Sesame-oil-cake (SOC) impacted consumer liking of a traditional Jordanian dessert; a mixture response surface model approach

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Abstract

Three factors mixture model incorporating sesame oil cake, dates and sugar combinations totaling 100% of the Ma'amoul's filling, a traditional Jordanian dessert, were used in this study. Ma'amoul was made using 20 grams of a controlled dough recipe combined with 10 grams of filling combinations. Dates filling significantly (P<0.05) impacted overall sensory of Ma'amoul having a score of 7.0 out of 9. Softness, stickiness and overall sweetness liking was improved with the use of sesame oil cake as part of the filling having scores of 6.6, 6.0 and 6.4 compared to 5.2, 4.7 and 6.2, respectively. Response Surface Models parameters of estimates were used as indications of the factors influence of the sensory attributes of Ma'amoul's filling. The use of sesame oil cake in the filling significantly (P<0.05) improved overall liking, overall sweetness and Mouthfeel of Ma'amoul perception having model parameter's of estimates of 9.20, 10.00 and 9.90 respectively compared to 7.79, 7.00 and 5.86 for dates and 2.97, -1.11 and 0.03 for sugar.

Introduction

The use of agricultural and food byproducts in food and feed processing have increase considerably in the last decades to either increase products biological value or to enhance products' functional properties (Han *et al.*, 2010). Nascimento *et al.* (2012) for instance indicated the use of pulse proteins including lentils, peas, and chickpeas and rice bran are examples agricultural byproducts cereal-based products. Abo Omar (2002) also evaluated the use of agricultural and industrial byproducts including sesame oil cake (SOC) as a low cost animal feeds. Hassan *et al.* (2013) incorporated SOC as an animal feed and reported an improvement in dry matter ingestion, crude protein and fiber content as well as ether extract digestibility. Abo Omar and Hejazi (2009) investigate the effect of feeding SOC containing diet on the performance of Anglo-Nubian goat's milk yield, quality and cheese characters. The authors reported a significant increase in milk yield, milk fat and improved cheese quality characteristics of SOC goats' containing diets. Furthermore, Jahanbakhshi *et al.* (2012) studied the effect of SOC and corn gluten on growth performance, survival and carcass quality of Juvenile Beluga *(Huso huso)*. The authors showed the possibilities of 16-48% substituting fish meal by

corn gluten meal and sesame oil cake in diets without affect Beluga *(Huso huso)* performance, biomass gain, growth rate, feed conversion rate and protein efficiency.

Sesame (*Sesamum indicum* L.) is a nutritious plant that is known to have several amino acids including methionine, vitamins and minerals, particularly calcium and significant amount of fat soluble antioxidant and essential fatty acids (Rangkadilok *et al.*, 2012). In the sesame oil extraction process, a byproduct; SOC is produced and is reported significant amounts of proteins and calcium (Bouvier *et al.*, 1997) that is comparable to that of cow milk (Franco, 1999). More specifically, SOC was reported to have 5-12% crude fiber (i.e., dry matter basis), 7.5-17.5% ash, 1.4-27% ether extract and 25-31% nitrogen free extracts (Mohdaly *et al.*, 2011)

The use of SOC as carriers for nutrients in cereal-based foods faces many complications due the critical quality deterioration of developed products as a result of SOC high fiber content (Onwulata *et al.*, 2000). Several researches were also studied the effect of thermo mechanical processes in order to overcome the negative impacts of higher fiber on the functionality properties cereal products (Nascimento *et al.*, 2012). The authors extruded a mixture of semi-defatted sesame cake (SDSC) and corn grits

to improve the nutritional value of corn extrudates and reported an improvement in the nutritional value but reduction in the sectional expansion of the corn extrudates with the increased percentage of SDSC. A 20% replacement using SDSC and corn resulted in a nutritionally balanced extrudates. Therefore, the ability of incorporating SOC with limiting the adverse quality characteristics is a vital area of research.

