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EFFECT OF SOAKING TIME, INTERVAL, TEMPERATURE AND GROUND CAROB SIZE ON CAROB PERMEATE BRIX VALUE

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Abstract: Being one of the traditional sweeteners used traditionally in the Middle Eastern countries there is a need to study the factors affecting the efficiency of carob molasses productions. Carob molasses processing steps start from: storing of whole pods, grinding of whole pods, deseeding, and curing of ground pods, soaking of cured ground pods with water, boiling of carob permeate, cooling of carob molasses and then packaging into containers of end product of carob molasses. The main factor indicating the efficiency of the process is the brix-value of the carob permeates which is mainly affected by the soaking process and size of soaked ground carob pods. The soaking process is composed of soaking interval and total soaking time, soaking temperature and ground carob sizes, small, medium and large. As for the soaking interval, there was no significant difference between brix values of one hour with a total of three hours soaking (22.7^{o}B ± 14.75), two hours with a total of six hours soaking (22.27^{o}B ± 12.25) and three hours with total of nine hours soaking (21.77^{o}B ± 12.71) of mixed ground carob pods equally of small, medium and large ground carob size. Brix values of carob permeate resulting from soaking mixed size ground carob pods at different temperatures at different times showed no significance ed within the same time slot. Soaking medium size ground carob pods for three hours resulted in the significantly highest Brix (11.18^{o}B ± 0.26), followed by mixed (10.18^{o}B ± 0.22), large (9.3^{o}B ± 0.66) then small (8.88^{o}B ± 0.53).
Keywords: carob molasses; carob permeate; Brix; soaking interval; soaking time; soaking temperature; ground carob pod size.

Introduction

Molasses is a liquid food where its rheological characteristics, chemical and physical properties are important for the production process. Molasses is a traditional food product commonly consumed as a breakfast in Turkey and Middle Eastern countries (*1*). The operations of molasses production vary depending on the origin of fruits; however, the basic concept is to increase the total soluble solids up to a desired level (*2*). Concentrating juice syrups, molasses, via evaporation means no sugar or any other component is added to reach the desired total soluble solids content usually 70% to 80% (*1*). High brix value can also be achieved by addition of sugar or can be collected from the byproduct of the sugar production

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industry (*3*). Carob molasses is thick syrup made by soaking milled carob pulp in water and reducing the extracted liquid by boiling (*4*) .

The first step of molasses production is collecting the dry carob pods which are then thoroughly washed and crushed (*5*). The ground carob pods are then placed in vats together with water and kept for soaking for one or two days to allow its essence to penetrate into the water. The mixture of water and ground carob pods is then strained and the carob permeate is then thickened using heat (*6*) (*7*). No sugar or any other substance is added during the carob molasses production.

Studies done concentrate on the properties of the end product and very few did study the effect of each step on the efficiency of production (*8*) (*9*). Thus this study was designed to fill this gap and the permeate brix value at each step was measured. The higher the starting permeates brix value the lower the boiling time needed to reach the target Brix value of the end product (*10*). Since the most essential step to extract the essence from the carob is soaking, the effect of soaking interval, time and temperature of mixed ground carob pods was studied. In addition to that the effect of the ground carob pod size was investigated.

Soaking time is important since the longer the time needed to have the desired starting permeate Brix the longer the thickening time to reach the target Brix of the end product and thus the less the production efficiency. Furthermore, soaking temperature was investigated. Last but not least the soaked material size, i.e. the ground carob pods might also reveal an optimum size to be favored in order to have higher carob permeate Brix values. This would lead to a recommendation of the optimum soaking time, interval and temperature and, ground carob pod size.

Materials and Methods

Refractometer

The Brix value was measured using RFM700 Refractometer (Bellingham and Stanley LTD. United kingdom). OHAUS YJ102 Portable Electronic Balance for Gold/Fine Jewelry, was used to measure the weight (Fotronic Corporation. Melrose-USA).

Effects of Soaking Temperature, Soaking Time, Soaking interval and Different Ground Carob Sizes on Brix

To study the effect of soaking time and temperature carob permeate production was simulated using 16 conical tube (vials). The sixteen were divided into four groups. The small size, medium size and large size vials were filled with 9g of the assigned size of ground carob pieces each. As for the mixed size vials they were filled by equal weights of small (3g),

medium (3g) and large (3g) sizes of ground carobs. The small are those pieces collected after using a sieve with pores of 0.4cm diameter. The pores of the medium size sieve were 0.7cm and those of the large size sieve were 1cm.

