L.S.D 0.05**	**B 0.07**	**AB 0.09**	**C 0.12**	**AC 0.11**	**BC 0.12**	**ABC 0.17**	

F-test L.S.D 0.05
A= Temperatures *

B= Packaging materials 0.07
C= Storage periods 0.12
AB= interaction between temperatures x packaging materials 0.07
AC= interaction between temperatures x storage periods 0.11
BC= interaction between packaging materials x storage periods 0.12
ABC= interaction between temperatures x packaging materials x storage periods 0.17

3.1.4. Effect of packaging materials and storage temperatures on total sugar content

From the results in Table (4), it could be noticed that the total sugar content of samples packaged in different packaging materials were decreased from 78.90% initial period to 75.10, 74.20, 74.00, and 74.10% after storage 12 months at 40ºC. Meanwhile, the total sugar content loss of glass jar and other packaging at 20°C was slightly lower than that of the same packaging during storage. For example, the loss rate of total sugar content of pottery pitcher was 5.95% at 40ºC and 3.17% at 20ºC after storage period. From the statistical analysis, there were significant differences ($p \leq 0.05$) between all packaging materials in their total sugar content at different storage temperatures, storage periods, and interactions. The higher loss of total sugar content was observed in the packaged samples stored at the highest temperatures. The exploitation of sugars in the non-enzymatic browning reaction that occurs during storage could explain the decrease in total sugar concentration [15]. [16] discovered that the total sugar content of date syrup ranged from 71.20 to 91.09 %.

Table (4): Effect of packaging materials and storage temperatures on total sugar content

Tem.	Packaging materials	Storage periods (months)							Mean
		0	2	4	6	8	10	12	
Temperature 40 °C	**Glass jars**	78.90	77.60	77.50	77.30	76.80	76.20	75.10	**77.06**
	Pottery pitchers	78.90	77.80	77.60	77.30	76.20	75.40	74.20	**76.77**
	Plastic jars	78.90	77.30	77.20	77.00	76.00	75.30	74.00	**76.53**
	Tin containers	78.90	77.30	77.20	77.00	76.10	75.50	74.10	**76.59**
Mean		**78.90**	**77.50**	**77.38**	**77.15**	**76.28**	**75.60**	**74.35**	**76.74**
Temperature 20ºC	**Glass jars**	78.90	77.70	77.60	77.50	77.10	77.00	76.80	**77.51**
	Pottery pitchers	78.90	77.90	77.70	77.40	77.00	76.70	76.40	**77.43**
	Plastic jars	78.90	77.70	77.60	77.30	77.10	76.40	76.00	**77.29**
	Tin containers	78.90	77.50	77.40	77.30	77.20	76.20	76.00	**77.21**
Mean		**78.90**	**77.70**	**77.58**	**77.38**	**77.10**	**76.58**	**76.30**	**77.36**
Mean effect		**78.90**	**77.60**	**77.48**	**77.26**	**76.69**	**76.09**	**75.33**	
F-test A=*		**L.S.D 0.05**	**B 0.08**	**C 0.01**	**AB 0.09**	**AC 0.71**	**BC 0.13**	**ABC 0.17**	

F-test L.S.D 0.05
A= Temperatures *
B= Packaging materials 0.08

C= Storage periods 0.01
AB= interaction between temperatures x packaging materials 0.09
AC= interaction between temperatures x storage periods 0.71
BC= interaction between packaging materials x storage periods 0.13
ABC= interaction between temperatures x packaging materials x storage periods 0.17

3.2 Effect of packaging materials and storage temperatures on antioxidant activity

In the results in table (5) it could be observed that the antioxidant activity of the packaging materials of glass jars, pottery pitchers, plastic jars and tin containers packaging decreased from exhibit 21.70% of DPPH inhibition at zero time to 16.33, 17.62, 16.23, 15.96, 17.65, 18.41, 17.23 and exhibit 17.10 % of DPPH inhibition after storage periods at 40^{o}C and 20^{o}C temperatures, respectively. The higher loss of antioxidant activity was observed in packaging stored at the highest temperatures. For example, it was clear that the pottery pitcher recorded the lowest loss (15.16%) at the end of storage at 20^{o}C temperature compared with that at 40^{o}C temperature (18.80%). Meanwhile, the glass jar recorded a loss (18.66%) at the end of storage at 20^{o}C temperature compared with that at 40^{o}C temperature (24.75%).