Ma'amoul is a traditional Jordanian dissert that is also known to have world wide reputation of being the most famous Middle Eastern desserts. Number of Ma'amoul types is available and are usually made of different shapes using variety of filling. Ma'amoul types are exclusively made using similar dough ingredients and vary only of its shape and/or fillings. Ma'amoul can also be considered as a cookie or a small shortbread pastry that can be stuffed with dates, pistachios or variety of walnuts. One of the detrimental quality attributes of Ma'amoul is its grainy texture perception due to the use of dates filling. On the other hand, SOC are known of its smooth texture that is expected to play a role in enhancing the texture of Ma'amoul's filling. The use of SOC, however, is expected to affect Ma'amoul's flavor profile. Therefore, the objective of this study was to evaluate the effect of incorporating SOC in the filling of Ma'amoul using a three factor mixture response surface model on the acceptability Ma'amoul. The use of SOC in the filling of Ma'amoul is also expected to improve the nutritional value of Ma'amoul.

Materials and Methods

Design of the experiment

A three factors mixture response surface design was used as described by Scheffé (1965). The three mixture components evaluated in this study were dates (x1), sesame oil cake (x2) and sugar (x3). The proportions for each ingredient were expressed as a fraction of the mixture and for each treatment combination, the sum of the component proportions was equal to one, where:

$$X_i = X_1 + X_2 + X_3 = 1$$

In this design, the number of points (n) necessary to run a mixture experiment is: $n = 2_q - 1$ where q is equal to the number of components being studied (i.e., 3 factors). JMP release 10.0 (SAS institute, Cary, NC) was used to build up the model parameters. The 100% sugar and 100% sesame oil cake were kept out of the models due to the leaching out of these ingredients during baking of Ma'amoul when used as the filing agents. Table 1 present the percentages of three variables used as filling agents for Ma'amoul.

Ma'amoul molding

For all Ma'amoul treatments (i.e., different fillings combinations of Date, Sesame Oil Cake (SOC) and Sugar presented in Table 1), similar ingredients including wheat flour, corn oil, margarine and yeast were used. Dough was made by adding enough warm water (40°C) into the mixture of ingredients until the paste become homogenous. Dough was allowed to set for 30 min before molding into Ma'amoul shapes. Fillings combinations (10 g) were placed in the center of dough (15 g) that was then closed and molded into Ma'amoul samples. Ma'amoul was then baked in a home-style oven at 180°C for 30 min. Ma'amoul was then allowed to cool 24 h at room temperature before evaluation.

Proximate analysis

Moisture content, AACC, 2000 methods 44-15.02, total lipid content, AACC, 2000 methods 30-25.01, protein content, AACC, 2000 method 46-13.0, dietary fiber, AACC, 2000 method 32-10.01and ash content, AACC, 2000 method 08-01.01 were used to determine the chemical composition of the Ma'amoul fillings (sesame oil cake, dates and sugar combinations). Carbohydrates were calculated by calculation methods of subtracting ash, moisture, proteins and total lipids from 100%.

Sensory descriptive testing

To establish sensory profile for Ma'amoul, seven panelists trained in descriptive analysis techniques according to the Spectrum methodology (Meilgaard *et al.*, 1999) developed texture profiles and rancidity note for Ma'amoul. Ma'amoul lexicon was developed and test methodologies necessary to describe both texture and rancidity characteristics of Ma'amoul was performed. Sweetness, stickiness, grainy feel (mouth feel), and hardness (i.e., force required of the first bite samples) were evaluated while product was chewed up to four times. Rancidity notes were evaluated 30 s of chewing (aftertaste) stage. Descriptive lexicon was used to develop the consumer ballot for texture and rancidity testing. Texture mouth feel for example was presented as the amount of small pieces of sample (Ma'amoul fillings) remaining in mouth just after swallowing. Hardness was presented as the force required to completely biting through the filling on first bite down with the molars. Stickiness was presented as the effort it takes to completely remove sample from the palate during tongue manipulation; measured after five chews.

