Original Research Article

Physicochemical Evaluation of Sugarcane Molasses (black honey) during Storage in Various Packaging Materials

Abstract

Sugarcane molasses is a nutritious drink with a black color, characterized by its viscosity, distinctive taste and aroma, which makes it a unique food with high nutritional value. The quality characteristics of sugarcane molasses stored inside various packaging materials at different storage periods were evaluated. The evaluation included the determination of the physicochemical properties of sugarcane molasses stored in four types of packaging materials (glass jar, pottery pitcher, plastic jar and tin container). The stored sugarcane molasses were analyzed periodically at 2, 4, 6, 8, 10 and 12 months for the optical density (at 420 nm), acidity, viscosity values and total phenol content. All studied physicochemical properties increased significantly ($p \leq 0.05$) with increasing storage time, the results showed that pottery pitchers and glass jars are suitable for packing sugarcane molasses. They produce the most stable sugarcane molasses, so they are practical containers to use. Therefore, it is recommended to use this type of packaging materials with care of the storage temperature.

Keywords: Sugarcane, molasses, storage time, packaging materials, physicochemical properties

1-INTRODUCTION

Sugarcane (*Saccharum officinarum Linn*.) is a plant of the Poaceae family collected worldwide for its products of economic and medicinal value, such as cane juice, pulp, paper, xylitol, chemical alcohol, electricity, fodder and bore [1]. The original habitats of this species are Southeast Asia and South Tropical Asia. Even in hot and humid conditions, it thrives in tropical and subtropical regions with an abundance of natural materials and highly drained soils (pH 7.5-8.5) [2]. Sugarcane is the cheapest source of energy because it contains fructose and glucose. [3]. Sugarcane syrups and juices have an antioxidant effect due to the presence of flavonoids, phenolic acids and various other phenolic compounds. [4]. In addition, various studies have shown that blackstrap molasses is a valuable source of phenolic compounds [5].

Sugarcane honey is in great demand in the natural food market because it retains nutrients from cane juice, such as iron, phosphorus, salt, magnesium, calcium, potassium, and chlorine. [6]. Sugarcane syrup is a sweetener that can be used in place of refined sugar in recipes, as well as consumed alone or in combination with flour, cookies, and cakes. [7]. Sugarcane syrup production is a traditional agro-industrial process, in which industrial production is readily available on the market. The juice industry has proven to be a profitable option for small rural producers to profit from sugarcane through the use of low-cost equipment and family labor, but basic hygiene and quality control requirements in the production process are often ignored and depend on producer expertise [8]. Aimed at [7], the lack of sanitary requirements leads to the presence of some or whole insects, soil, fungi, yeasts and coliform, which are the most common problems affecting the quality of cane syrup. The lack of adequate equipment and technology to remove impurities can expose the final product to microbiological and chemical contamination when cane honey comes from nonstandard production methods. However, small adjustments to the production process such as washing the cane sticks with drinking water and filtering the broth, and then some investments such as the acquisition of suitable special cooking vessels and a sterilized place for the manufacture of cane syrup, will be sufficient to improve the quality of the product.

Few studies record how this food is produced and monitored in terms of nutritional quality characteristics. In this context, studies must be done about the product to raise knowledge and then raise consumption, achieve a great deal of reliability, increase demand for the product, and ultimately raise income for small producers. This study aims to evaluate the quality characteristics of sugarcane syrup by studying the characteristics.

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:

Color was measured as the optical density (OD) of the diluted extract (5% TSS), and the absorbance at 420nm was measured using a Perkin Elmer Lambda-UV/VIS spectrophotometer [11]. The viscosity was measured by viscometer (Brookfield Engineering Stoughton MA02072 U.S.A) [15]. Acidity was calculated as the number of milliliters of sodium hydroxide (0.1 N) required neutralizing a gram of the sample [14]. The total phenolic content was evaluated by using Folin-Ciocalteu for sugarcane molasses [9].

2.4. 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 $p \leq 0.05$. [10].

3. Results and Discussion

3.1. The physicochemical characteristics:

3.1.1. The optical density value (at 420 nm):

Firstly, the results are in the table (1) it was observed that the optical density of sugarcane molasses (black honey) was 0.550 (OD) at 420 nm, at zero time. The optical density value findings confirmed those previously reported by

[11], who studied whether the pre-treatment of sugarcane juice has an effect on the quality and crystallization of sugarcane syrup (treacle). He concluded that color samples at that level extended from 0.191 to 0.626 (OD) at 420 nm. This may be due to the diversity of sample sources. The results are in the same table it can be seen that the color values of sugarcane molasses gradually increased with the progression of the storage period, and the higher the storage temperature of all packages until the end of the storage period. During the storage periods, the optical density of all packages (glass jar, pottery pitcher, plastic jar and tin container) increased from 0.550(OD) at the time of zero at temperatures of 40°C and 20°C to 0.840, 0.820, 0.970, 0.990, 0.780, 0.750, 0.800, and 0.850 (OD), respectively. At the end of storage, the lowest optical density value is found in the pottery pitcher followed by a glass jar for each of the two storage temperatures, where they recorded the lowest rate of change among the rest of the packages, as it appears from the same table.