Furthermore, 36g of distilled water was used to fill the vials. For the temperature study the distilled water was cooled for the 10^{o}C and the rest heated to the assigned temperature and was placed in an incubator. Perform this experiment for temperatures: 10^{o}C, 25^{o}C, 35^{o}C, 45^{o}C, 44^{o}C, 65^{o}C and 75^{o}C. Brix value was tested every 30 minutes for 3 hours duration. It was repeated three times for every variable.

Concerning the soaking interval the vials to be soaked were three groups. Group i: 3 hours soaking with Brix measured every one hour. Group ii: 6 hours soaking with Brix value measured every 2 hours. Finally, Group iii: 9 hours soaking with Brix value measured every 3 hrs.

Statistical Analysis

All tests and analyses were run triplicate and averaged. Quantitative presented data were mean ± SEM. One way analysis of variance consisted of univariate and bivariate analysis and Least Significance Difference test (LSD) by General Linear Model (GLM) (high significance at $p < 0.01$ and significance at $p < 0.05$) was used to separate the means difference results, and this was performed using SPSS (Statistical Package for the Social Sciences, version 17.0) program.

Results and Discussion

Effect of Different Ground Carob Sizes on Brix within Different Time Slot

The results of Brix for ground carob soaked with distilled water for different hours. At 30 minutes are showed in table 1, there was no significant difference between the small and large ground size, however the Brix of the medium sized was significantly higher from all. The Brix of the mixed size ground carobs was significantly higher than small and large sizes and lower from the medium size ground carob (Table1). At 60 minutes, the Brix differed significantly between all sizes with the Brix of medium size ground carob being the highest followed by mixed then large, ending by small consequently. This situation persisted at 90 minutes, 120 minutes, and 180 minutes. At 150 minutes, the significance between the medium and mixed sizes was not detected in this experiment.

Applying general linear model, it was found that the interaction between time and size is significant, thus comparing the means of different sizes within the same time slot showed that the medium size ground carob resulted in the highest Brix value, followed by the mixed, then

large, then small. This implies that increasing the percentage of the medium sized carob pods might decrease the carob to molasses conversion factor; thus improving the efficiency of carob molasses production.

Soaking Time Effect on Brix within Different Ground Carob Sizes

The Brix values were following an ascending order throughout time of soaking with Brix value at 30 min being the minimum, and Brix value at 180 min being the maximum. Comparing the effect of time within the different ground carob sizes; Brix at 30 min was significantly lower from all sizes for small size ground carob. 60 min, 90 min, 120 min, and 150 min didn't differ significantly from each other, with Brix at 180 min differing only from Brix at 30 min and 60 min as in (Table 2).

For medium size ground carob, Brix at 30 min was significantly the lowest of all. However, Brix at 60 min was significantly different from all being larger than Brix at 30 min and lower than Brix of others. Brix at 90 min was not significantly different from Brix at 120 min, but significantly different from all others, being higher than Brix at 30 min and 60 min and lower that Brix at 120 min, 150 min and 180 min. The Brix at 120 min, 150 min and 180 min didn't differ significantly (Table 2).

For large size ground carob, Brix at 30 min was being the lowest followed by Brix at 60 min, then 90 min then 120 min. The Brix didn't differ significantly between 150 min and 180 min (Table 2).

For mixed ground carob Brix at 30 min was significantly the lowest of all. However, Brix at 60 min was significantly different from all being larger than Brix at 30 min and lower than Brix of others. Brix at 90 min was not significantly different from Brix at 120 min, but significantly different from all others. The Brix at 120 min and 150 min didn't differ significantly. Brix values at 180 min and 150 min did not differ significantly but it was higher than brix values at 30, 60, 90 and 120 min (Table 2).

Effect of total Soaking duration on permeate Brix

There is no significant difference between three hours total soaking duration, six hours total soaking duration, and nine hours total soaking duration of ground carob with water at room temperature (Table 2). Thus soaking for more than three hours should be verified since more time means longer production time and thus lower production efficiency.