Table 1. Mixture response surface model of Dates, Sesame Oil Cake (SOC) and Sugar
fractions used as fillings of Jordanian sweet (Ma'amoul)

Treatments	Filling Fractions		
	Date (%)[1]	Sesame Oil Cake (%)	Sugar (%)
100% Dates	100.0	0.0	0.0
66.7% Dates, 16.7% SOC, 16.7% Sugar	66.7	16.7	16.7
50% Dates: 50% SOC	50.0	50.0	0.0
33.3% Dates, 33.3% Sugar, 33.3% SOC	33.3	33.3	33.3
16.7% Dates, 16.7% Sugar, 66.7% SOC	16.7	66.7	16.7
50% SOC: 50% Sugar	0.0	50.0	50.0

[1] Values represent percentage of contribution of dates, sesame oil cake and sugar in the filling of
Jordanian sweet (Ma'moul).

Consumer testing

Consumer testing was conducted in the department of Nutrition and Food Technology, The University of Jordan. Criteria for selection of panelists were that panelists were regular consumers of Ma'amoul and were not allergic to any food. A total of 40 consumers recruited among the students community at The University of Jordan participated in this study. Each participant was assigned a log number, given a brief explanation of the test objectives and seated at a testing booth. A randomized complete block design was used whereby each panelist evaluated all the samples prepared for each treatment. For evaluation, samples were presented and identified by a three digit code. Each consumer evaluated six different samples in a session. Consumers were asked to record the three-digit code for the sample about to be tasted on the ballot provided and evaluated only the various aspects of the Ma'amoul filling. The ballot consisted of six questions designed to evaluate the consumers' liking of various aspects of Ma'amoul' filling to be tested. A 9 point verbal hedonic scale labeled from "dislike extremely" to "like extremely" was used (Resurreccion *et al.*, 1999). Consumers were first asked to express their overall liking, their liking degree of the filling's sweetness, stickiness, hardness, grainy particles as well as rancidity (i.e., off note) aftertaste.

Statistical analysis

Analysis of variance (ANOVA) was carried out on sensory performed data using JMP release 10.0 (SAS institute, Cary, NC). Least significant differences (LSD), at a 5% level of probability, were determined between sensory attributes of cooked Ma'amoul treatments. A mixture response surface models were fitted using date, sesame oil cake and sugar as three factors. The model search was started with the special cubic equation (Eq. 1):

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_{12} X_1 X_2 + \beta_{13} X_1 X_3 + \beta_{23} X_2 X_3 \qquad [1]$$

where Y is the predicted response, β's are the parameter estimates for each linear and cross product term for the prediction model, X_1, X_2, X_3, $X_1 X_2$, $X_1 X_3$ and $X_2 X_3$ are the linear terms of date, sesame oil cake (SOC) and sugar and the cross product terms of (date x sesame oil cake), (date x sugar) and (sesame oil cake x sugar), respectively. The model chosen was based on its significance ($p < 0.05$), the insignificance of the lack of fit and the highest R^2 according to Cornell (1986).

Results and Discussion

Table 1 represents three factors (Dates, Sesame oil cake and Sugar) used in a mixture model as fillings for Ma'amoul. Mixture fractions of variables used in the filling were calculated using JMP release 10.0 (SAS institute, Cary, NC). A 100% SOC incorporation in the filling of Ma'amoul was excluded from the model due to the leaking out of SOC from the molded Ma'amoul during cooking. Table 2 presents the chemical composition of sesame oil cake (SOC) and dates used in the filling of Ma'amoul. Results of the chemical composition are in agreement with (Hassan *et al.*, 2013).

Means of sensory attributes of the filling of Ma'amoul made by incorporating dates, SOC and sugar in the filling are presented in table 3. Dates' filling alone produced the hardest filling among other filling combinations with a softness degree of likening score of 5.2. Incorporating SOC in the filling resulted in a significant improvement in the filling softness. For example, the addition of 16.7% of SOC significantly ($P < 0.05$) increased the fillings' softness score from 5.2 to 6.6 (Table 3). However, greater percentage of SOC resulted in a decrease in the filling softness. This was related to the "leakage

Table 2. Chemical characteristics of sesame oil cake and dates used in the filling of Ma'amoul

Chemical Composition	SOC (%)	Dates (%)
Moisture	1.99 ± 0.20	24.60 ± 1.23
Protein	32.98 ± 1.01	2.53 ± 0.05
Total Fat	9.10 ± 0.72	0.40 ± 0.04
Ash	5.60 ± 0.73	1.62 ± 0.11
Carbohydrates	50.32 ± 2.45	72.47 ± 2.65
Dietary Fiber	14.90 ± 1.62	5.10 ± 0.71