On the other hand, the highest loss of antioxidant activity was observed in a tin container at two storage temperatures. As shown by the values of the statistical analysis, the interaction between the factors had a significant effect on the antioxidant activity at level ($p \leq 0.05$). The decrease antioxidant activity of sugarcane molasses due to the antioxidant activity have double bonds in their carbon chains, they are sensitive to reactions like oxidation and isomerisation (cis-trans) during storage, especially when exposed to light, heat, acids, and oxygen, resulting in loss [17] **.**

Table (5): Effect of packaging materials and storage temperatures antioxidant activity

Tem.	Packaging materials	Storage periods (months)							Mean
		0	2	4	6	8	10	12	
Temperature 40 °C	**Glass jars**	21.70	20.86	20.03	19.34	18.56	17.23	16.33	**19.15**
	Pottery pitchers	21.70	21.13	20.76	20.10	19.77	18.42	17.62	**19.93**
	Plastic jars	21.70	20.71	19.98	19.24	18.31	17.04	16.23	**19.03**
	Tin containers	21.70	20.68	19.78	19.03	18.12	16.86	15.96	**18.88**
Mean		**21.70**	**20.85**	**20.14**	**19.43**	**18.69**	**17.39**	**16.54**	**19.25**
Temperature 20°C	**Glass jars**	21.70	21.06	20.87	20.11	19.61	18.65	17.65	**19.95**
	Pottery pitchers	21.70	21.43	20.98	20.28	19.98	19.13	18.41	**20.27**
	Plastic jars	21.70	20.97	20.01	19.77	19.01	18.34	17.23	**19.58**
	Tin containers	21.70	20.73	19.97	19.37	18.45	17.46	17.10	**19.25**
Mean		**21.70**	**21.05**	**20.46**	**19.88**	**19.26**	**18.40**	**17.60**	**19.76**
Mean effect		**21.70**	**20.94**	**20.28**	**19.63**	**18.94**	**17.84**	**17.01**	
F-test A=*		**L.S.D**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**	

	0.05	**0.31**	**0.47**	**0. 20**	**0.51**	**0.61**	**0.82**

F-test L.S.D 0.05
A= Temperatures *
B= Packaging materials 0.31
C= Storage periods 0.47
AB= interaction between temperatures x packaging materials 0. 20
AC= interaction between temperatures x storage periods 0.51
BC= interaction between packaging materials x storage periods 0.61
ABC= interaction between temperatures x packaging materials x storage periods 0.82

3.3 Sensory evaluation

The sensory changes are given in Tables 6 and 7. The panelists gave the sugarcane molasses at initial period sensory scores of 9.00 and 9.00 for flavor and overall acceptability. The sensory scores decreased significantly with the advancement of the storage period. The lowest reduction in sensory scores was observed in pottery pitchers and glass jars. This may be because of their inert activity with these chemical molecules. [15] found that sensory evaluation was reduced during the storage time of sugarcane syrups.

Table (6): Effect of packaging materials and storage temperatures on flavor score

Tem.	**Packaging materials**	**Storage periods (months)**							**Mean**
		0	**2**	**4**	**6**	**8**	**10**	**12**	
Temperature 40 °C	**Glass jars**	9.000	8.500	8.000	8.000	7.000	6.500	5.500	**7.500**
	Pottery pitchers	9.000	8.500	8.000	7.500	7.000	7.000	6.000	**7.571**
	Plastic jars	9.000	8.500	8.500	8.000	7.500	7.500	5.000	**7.714**
	Tin containers	9.000	8.000	8.000	8.000	7.500	7.000	5.000	**7.500**
Mean		**9.000**	**8.375**	**8.125**	**7.875**	**7.250**	**7.000**	**5.375**	**7.571**
Temperature 20°C	**Glass jars**	9.000	9.000	8.500	8.000	8.000	7.500	7.000	**8.143**
	Pottery pitchers	9.000	9.000	8.500	8.500	8.000	7.500	7.500	**8.214**
	Plastic jars	9.000	8.000	8.000	7.500	7.000	7.000	6.000	**7.500**
	Tin containers	9.000	8.500	8.000	7.500	7.500	7.000	6.000	**7.643**
Mean		**9.000**	**8.625**	**8.250**	**7.875**	**7.625**	**7.250**	**6.500**	**7.875**
Mean effect		**9.000**	**8.500**	**8.188**	**7.875**	**7.438**	**7.125**	**5.938**	
F-test A=*		**L.S.D 0.05**	**B 0.21**	**C 0.68**	**AB 0. 43**	**AC 0.91**	**BC 0.89**	**ABC 1.2**	

F-test L.S.D 0.05
A= Temperatures *
B= Packaging materials 0.21
C= Storage periods 0.68
AB= interaction between temperatures x packaging materials 0. 43
AC= interaction between temperatures x storage periods 0.91
BC= interaction between packaging materials x storage periods 0.89
ABC= interaction between temperatures x packaging materials x storage periods 1.2

Table (7): Effect of packaging materials and storage temperatures on overall acceptability score

Tem.	Packaging materials	Storage periods (months)							Mean
		0	2	4	6	8	10	12	
Temperature 40 °C	**Glass jars**	9.000	8.500	8.000	7.500	7.500	7.000	6.000	**7.643**
	Pottery pitchers	9.000	8.500	8.500	8.000	8.000	7.500	6.500	**8.000**
	Plastic jars	9.000	8.000	7.500	7.000	6.500	6.000	5.500	**7.071**
	Tin containers	9.000	8.000	7.000	6.500	6.000	6.000	5.000	**6.786**
Mean		**9.000**	**8.250**	**7.750**	**7.250**	**7.000**	**6.625**	**5.750**	**7.375**
Temperature 20°C	**Glass jars**	9.000	9.000	8.500	8.000	8.000	7.000	6.500	**8.000**
	Pottery pitchers	9.000	8.500	8.000	7.500	7.500	7.000	7.000	**7.786**
	Plastic jars	9.000	8.500	8.000	8.000	7.000	6.500	6.000	**7.571**
	Tin containers	9.000	8.000	7.500	7.500	7.000	6.000	6.000	**7.286**
Mean		**9.000**	**8.500**	**8.000**	**7.750**	**7.375**	**6.625**	**6.375**	**7.661**
Mean effect		**9.000**	**8.375**	**7.875**	**7.500**	**7.188**	**6.625**	**6.063**	
F-test A=*		**L.S.D 0.05**	**B 0.45**	**C 0.72**	**AB 0. 84**	**AC 0.91**	**BC 0.91**	**ABC 1.1**	