Effect of Soaking Temperature within soaking time on permeate Brix

Table 4 shows that permeate brix at different temperatures throughout the time slots showed that brix at 10^{o}C was the lowest and that brix at 75^{o}C was the highest among the different

time slots. According to this experiment temperature, within the same time slot the dynamics of extraction of soluble solids from ground molasses pods is more complex than expected. For the proper understanding of the dynamics behind this insignificance further studies should be conducted. Nonetheless it is an interesting result since is shows that permeate brix at temperature 35^{o}C did not differ significantly from brix value extracted at 10^{o}C except at the first time slot namely 30 minutes, thus 35^{o}C as a soaking temperature should be avoided since extra energy cost would be needed and it would result with lower permeate brix value. In addition to that brix of permeate extracted at 25^{o}C differ significantly from that at 75^{o}C throughout the time slots except at 180 min where that significance disappeared. If soaking is done for 120 to 150 min either keep them soaked at 25^{o}C if no extra energy cost is desired. But once cost of energy is expended soaking temperature should be at 75^{o}C. At 180 min soaking time 10 and 35^{o}C should be avoided and 25^{o}C is recommended since brix measured at that time showed no significant differences when compared to 45, 55, 65 and 75^{o}C.

Effect of Different Ground Carob Size within different Soaking Temperatures on Brix

After studying the effect of size within the same time on Brix, temperature is taken as another factor to check its significance on Brix averages. At 10, 25 and 45^{o}C there was no significant difference between brix from permeate extracted from soaking of medium, small and mixed ground carob pods with the brix resulted from soaking of the large sizes was significantly the lowest (Table 5).

At 35, 55, 65 and 75^{o}C brix of permeate from soaking of medium size ground carob pods was significantly the higher than those recorded for permeate recorded for soaking mixed ground carob pods. Furthermore, the brix at these temperatures tended to be highest as a result of soaking medium ground carob pods (Table 5).

Conclusion

Brix is the most important property in molasses production since it influences the efficiency and feasibility of processing and production. Higher Brix samples have higher values of energy content (Kcal). For soaking of different ground carob sizes within the same time range, the medium size was significantly different from all other sizes affecting Brix. Concerning the soaking interval, there was no significant difference between one hour (total of three hours soaking), two hours (total of six hours soaking), and three hours (total of nine hours soaking). Within the same temperature range, soaking time had no significance on Brix. For the same soaking duration, but different temperature ranges at 10^{o}C and 25^{o}C, small

size ground carob tended to have in higher Brix, this tendency moved to the medium size carob at temperatures 35°C, 55°C, 65°C and 75°C.

Table 1: Average Brix value of different ground carob sizes soaked with distilled water at different times for three hours with 30 minutes interval at room temperature

Soaking time (min)	Ground carob size	Brix
		AVG ± SEM
30	Small	4.7[a1]±0.5
	Medium	7.9[b]±0.26
	Large	5.13[a]±0.57
	Mixed[2]	6.48[c]±0.87
60	Small	5.73[a]±0.57
	Medium	9.15[b]±0.35
	Large	6.5[c]±0.64
	Mixed	8.35[d]±0.35
90	Small	6.13[a]±0.57
	Medium	10.13[b]±0.28
	Large	7.8[c]±0.66
	Mixed	10.11[d]±0.29
120	Small	6.25[a]±0.6
	Medium	10.63[b]±0.28
	Large	9.22[c]±0.71
	Mixed	10.38[d]±0.3
150	Small	8.76[a]±0.56
	Medium	10.95[b]±0.31
	Large	9.28[c]±0.69
	Mixed	10.59[b]±0.13
180	Small	8.88[a]±0.53
	Medium	11.18[b]±0.26
	Large	9.31[c]±0.66
	Mixed	10.8[d]±0.22

[1] Values with same letter show no significance difference, values with different letters show significance difference

[2] Equal percentages of small, medium and large ground carob sizes

Table 2: Brix of carob permeate from soaking of small, medium, large and mixed ground carob pods at different soaking times