Table 3. Overall means of sensory attributes of the filling of Jordanian sweets (Ma'amoul) made by incorporating Date, Sesame Oil Cake (SOC) and Sugar in the filling regardless of storage durations

Treatments	Sensory Attributes					
	Overall Liking	Softness	Stickiness	Overall Sweetness	Mouth Feel	Rancidity
100% Dates	7.0 [a]	5.2 [b]	4.7 [b]	6.2 [a]	5.9 [a]	1.8 [a]
66.7% Dates, 16.7% SOC, 16.7% Sugar	6.3 [ab]	6.6 [a]	4.7 [b]	6.4 [a]	4.0 [c]	1.8 [a]
50% Dates: 50% SOC	4.5 [c]	5.8 [ab]	4.8 [b]	3.3 [c]	4.9 [b]	1.6 [a]
33.3% Dates, 33.3% Sugar, 33.3% SOC	3.3 [d]	5.7 [ab]	5.8 [a]	4.0 [c]	4.2 [bc]	1.6 [a]
16.7% Dates, 16.7% Sugar, 66.7% SOC	5.9 [b]	5.5 [b]	4.9 [b]	5.7 [ab]	3.0 [d]	1.6 [a]
50% SOC: 50% Sugar	6.1 [b]	5.8 [ab]	6.0 [a]	5.4 [b]	4.4 [bc]	1.5 [a]

[1] For same attribute, treatments means having different letters are significantly different (p<0.05) according to the LSD

out" of the Ma'amoul filling out of the molds during baking due to the higher oil content of the SOC.

Sugar was used as a third factor to improve the sweetness taste to SOC that is known to have a bland taste. Incorporating equal ratio of dates and SOC resulted in the lowest overall sweetness scores (i.e., 3.3) that was related to the bland sweetness of SOC. Results also agreed that dates improved overall sweetness due to the great percentage of sugars in dates (i.e., dates are known to have 40-62% total sugars) (Al-Farsi *et al*., 2005). An equal ratio (50: 50%) of SOC and sugar needed to produce an overall sweetness score 5.4 compared to 5.7 when adding only 16.7% dates to 16.7% sugar and 66.7% SOC (Table 3).

Figures 1 present ternary graphical representation; Cubic Model, that is plotted to better understand the interaction of three mixture variables and to determine the optimal level of each variable for maximal sensory response. Since mixture response surface plots present the effect of two combinations of the three mixture factors while maintaining the other variable at the zero level, ternary plots were used to study the effect of combining three factors, simultaneously on the sensory attributed of Ma'amoul filling.

Table 4 shows the coefficient estimates, model significance and regression coefficients for sensory attributes of Ma'amoul filling made by Date, SOC and Sugar in the filling. The multiple regression analysis showed that the cubic model was significant in predicting overall liking (P=0.0007), softness (P=0.0024), stickiness (P=0.0004), overall sweetness (P=0.0002) and Mouthfeel (P<0.0001) of the Ma'amoul filling. Models were capable of explaining 62%, 56%, 64%, 67% and 71% overall liking, softness, stickiness, overall sweetness and Mouthfeel of the Ma'amoul filling, respectively. Furthermore, models did not show a significant lack of fit. Lack-of-fit (Table 4) test measures the adequacy of the model and decomposes residual errors into a component due to the variation of the replications around their mean value, and a component due to the variation of the mean values around the model prediction. Significant lack of fit model is not a good indicator of the response and should not be used for the prediction (Myers *et al*., 2009).

Figure 1 present the effect of models components on the sensory attributes of Ma'amoul filling. The positive sign of the coefficient estimate indicated the increased response with the increase in models factor while the negative sign indicates that the response decrease with the increase in the models factor. Results showed that the ternary representation; Cubic Model was significant in predicting the sensory attributes of Ma'amoul's filling.

