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COMPOSITION AND PROPERTIES OF EGYPTIAN BEET MOLASSES

El-Geddawy, Mennat-Allah M. A. ; M. B. Omar ; Magda M. seleim and S. I. Elsyiad
Food Science and Technology Department, Faculty of Agriculture, Assuit University, Assuit , A.R.Egypt

ABSTRACT

Beet sugar molasses studied in this investigation were kindly provided by Delta Sugar Factory, Kafr El-sheikh governorate, Egypt. During the 2011 working season, the samples of molasses were analyzed for the following: Brix, sugar, purity, non-sugar, ash, organic non-sugar, as well as relations between analytical values characterizing beet molasses.

The obtained results illustrated the following conclusions:

1- Refractive index was greater accuracy in measuring the soluble solids content in molasses.

2- Approximate analysis of beet molasses were: Brix 80.20 - 81.61, sucrose 48.36 - 49.56, ash 12.11 - 12.35 and organic non-sugar 18.48 - 20.89 %.

3- Betaine was the most abundant nitrogenous compound found in molasses (3 – 4 %).

4- The non-sucrose carbohydrate of molasses consist of invert sugar, usually less than 1% in molasses.

5- Other nitrogen free organic impurities in beet molasses were the acids – lactic, citric, malic, and acetic and others.

INTRODUCTION

The economical importance of molasses that it was used in backing industries and in animals feed industries. Molasses is the final syrup spun off after repeated crystallization in the extraction of sucrose (Douglas and Glenn 1982). It is so low in purity that further crystallization from it is impractical. It is therefore discarded from the sugar end , carrying with it all of the non-sucrose of the beet not eliminated by the juice purification process , the soluble impurities added in processing and the degradation produced formed during processing . It also carried out about one to one and half pounds of sugar with each pound of impurities. It represents therefore an important loss of extraction, amounting 12 to 16 % of the sugar in the beet.

. The amount of molasses produced depended up on the impurities left in the juice after purification and upon the degree of exhaustion of final syrup.

There are some attempts should be made to prepare clarified solution of molasses to be used in food industries and sucrose recovery from beet sugar molasses to be used in refined sugar *production* (Po-wah 1982). Especially sucrose, invert sugars and other as well. The cheap price of molasses will justify expenses of clarification for edible consumption. This study aimed to evaluate the gross chemical composition of beet molasses. Such analysis will furnish enough data to set up standard of identification and general specification to be used in food industries.

MATERIALS AND METHODS

1- Materials:

Beet sugar molasses studied in this investigation were obtained from Delta Sugar Factory , Kafr El-Sheikh , governorate , Egypt during 2011 working season .

2- Methods:

2.1 Physical analysis

2.1.1 Total soluble solids (T.S.S.)

The total soluble solids in molasses were determined by two methods, hydrometer and refractometer .

Hydrometer: A diluted solution of molasses 1:6 (molasses: water) was used as it gave the most accurate results. A "Brix" Hydrometer was applied according to the method described by Plews (1970). Then multiplied by b gives the hydrometer solids in the undiluted molasses.

Refractometer : using double dilution method . About two grams of molasses were diluted with equal volume of distilled water and thoroughly mixed at 20 ºC as described in Plews (1970).

2.1.2 Specific gravity:

Specific gravity was determined according to A.O.A.C (1995) at 20 ºC .

2.1.3 pH value

Samples of molasses should be diluted to 60 BX (77-19 gm of original molasses . 100 ml of hot distilled water) , and must be cooled to room temperature before pH measurement , by a Beckman pH meter was carried out according to Olbrich (1963a)

2.2 Chemical analysis:

2.2.1 Moisture content and total solids:

Total solids (T.S) were estimated by the drying method under vacuum at a temperature of 70 ºC and a pressure of 50 mm . The determination was carried out according to the method recommended in A.O.A.C (1995).

Moisture %=100-total solids %

2.2.2 Total nitrogen content:

Total nitrogen content was determined by the MicroKejedahl method as described in A.O.A.C (1995) .

2.2.3 Minerals content of molasses:

Sodium, potassium and calcium content were determined by "Carl Zeiss" flame photometer applying the method explained by Jackson (1958)and Mathur(1981).

Ash content:

The method described by A.O.A.C (1995) was used. Ash determination was carried out at 550 ºC with 2 gm of samples.

- Reducing sugars was determined by lane &Eynon method as described in A.O.A.C (1995).