Soaking time (min)	Ground carob size	Brix AVG± SEM
30	Small	4.7[a1]±0.5
60		5.73[b]±0.57
90		6.13[bc]±0.57
120		6.25[bc]±0.6
150		8.76[bc]±0.56
180		8.88[c]±0.53
30	Medium	7.9[a]±0.26
60		9.15[b]±0.35
90		10.13[c]±0.28
120		10.63[cd]±0.28
150		10.95[d]±0.31
180		11.18[d]±0.26
30	Large	5.13[a]±0.57
60		6.5[b]±0.64
90		7.8[c]±0.66
120		9.22[d]±0.71
150		9.28[e]±0.69
180		9.31[e]±0.66
30	Mixed[2]	6.48[a]±0.87
60		8.35[b]±0.35
90		10.11[c]±0.29
120		10.38[cd]±0.3
150		10.59[de]±0.13
180		10.8[e]±0.22

[1]Values with same letter show no significance difference, values with different letters show significance difference

[2] Equal percentages of small, medium and large ground carob sizes

Table 3: Permeate Brix value of mixed ground carob size within 3, 6 and 9 hours. Total soaking

Soaking duration (hr)	Brix
	AVG ± SEM
3	22.7[a1] ± 14.75
6	22.27[a] ± 12.25
9	21.77[a] ± 12.71

Table 4: Permeate Brix of soaked mixed 5 ground carob at different temperatures within the same soaking interval (30 min each)

Soaking temperature (^oC)	Soaking time (min)					
	30min	60min	90min	120min	150min	180min
10^{o}C	6.321[a] ± 1.339	7.540[a] ± 1.261	8.233[a] ± 1.056	8.746[a] ± 0.993	9.165[a] ± 0.907	9.577[ab] ± 0.884
25^{o}C	7.671[b] ± 2.258	8.796[b] ± 1.856	9.390[b] ± 1.603	9.702[bc] ± 1.36941	10.114[ab] ± 1.183	10.357[ac] ± 1.033
35^{o}C	6.046[c] ± 1.398	7.427[a] ± 1.488	8.340[a] ± 1.637	8.833[ab] ± 0.62367	9.246[ac] ± 1.859	9.583[a] ± 1.959
45^{o}C	7.571[b] ± 1.701	8.765[b] ± 1.408	9.590[bc] ± 1.152	9.958[cd] ± 1.120	10.390[bd] ± 0.920	10.590[bc] ± 0.877
55^{o}C	8.127[bd] ± 1.748	9.383[bc] ± 1.185	10.152[bc] ± 0.920	10.527[cd] ± 0.624	10.758[bd] ± 0.577	10.983[c] ± 0.503
65^{o}C	8.158[bd] ± 1.386	9.521[bc] ± 1.150	10.221[bc] ± 0.817	10.446[cd] ± 1.120	10.696[bd] ± 1.035	10.927[c] ± 1.147
75^{o}C	8.658[d] ± 1.707	9.827[c] ± 1.031	10.365[c] ± 0.621	10.721[d] ± 0.457	11.002[d] ± 0.396	11.327[c] ± 0.591

[5]: Equal percentages of small medium and large ground carob sizes

[6, 8]: Values with same letter show no significance difference, values with different letters show significance difference

Table 5: Average Brix value of different ground carob size within different soaking temperatures

Ground carob size	Soaking temperature (°C)						
	10°C	25°C	35°C	45°C	55°C	65°C	75°C
Small	9.153[a] ±1.143	10.91[a] ±0.259	6.124[a] ± 0.787	9.753[a] ± 1.053	10.620[a] ± 0.353	9.775[a] ± 1.125	10.725[a] ± 0.545
Medium	8.716[ab] ±1.303	9.875[ab] ±1.076	10.34[b] ± 1.212	10.478[b] ± 1.172	10.81[ab] ± 0.873	10.783[b] ± 0.967	10.846[a] ± 0.749
Large	7.137[c] ±1.742	6.904[c] ±1.456	8.536[c] ± 1.966	8.542[c] ± 2.174	9.162[c] ± 1.812	9.546[a] ± 1.767	9.508[b] ± 1.748
Mixed[1]	8.612[b] ±1.045	9.562[b] ±0.892	9.696[d] ± 1.577	10.224[b] ± 1.174	9.375[c] ± 1.298	9.892[a] ± 1.519	10.204[c] ± 1.211

[1] Equal percentages of small, medium and large ground carob sizes

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