Overall likening of Ma'amoul's filling was presented in Figure 1A and shows that the type of filling has significantly (P<0.05) consumer liking with
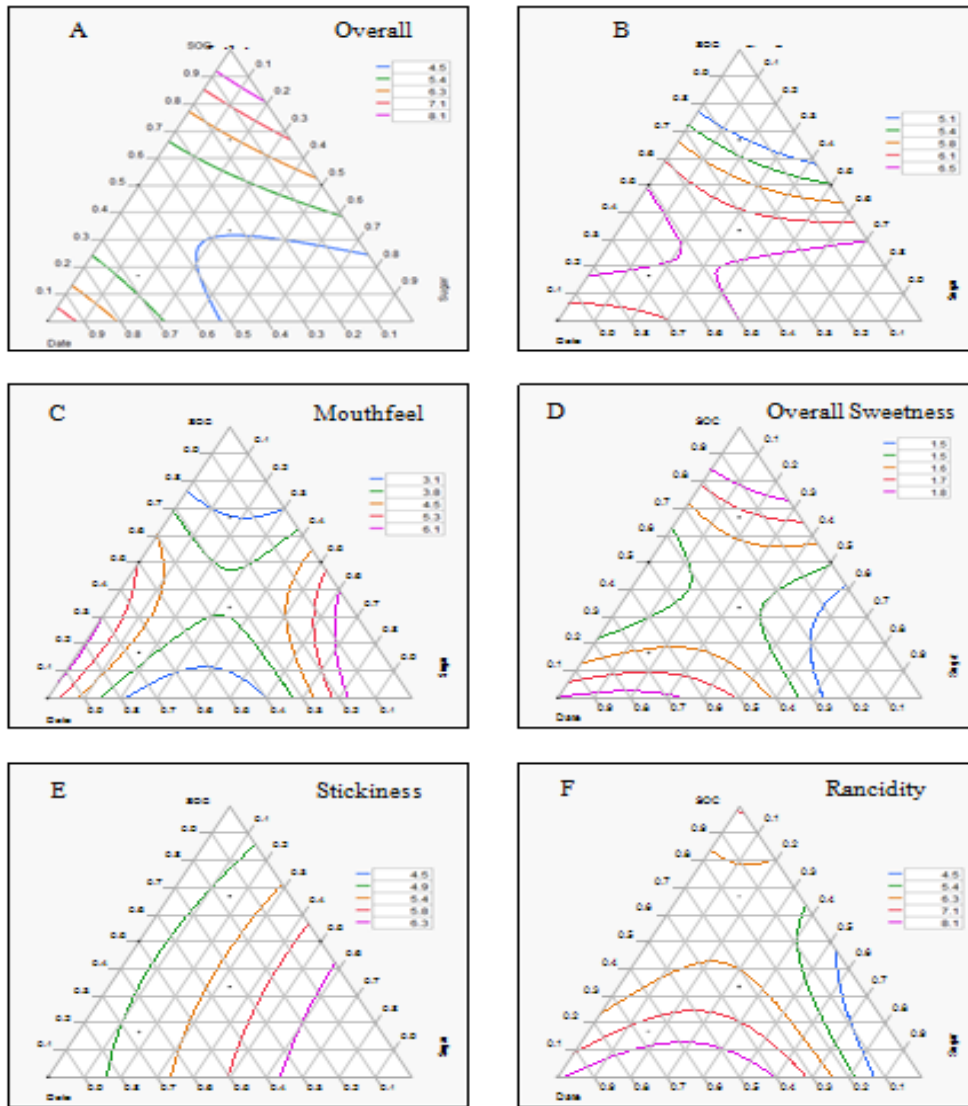
Figure 1. Effect of dates, Sesame Oil Cake (SOC) and Sugar on the Ma'amoul's filling overall liking (A), softness (B), Mouthfeel (C), overall sweetness (D), Stickiness (E) and Rancidity (F)

greater degree of liking for dates filling (i.e., hedonic scale of 7.0) compared to the other combinations (Table 3). However, combining dates with 16.7% of both SOC and sugar showed an acceptable degree of liking having a degree of liking of 6.3 (hence, a non significant degree of liking compared to the 100% dates as filling). The regression model for overall liking (Eq. 2) was:

$$\text{Overall liking} = 7.79X_1 + 9.20X_2 + 2.97X_3 - 14.97X_1X_2 - 4.09X_1X_3 \qquad [2]$$

The models indicated a significant influence of the linear terms on the overall liking of Ma'amoul filling. The equation suggests that the SOC produced the highest increase in overall liking score (i.e., model parameter estimate of 9.20) of Ma'amoul filling followed by dates (i.e., model parameter estimate of 7.20) and sugar (i.e., model parameter estimate

of 2.97). The model was able to explain 62% of the variations in the overall liking. The interaction of dates and SOC, however, showed a negative influence on the overall liking having a parameter of estimate of -14.97.