- Metalic ions were determined by atomic absorption spectrophotometry using a Pye UniCam sp 9-8—instrument.
- Sugars were determined by HPLC using an optilab 5931 liquid chromotograph (Tecator AB, Hòganàs , Sweden) provided with a refractometric detector .
- Organic acids from 30 g of final molasses were distilled previously with steam. The distillate was adjusted to pH 2 and injected directly into the column.
- Amino acids were estimated using an automatic amino-acid analyzer (Hitachi KL A-5) by ion exchange chromatography.

Purity:

Purity was carried out according to Silin and Silina (1977) using the following equation:-

$$P = \frac{sucrose\%}{T.S.S\%} \times 100$$

RESULT AND DISCUSSION

Sugar beet molasses can be divided into water and dry matter. The later may subdivided into sugar and non-sugar constituents. Finally, non-sugars may be further sub-divided as shown in Table 1:-

Table (1): Non-sugar component in beet molasses:

Inorganic	N-containing non-sugars	N-free non-sugar
Ash	Total nitrogen	Lactic acid
K	Crude protein	Citric acid
Ca	Betaine	Glycolic acid
Mg	Neucleic acid components	Formic acid
Na	Amino acids sugar complex	Acetic acid
Trace elements		Propionic acid
		Valeric acid
		Butyric acid

In addition to those mentioned in the figure, there are many other substances which have been found in molasses and reported else where (Stark *et. al.* 1959, Po-wah 1982 and .Barker 1986)

Final molasses is composed of organic and inorganic matter. About 49% sugar beet molasses are sucrose and about 12% or more were inorganic matter (potassium, sodium and calcium salts) and considered in molasses forming. The analysis of molasses , and particularly of sugars in it , may vary considerably depending on the variety of sugar beet , soil , climate , period of crop , efficiency of crystallizes etc . Its composition would make it suitable for human consumption provided. It is manipulated in such a way to clarify free from foreign matter and adjust the concentration of some of its components. Such analysis would be of value in prescribing specifications for local molasses to be used in bases its industrial and commercial utilization (Calik et al. 2001).

The results of chemical composition of sugar beet molasses was illustrated in Table (2) and indicate that sucrose content was 49% , purity 60.55 % , non-sugar 31.94 , ash 12.18 and organic non-sugar 19.76% . These data were comparable with those reported by many authors (Raiakylă and Paloposki 1982 , Barker 1986, and Alcalde at al. 2006) .

Table (2): composition of beet molasses :

Replicate	Brix	Sugar	Purity	Non-sugars	Ash	Organic non-sugar
1	81.60	48.36	59.26	33.24	12.35	20.89
2	81.00	49.00	60.49	32.00	12.12	19.88
3	81.40	48.88	60.05	32.52	12.04	20.48
4	81.00	48.76	60.20	32.24	12.09	20.15
5	80.60	48.88	60.65	31.72	12.11	19.61
6	80.80	49.12	60.69	31.77	12.20	19.57
7	80.80	49.56	61.33	31.25	12.25	18.99
8	80.20	49.44	61.65	30.76	12.28	18.48
Average	80.93	49.00	60.55	31.94	12.18	19.76

The relations between analytical values characterizing beet molasses are shown in Table (3).

Chemical and physical characteristics of beet sugar molasses

- Total solids:

The soluble content of sugar beet molasses were measured by the refractometer and hydrometer, as well as by drying method under vacuum as indicated in Table (4). The soluble solids of molasses measured by hydrometer ranged between 91.5 to 95.0 degree Brix with an average of 92.91 degree Brix. The soluble solids of molasses measured by refractometer ranged from 87.5 to 90.5 with an average of 88.61 %. The relatively higher values for soluble solids recorded by the hydrometer method could be attributed to several the factors interfering this particular method. Most important of such factor is the contraction phenomenon takes place upon diluting molasses. The relatively large content of non-sucrose component of different nature as well as the relatively large amount of colloidal and foams presents in the mater under test. Thus, it seems that refractometer is of greater accuracy in measuring the soluble solids content of molasses. But the soluble solids of molasses measured by dry substances ranged from 77.53 to 82.09% with an average of 80.37. The refractometer method was demonstrated to be of practical utility is sugar housework. It gives an accurate measure of soluble solids in almost all manufacturing and refinery products (Mathur,1981 and Barker , 1986) .