As per statistical data, every one of the studied factors (storage temperatures, packing types, and storage period) had a significant effect, and the interaction between the factors had the same effect at level ($p \leq 0.05$). These results are in agreement with those reported by [12],who studied color index changes in clarified sugarcane syrup during storage in pan supply tanks, pointing to the color development was significant during storage, Iron reacts with polyphenols in particular to produce coloured compounds. Also, when syrup is exposed to the air color development may occur. A similar pattern of results was reported by [13], who showed that once the pH of the syrup is reduced, it is more likely that some reactions may occur during storage, resulting in a darker color. Sucrose would partially convert to dark colors and other important sugars like glucose and fructose, resulting in a reduction in its quantity and changes in other quality characteristics, such as high temperature and changes in syrup acidity, temperature, concentration, and especially pH, can also induce browning reactions.

Table (1): Effect of packaging materials and storage temperatures on the color value sugarcane molasses.

Tem.	packaging materials	Storage periods (months)							Mean	rate of change%
		0	**2**	**4**	**6**	**8**	**10**	**12**		
Temperature 40 °C	**Glass jar**	0.550	0.620	0.670	0.690	0.740	0.790	0.840	**0.700**	52.73
	Pottery pitcher	0.550	0.630	0.690	0.700	0.720	0.800	0.820	**0.701**	49.09
	Plastic jar	0.550	0.700	0.750	0.820	0.890	0.920	0.970	**0.800**	76.36
	Tin container	0.550	0.670	0.800	0.840	0.900	0.950	0.990	**0.814**	80.00
Mean		**0.550**	**0.655**	**0.728**	**0.763**	**0.813**	**0.865**	**0.905**	**0.754**	
Temperature 20°C	**Glass jar**	0.550	0.570	0.590	0.640	0.680	0.700	0.780	**0.644**	41.82
	Pottery pitcher	0.550	0.580	0.600	0.670	0.730	0.750	0.750	**0.661**	36.36
	Plastic jar	0.550	0.560	0.650	0.700	0.750	0.770	0.800	**0.683**	45.45
	Tin container	0.550	0.570	0.670	0.760	0.800	0.820	0.850	**0.717**	54.55
Mean		**0.550**	**0.570**	**0.628**	**0.693**	**0.740**	**0.760**	**0.795**	**0.676**	

F-test	A= temperatures	*
	B= packaging materials	0.044
	C= Storage periods	0.069
L.S.D0.05	AB= interaction between temperatures x packaging materials	0.068
	AC= interaction between temperatures x storage periods	0.080
	BC= interaction between packaging materials x storage periods	0.110
	ABC= interaction between temperatures x packaging materials x storage periods	0.167

3.1.2. The viscosity value (sentistock cm^2/s):

The data in the table (2) indicates that the viscosity of sugarcane molasses (black honey) was 480.0 (s t) at zero time. During the storage periods, the viscosity of all packages (glass jar, pottery pitcher, plastic jar and tin container) increased to 556.1, 549.6, 562.7, 574.2, 546.6, 543.2, 556.3, and 563.1(s t) at 40°C and 20°C temperatures, respectively. With increasing storage time, the viscosity values of sugarcane molasses packing increased. The increase in the viscosity values during storage at 20°C temperature was lower than that of packing stored at 40°C temperature.

The highest increase in the viscosity values was observed in plastic jars and tin containers during storage until the end of the storage period at both temperatures. They recorded the highest rate of change for both storage temperatures. Meanwhile, pottery pitcher packing and glass jar recorded the lowest rate of change, as shown in the same table at the end of storage. The results in the table (2) show that the viscosity values of sugarcane molasses (black honey) increased with the progression of the storage period and the increase in the storage temperature. As per statistical data, the interaction between the factors (temperature, types of packing, storage period) It had a significant effect at a level ($p\leq 0.05$). Every one of the studied factors (storage temperatures, packing types, and storage period) had a significant effect, and the interaction between the factors had the same effect at level ($p\leq0.05$). This result is consistent with that mentioned by [16], who mentioned that the production of dextran, a gummy compound produced by bacteria such as Leuconostoc mesenteroides, may be responsible for the increase in viscosity of sugarcane juice.