F-test L.S.D 0.05
A= Temperatures *
B= Packing materials 0.45
C= Storage periods 0.72
AB= interaction between temperatures x packing materials 0. 84
AC= interaction between temperatures x storage periods 0.91
BC= interaction between packing materials x storage periods 0.91
ABC= interaction between temperatures x packing materials x storage periods 1.1

4 Conclusions

These results imply that temperatures and storage time are the most important factors in affecting sugarcane molasses quality. As a result, it was discovered that both glass jars and pottery pitchers packaging materials have good effects as stability and quality agents and could be employed as safe packaging preservatives to improve the shelf-life of sugarcane molasses.

5 References

[1] Amin, W.A.; Safwat, M. and El-Iraki, S.M.: Quality criteria of treacle (blackhoney): Food Chem.1999 ; 67 (1):17-20.

[2]Mejía, V.C.; Martínez,A.B.; Yordi, A.G.and Mejia,G.C.(2021):Simulation Strategy to Reduce Quality Uncertainty in the Sugare Cane Honey Process Design. Chemical, Food and Environmental Engineering.2021; 41(8)2-11.

[3] Sampaio, M.R.; Tomasini, D.; Cardoso, L.V.; Caldas, S.S. and Primel, E.G. (2012): Determination of pesticide residues in sugarcane honey by QuEChERS, and liquid chromatography. J. of the Brazilian Chem. Society. 2012 ; 23 (2): 197-205.

[4] Abdel-Aleem, W. M. Effect of Sugarcane Juice Pre-Treatment on the Quality and Crystallization of Sugarcane Syrup (Treacle). Journal of Food Processing & Technology. 2020; 11(7)1-11

[5] Colombo, R.; Yariwake, J.H. and McCullagh, M. : Study of C-and O-glycosylflavones in sugarcane extracts using liquid chromatography: exact mass measurement mass spectrometry. J. of the Brazilian Chem. Society. 2008; 19(3): 483-490.

[6] Anonymous : Egyptian Organization for Standardization and Quality Control, Sugarcane syrup, Egyptian Standard. 2006 No.356. A.R.E.

[7] Polette, C.M.; Bele, J.S and Bernardi, R.M. Physicochemical and sensorial characterization of commercial sugarcane syrups: Revista de Ciecias Agrarias. 2019 ;42 (3) : 808-816

[8] AOAC. Official methods of analysis. Associatation of Official Analytical, Chemists 20th ed., Washington DC, USA; 2016.

[9] Ao, C.; Li, A.; Elzaawely, A. A.; Xuan, T. D. and Tawata, S. Evaluation of antioxidant and antibacterial activities of Fichus microcarpa L. fil. extract. Food Control. (2008;19: 940–948.

[10] Molander, A. L. Discernment of primary test substances and probable ability to judge food. Iowa state university pub., Aimess, USA. C.F., Egypt Agric., Res., 1960; 77 (2): 873 - 889.

[11] Montgomery DC. Introduction to factorial design. Design and analysis of Experiments, Minitab Manual. John Wiley and Sons. USA. 2010;27-34.

[12] Zeeshan, M. 1.; Saleem, S. A. 1.; Ayub, M.; Shah, M. and Jan, Z. (2017) Physicochemical and Sensory Evaluation of Dhakki Dates Candy. J. Food Process Technol. 2017; l (8): 1- 4.

[13] Farrokhi, F.; Mizani, M. and Honarvar M. Study of probable physicochemical changes during the storage of light and thick sucrose syrups. World Applied Sciences Journal 2012; 18 (5): 715-721.

[14] Abker, A. M; Madwi, H. A. ; Dawood, S. Y and Elkhedir, A.E. (2016): Impact of Packaging and Storage on Quality of Watermelon Honey. Journal of Food Processing Technology. 2016;7(5)2-4.

[15] Thilagavathi,T. and Hemalatha, G.(2016): Evaluation of quality characteristics of sugarcane syrup. International Journal of Nutrition and AgricultureResearch.2016;3(2)49-55.

[16] Bolbol R. R.(2005): Preparation and Evaluation of Egyptian Date syrup, Food Science Technology, Dept., Faculty of Agric., Assiut University. Assiut, Egypt. 2005; 11(2) 86-98.

[17] Lin, C. H. and Chen, B. H. (2005). Stability of carotenoids in tomato juice during storage. Food Chemistry, (90): 837-84