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Table (4): Total solids content of beet molasses by different method

Brix	Refractometer	Drying
91.8	88.0	79.95
91.8	87.5	77.53
91.5	86.0	80.10
92.9	89.0	81.00
95.0	90.5	82.09
94.5	88.7	81.50
Mean 92.91	**88.61**	**80.37**

One difficulty in this method is the effect of dispersion caused by the deep colour of molasses. When diluted samples are to be studied, the effect of the phenomenon of contraction in encountered, resulting in relatively high results. These dilution help to overcome such difficulty. The most probably of the changes in volume and the presence of relatively large amount of suspended method which interfere with the adjustment of the borderline in the refractometer according to results of Mohamed (1966), and) Mohamed *et.al* (1985). Also most of inorganic non-sugars are higher density than the sugars. The hydrometer method should be used with great caustion because the results are considerably affected by such factor that influences the nature and amount of non-sugars in molasses. These factor include the variety of beet, agricultural practices, method of clarification, means of storage and probably other (Browne and Zerben ,(1955).

In general, it was noted from the results obtained (Table 4) that total soluble solids % determined by refractometer was higher than the total solids content determined by drying method under vacuum. This could be attributed to the loss in certain volatile organic components, as well as bicarbonate even at the temperature used. Also, some of inverted sugar (fructose are liable to decompose, Mohamed, 1977). The increase in hydrometer reading due to the relatively large amount of colloidal and foams present in the molasses (Mohamed *et,al* , 1985) . Relationship between Brix , refractometer and solids by drying, the salt present in low-purity products increase the specific gravity and there effect the Brix by hydrometer . Thus, it seems that refractometer is greater accuracy in measuring the soluble solids content of molasses (Mohamed , 1966) . Hence, the results by refractometers are closer to true dry substance than the figures obtained by hydrometer. Refractometer measurement is usually intermediate between Brix and dry substances.

Moisture content and specific gravity:-

The results in Table (5) revealed that moisture content of molasses ranged from 17-91 to 22-17 % with a mean value 19-63 %. This is to be expected since there were reversibly relationship between the moisture content and total solids (T.S) content. These results are agree with treatments were reported by Mohamed (1966) and Barker (1975).

Table (5): Moisture content and specific gravity of beet molasses

Replicate	Moisture	Specific gravity
1	20.05	1.5010
2	22.17	1.4964
3	19.90	1.5010
4	19.00	1.5096
5	17.91	1.5227
6	18.50	1.5070
Mean	19.63	1.5063

Also, the results in Table (5) indicated that specific gravity of sugar beet molasses was ranged from 1.4964 to 1.5227 with an average 1.5063 . On the other hand , specific gravity of American Cane blackstrap was reported from around 1.390 to about 1.44 at 20 ºc (Olbrich ,1963a). These results are in the same trend with those reported by Mohamed (1966) , who indicated that specific gravity of molasses ranged from 1.4812 to 1.5225 with an average 1.5014 $^{g}/_{cm^3}$ at $^{20}/_{20°C}$. He added that, the difference in specific gravity followed as would be presumed the changes in the total solids content.

Contents of Nitrogen-containing organic compounds:

The results illustrated in Table (6) should that on tents of nitrogen – containing non-sugars . The results indicate that the total nitrogen ranged from 8-12% with an average of 10% ; crude protein 7-12% , betaine 3-4% , glutamic acid , pyrrolidon – amino acids; carboxylic acids , peptides foam 2-3% , neucleic acides components 2-3% and amino acid sugar complexes 0.5-1.5% . This is in good accordance with those concluded by Stark *et al.* (1959) , and Barker (1986). They reported that nitrogenous substances such as amino acid could react with reducing sugar and form brownish compounds, which affected the beet sugar molasses colour during the processing. So removal of the nitrogenous compounds from the beet sugar molasses represents some importance. Betaine is the most abundant nitrogenous compound found in molasses, ranging from 3-4% , increasing some what toward the end of the campaigns . The next most abundant nitrogen compound is glutamic acid, pyrrolidon , amino acids , peptides

Table (6): Content of Nitrogen-containing organic components:

Total N-containing compounds	8-12%
Crude protein	7-12%
Betaine	3-4%
Glutamic acid –pyrrolidon – Amino acids – carboxylic acids – peptides	2-3%
Nucleic acid components	2-3%
Amino acid sugar complex	0.5-1.5%

Inorganic non-sugar:

The ash was fractionated into individual ions, and the results are shown in Table (7).

Table (7): Mineral, trace elements and inorganic anion in beet molasses

Minerals and trace element		**Content of inorganic anion**	
Potassium	3.6%	Chlorides	1.2
Calcium	0.6%	Sulfure	1.0
Magnesium	0.11%	Nitrate	0.25
Sodium	1.4%	Nitrite	120 mg/kg
Trace element	40 mg/kg		

The results indicated in Table (7) showed that more than 90% is composed of potassium and sodium from the results it could be noticed the molasses contained higher amount of potassium, calcium and sodium were considerably high in molasses. On the other hand, Olbrich (1963a) and Barnes (1964) mentioned that potassium content of black syrup were approach from 2.60 to 5.00% , while final beet molasses content from 3.77 to 4.19% . However, Mohamed *et al.* (1985) found that average content of potassium cation in beet molasses was 1.8%, also they mentioned that concentration of sodium in beet molasses was 0.7% . The high potassium content may be attributed to the concentration of beet juice-known to be rich in potash – several folds during sugar production. The increment in calcium content may be due to concentration as well as to the treatment of the juice with calcium salts in the clarification process.