Table (2): Effect of packaging materials and storage temperatures on the viscosity value (sentistock cm^2/s) of sugarcane molasses.

Tem.	packaging materials	Storage periods (months)							Mean	rate of change%
		0	2	4	6	8	10	12		
Temperature 40 °C	**Glass jar**	480.0	488.1	508.3	522.6	531.1	543.6	556.1	**518.5**	15.85
	Pottery pitcher	480.0	485.4	504.2	516.5	530.2	538.4	549.6	**514.9**	14.50
	Plastic jar	480.0	491.3	510.5	521.3	543.3	554.5	562.7	**523.4**	17.23
	Tin container	480.0	494.5	515.6	526.2	550.4	563.3	574.2	**529.2**	19.63
Mean		**480.0**	**489.8**	**509.7**	**521.7**	**538.8**	**550.0**	**560.7**	**521.5**	
Temperature 20°C	**Glass jar**	480.0	485.2	506.1	519.2	525.6	535.2	546.6	**514.0**	13.88
	Pottery pitcher	480.0	483.5	501.3	511.4	522.7	531.2	543.2	**510.5**	13.17
	Plastic jar	480.0	488.1	504.5	516.3	535.3	544.1	556.3	**517.8**	15.90
	Tin container	480.0	490.7	509.7	521.2	538.2	551.3	563.1	**522.0**	17.31
Mean		**480.0**	**486.9**	**505.4**	**517.0**	**530.5**	**540.5**	**552.3**	**516.1**	

F-test A= temperatures *

B= packaging materials 0.76

C= storage periods 0.87

L.S.D0.05 AB= interaction between temperatures x packaging materials 0.93

AC= interaction between temperatures x storage periods 1.23

BC= interaction between packaging materials x storage periods 1.73

ABC= interaction between temperatures x packaging materials x storage periods 2.50

3.1.3. The acidity value:

In the first, data in table (3) observed that the acidity of sugarcane molasses (black honey) were 0.120 (0.1milliliter NaoH Noramal / gram of sample) at zero time. The acidity value findings confirmed those previously reported by [14]. It was found that sugarcane syrup samples (treacle) had the titratable acidity (TA) of sugar cane syrup was 0.88 milliliter NoaH 0.1Normal/1gram. On the other hand, [15] studied some sugarcane syrup physicochemical and sensory properties of acidity (in fifteen brands and found that they ranged from 0.87 to .049% with citric acid. These differences can be linked to the shelf life of the syrup after the production stage.

During the storage periods, the acidity of all packages (glass jar, pottery pitcher, plastic jar and tin container) increased from 0.120 at the time of zero at temperatures of 40°C and 20°C to 0.240, 0.230, 0.270, 0.290, 0.190, 0.180, 0.200, and 0.210 respectively. At the end of storage, the lowest acidity value is found in the pottery pitcher followed by a glass jar for each of the two storage temperatures. The results in the table (3) show that the acidity values of sugar cane molasses (black honey) increased with the progression of the storage period and the increase in the storage temperature. Based on the rate of change evidence, we find that the increase in storage temperature had a clear effect in increasing the acidity, as the containers stored at 40°C had a rate of change twice as much as their counterparts at 20°C. According to of statistics, the interaction between the factors (temperature, types of packing, storage period) It had a significant effect at a level ($p \leq 0.05$). These results are in accordance with those stated by [16], pointed out that the acidity of the extracted juice increases during storage. The increase in acidity of samples stored at 30°C is higher than those stored at 10°C. This may be due to the consumption of sugar from the cane juice during storage.

Table (3): Effect of packaging materials and storage temperatures on the acidity value (0.1ml NaoH N/g) of sugarcane molasses.

Tem.	packaging materials	Storage periods (months)							Mean	rate of change%
		0	**2**	**4**	**6**	**8**	**10**	**12**		
Temperature 40 °C	**Glass jar**	0.120	0.130	0.150	0.170	0.190	0.220	0.240	**0.174**	100.0
	Pottery pitcher	0.120	0.130	0.160	0.190	0.200	0.200	0.230	**0.176**	91.67
	Plastic jar	0.120	0.140	0.170	0.200	0.220	0.230	0.270	**0.193**	125.0
	Tin container	0.120	0.150	0.160	0.220	0.230	0.240	0.290	**0.201**	141.7
Mean		**0.120**	**0.138**	**0.160**	**0.195**	**0.210**	**0.223**	**0.258**	**0.186**	
Temperature 20°C	**Glass jar**	0.120	0.140	0.150	0.160	0.160	0.180	0.190	**0.157**	58.33
	Pottery pitcher	0.120	0.120	0.150	0.170	0.170	0.170	0.180	**0.154**	50.00
	Plastic jar	0.120	0.130	0.160	0.180	0.180	0.190	0.200	**0.166**	66.67
	Tin container	0.120	0.140	0.170	0.170	0.170	0.190	0.210	**0.167**	75.00
Mean		**0.120**	**0.133**	**0.158**	**0.170**	**0.170**	**0.183**	**0.195**	**0.161**	