However, the markedly large content of potash in molasses necessitates its dilution before direct edible uses (Mathur, 1981). The data recorded would lead to the following

Conclusion:-

1- The average of K, Ca and Na were 3,6 , 0.6 and 1.4% respectively .

2-The exceeding high potassium content of molasses would make crystallization of sucrose quit difficult through its melassigenic effect .

Sugar content in beet molasses:

The sucrose and reducing sugars content, as well as unfermentables are shown in Table (8) . The sucrose content of molasses was 48% , this value is considerably higher than the corresponding value recorder for molasses produced in other sugars . Binkly and Wolfrom (1953) , found that sucrose ranged from 25.3 to 44.5% with an average of 33.8% and reducing sugars ranged from 4.7 to 34.9% In general , the results obtained lead to the following conclusion :

1- Sucrose content with an average 48% .

2- The sucrose content of beet molasses depend on the original sucrose content of sugar beet used as well as the condition of sugar production in the factory .
3- The reducing sugars content of beet molasses was an average 2% .
4- The total sugars content of molasses was an average of 52% .

Table (8) : Sugar content in beet molasses , all results in % beet molasses

Sugars	%	Unfermentable	%
Sucrose	48	Gums-Starch-Levans	1
Glucose	0.4	Dextrans-Cellulase	3
Fructose	0.6	Waxes-Vanillin-Lignins	0.2
Ketoses	0.15	Hexitols,myo-Insitol,Mannitol,polymers	0.2
Raffinose	1.25		
Other oligo saccharides	1		
Galactinol	0.2		
Reducing sugar derivatives	1		

pH and titratable acidity :

The pH and titratable acidity of molasses shown in Table (9) . The titratable acidity was presented as acetic acid . The titratable acidity has mean value of 1.456 % . Barnes (1964) and Mohamed (1966) , they found that the acidity of final beet molasses is derived from the organic acids present in the juice and the acids formed during process . Payne (1960) and Martin (1960) found that the organic acids are always represent significant proportion of the total non-sugars of sugar juice, and are responsible for most of the titratable acidity of the juice . Most of organic acid is concentrated in sugar beet molasses.

The pH of molasses was ranged from 5.30 to 5.60 . Honig (1963),Moros (1963) and Olbrich (1963b) illustrated the pH value of beet molasses was approximately in the range from 5.5-6.0 .

Table (9) :- pH and titratable acidity of molasses :

Sample	pH	T.A %
1	5.42	1.157
2	5.52	1.01
3	5.49	1.01
4	5.30	0.84
5	5.60	2.57
6	5.55	2.15
Mean	**5.48**	**1.456**

The results obtained in this investigation would generally lead to the following conclusions :

1- The soluble solids content of molasses determined by hydrometer ranged from 91.5 to 95.0 degree Brix with a mean value of 92.91 degree Brix .

2- Refractometer determinations should soluble solids to range 87.5 to 90.5 % with an average of 88.61 % .
3- Specific gravity were ranged from 1.4964 to 1.5227 with an average of 1.5063 .
4- Dry substance showed the soluble solids to range 77.53 to 82-90% with an average of 80.37%
5- Refractometer is usually intermediate between Brix and dry substance .

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تركيب وخواص مولاس البنجر المصري

منـــة الله محمــد الأنورالجــداوي ، محمــد بهـــاء الــدين عمــر ، ماجــدة محمــد ســليم و سامي ابراهيم الصياد
قسم علوم وتكنولوجيا الأغذية – كلية الزراعة – جامعة اسيوط

تم الحصول على مولاس سكر البنجر المستخدم في هذه الدراسة من مصانع شركةالدلتا للسكر، محافظة كفر الشيخ ، مصر خلال موسم تشغيل٢٠١١ ، وقد تم إجراء التحليلات لعينات المولاس :البركس، والسكر، والنقاوة %، المواد الغير سكرية العضوية، الرماد ،المواد غير السكرية، وكذلك إيجاد العلاقات بين القيم التي تميز تحليلات مولاس البنجر .

وقد تم الحصول على الاستنتاجات التالية :-

١- يعتبر الرفراكتوميتر من أهم الأجهزة من حيث الدقة في قياس محتوى المواد الصلبة الذائبة في مولاس البنجر.
٢- التحليل التقريبي لمولاس البنجر هو :بركس 80.20 - 81.61، والسكروز 48.36 -49.56، الرماد 12.11 -12.35، والمواد العضوية الغير السكرية 48. 18 - 20.89 ٪ .
٣- البيتان هو المركب الأكثر وفرة في المواد النيتروجينية و قد وجد بنسبة 4 - 3 ٪.
٤- المواد الكربوهيدراتيه غير السكروز تتكون من سكريات محولة عادة أقل من 1% في المولاس.
٥- المواد غير النيتروجينية الأخرى والعضوية الحرة في مولاس البنجر هي الأحماض العضوية مثل حامض الستريك ، اللاكتيك ، الماليك، الخليك وغيرها.

قام بتحكيم البحث

أ.د / محمد طه شلبى	**كلية الزراعة – جامعة المنصورة**
أ.د / احمد حامد خليفه	**كلية الزراعة – جامعة اسيوط**

Table (3): calculation of the composition of beet molasses :

Given	T.S	S	Q	H	A
T.S,S	-	-	$\frac{100\times S}{T.S}$ $\frac{100\times 49}{80.93}=$ 60.55	$\frac{S}{100-TS}$ $\frac{49}{100-80.43}=$ 2.57	$\frac{TS-S}{100-TS}$ $\frac{80.39-49.0}{100-80.93}$
TS,Q	-	0.01TS $\times Q$ 0.01 $\times 80.93\times 60.55=49.001$	-	$\frac{0.01\times TS\times Q}{100-TS}=2.57$	$\frac{TS}{100}\times\frac{100-Q}{100-TS}$ 0.8693 $\times 2.069=1.67$
TS,H	-	H(100-TS) =2.57 $\times 19.07=49.00$	$H\frac{(100-TS)}{TS}$ $=2.57\times 23.6=$ 60.55	-	$\frac{TS}{100-TS}-H$ 4.24-2.27=1.67
TS,A	-	$TS(HA)-100A$ 216.08-167=49.00	$100\left(A-H-\frac{100}{TS}\right)$ =100 $\times 0.6062$ =60.62	$\frac{TS}{100-TS}-A$ $\frac{80.93}{100-80.93}-1.67$ =2.57	-
S,Q	$\frac{100\,S}{Q}$ $\frac{100\times 49}{60.55}=80.93$	-	-	$\frac{S}{100}\times\frac{Q}{Q-S}$ 0.49 $\times\frac{60.55}{60.55-49}=2.57$	$\frac{S}{100}\times\frac{100-Q}{Q-S}$ 0.49 $\times\frac{139.45}{11.55}$ =1.67
S,H	$100-\frac{H}{S}$ = $\frac{100\times 49}{60.55}$ =80.93	-	$\frac{100S\times H}{100H-S}$ $\frac{100\times 49\times 2.57}{100\times 2.57-49}$ =60.54	-	$\frac{100H}{S}-H-1$ = $\frac{257}{49}$ -2.57-1=1.67
S,A	$\frac{100A+S}{A+1}$ $\frac{167+49}{1.67+1}$ $=80.9$	-	100S $\frac{A+1}{100A+S}$ =4900 $\frac{2.67}{1.67+49}$ =60.57	$S\times\frac{A+1}{100-S}$ = $49\times\frac{2.67}{51}$ = 2.57	-
Q,H	$\frac{H\times 100}{0.010+H}$ =2.57 $\times 31.49=80.93$	$H\frac{Q}{0.01Q+H}$ = $2.57\times 19.062=49.00$	-	-	-
Q,A	$A\times\frac{100}{A+1-0.01}$ =2.67 $\times 48.438=80.89$	$A\times\frac{Q}{A+1-Q}$ = $1.67\times 29.324=48.98$	-	$A\times\frac{Q}{100-Q}$ = $1.67\times 1.535=2.56$	-

H,A	$100 - \frac{A+H}{A+H+1}$ $=100-\frac{4.24}{5.24}=80.92$	$100\frac{H}{A+H+1}$ $=100 \times 0.4905 = 49.05$	$100 \times \frac{H}{A+H}$ =100 $\times 0.6061 = 60.61$	-	-

Honig(1963)
Where :

S=sugar% ***H=*** $^{Sugar}/_{Water}$

NS=Non-sugar% ***A=soluble non-sugar (*** $^{Ns}/_{W}$ ***)***

W=Water ***Q=Purity 100*** $^{S}/_{TS}$
TS=Total solids %