F-test	A= temperatures	*
	B= packaging materials	0.056
	C= storage periods	0.070
L.S.D0.05	AB= interaction between temperatures x packaging materials	0.060
	AC= interaction between temperatures x storage periods	0.010
	BC= interaction between packaging materials x storage periods	0.011

ABC= interaction between temperatures x packaging materials x storage periods 0.170

3.1.4. The total phenolic content:

The data in the table (4) indicates that at zero time, the total phenolic content of sugarcane molasses (black honey) was 335.3 (mg/100g). During the storage periods, the total phenolic content of all packages increased. With increasing storage time, the increase in total phenolic content during storage at 20 °C was less than that observed in packing stored at 40°C. The highest increase in the total phenolic content was observed in plastic jars and tin containers during storage until the end of the storage period at both temperatures. Meanwhile, pottery pitcher and glass jar packing were 376.1 and 384.5 (mg/100g) at the end of storage at 20°C respectively. Looking at the rate of change data, we find that the aforementioned two packages (pottery pitcher and glass jar) recorded the lowest rate of change during the storage period.

The results shown in the table (4) show that the total phenolic content of sugarcane molasses increased with the progression of the storage period and the increase in the storage temperature. Statistical analysis confirms that each of the factors under investigation (storage temperatures, types of packing, and storage period) had a significant effect, and also that the interaction between the factors had the same effect at level ($p \leq 0.05$). These results are in treaty with what was mentioned by [12], who studied color index changes in clarified sugarcane syrup during storage in pan supply tanks, state that the clearer sugarcane molasses contains a high total phenolic content, which induces the polyphenols to increase with color development.

Table (4): Effect of packaging materials and storage temperatures on the total phenolic content of sugarcane molasses.

Tem.	Packaging materials	Storage periods (months)							Mean	rate of change%
		0	**2**	**4**	**6**	**8**	**10**	**12**		
Temperature 40 °C	**Glass jar**	335.3	349.3	354.6	361.7	371.3	382.9	395.0	**364.3**	17.80
	Pottery pitcher	335.3	348.2	351.8	358.8	366.6	374.6	382.1	**359.6**	13.96
	Plastic jar	335.3	349.4	353.2	362.6	368.5	385.6	398.4	**364.7**	18.82
	Tin container	335.3	348.8	354.2	364.7	372.9	388.0	402.8	**366.7**	20.13
Mean		**335.3**	**348.9**	**353.5**	**362.0**	**369.8**	**382.8**	**394.6**	**363.8**	
Temperature 20°C	**Glass jar**	335.3	347.4	351.2	357.0	365.9	374.7	384.5	**359.4**	14.67
	Pottery pitcher	335.3	346.5	349.8	355.6	362.7	367.8	376.9	**356.4**	12.41
	Plastic jar	335.3	347.0	351.6	356.9	366.6	377.6	390.7	**360.8**	16.52
	Tin container	335.3	347.1	349.8	357.6	368.8	373.8	383.9	**359.5**	14.49
Mean		**335.3**	**347.0**	**350.6**	**356.8**	**366.0**	**373.5**	**384.0**	**359.0**	

F-test A= temperatures *

B= packaging materials 0.81

C= storage periods 0.89

L.S.D0.05 AB= interaction between temperatures x packaging materials 0.93

AC= interaction between temperatures x storage periods 0.99

BC= interaction between packaging materials x storage periods 1.70

ABC= interaction between temperatures x packaging materials x storage periods1.90

4. CONCLUSIONS:

The results seem that, the longer the storage time of sugarcane molasses, the greater the rate of change in physicochemical properties, especially while the temperature increases. The most appropriate packaging materials for sugarcane molasses are pottery pitchers and glass jars, as they recorded the lowest rates of change of the studied properties during the storage period. This may be because of their inert activity with these chemical molecules. High acidity affected color development over storage time. This work provides information on the most appropriate storage conditions and the selection of the best containers.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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