Incorporating SOC in a filling of Ma'amoul resulted in increasing the degree of softness of the filling; a major improvement in the Ma'amoul filling characteristics. Softness liking scores of Ma'amoul filling was improved from 5.2 of dates to 6.6 when replaced with 16.7% of both SOC and Sugar. SOC and dates appear to play significant (P<0.05) role in affecting Ma'amoul softness having model coefficients of 8.07 and 5.79 respectively (Figure 1B). SOC and dates interaction positively influenced the softness of the models having a coefficient of 8.82 (Eq. 3).

$$\text{Softness} = 5.79X_1 + 2.75X_2 + 8.07X_3 + 8.82X_1X_2 - 1.73X_1X_3 \qquad [3]$$

Table 4. Coefficient estimates, model significance and regression coefficients for sensory attributes of Ma'amoul filling made by Date, SOC and Sugar in the filling

Variable	Overall Liking	Softness	Stickiness	Overall Sweet	Mouth Feel	Rancidity
X_1	7.79	5.79	4.59	7.00	5.86	1.78
X_2	9.20	2.75	4.51	10.00	9.90	1.73
X_3	2.97	8.07	7.51	-1.11	0.03	1.21
$X_1 X_2$	-14.97	8.82	0.90	19.31	8.92	-0.82
$X_1 X_3$	-4.09	-1.73	-0.90	12.33	-22.08	1.49
$X_2 X_3$	0.0	0.0	0.0	0.0	0.0	0.0
Model Significance	0.0007	0.0024	0.0004	0.0002	<0.0001	0.8568
Lack of Fit	0.56	0.33	0.45	0.61	0.74	<0.001
RSquare (R^2)	0.62	0.56	0.64	0.67	0.71	0.06
Root Mean Square Error	0.98	0.53	0.40	0.86	0.67	0.47
Mean of Response	5.5	5.8	5.2	5.2	4.4	1.7

[1] Model significance at the 5% level ($p<0.05$), X_1: dates; X_2: Sesame Oil Cake (SOC); X_3: Sugar.

Moreover, incorporating SOC in the filling of Ma'amoul enhanced the mouth feel of the filling. Date pastes are expected to produce a grainy feel during processing. Dates are considered berry fruit that is consisting of a single seed surrounded by a fibrous, parchment-like endocarp giving dates its grainy mouth feel (Barreveld, 1993). This was supported by Habiba and Mehaia (2007) findings that replacing sugar with dates paste decreased texture preference when used in carrot jams. Sugar has the lowest effect on the Mouthfeel of Ma'amoul's filling having a coefficient of 0.03 with SOC significantly affecting the Mouthfeel of filling (Figure 1C) having an estimate coefficients of 9.90 followed by dates (i.e., estimate coefficient=5.86) and the interaction between dates and SOC (i.e., estimate coefficient= 8.92) (Eq. 4).

$$Mouthfeel= 5.86X_1 + 9.90X_2 + 0.03X_3 +8.92X_1X_2 -22.08X_1X_3 \quad [4]$$

Equal combinations of dates, SOC and sugar showed the lowest consumer degree of overall liking having a hedonic scale value of 3.3. Sugar melting and leaking out of the filling high in sugar and SOC during baking appear to improve the overall degree of liking and reduce the products' sweetness. Dates are known to have 40-62% total sugars that are of two monosaccharides; fructose and glucose (Imad and Abdul-Wahab, 1995). Introduction of sugar (i.e., as sucrose) in the filling, therefore decreased the degree of sweetness of Ma'amoul's filling resulted in the improvement in the overall liking degree sweetness. This is presented in the negative impact of sugar on the degree of model prediction of Ma'amoul's overall liking of sweetness (Figure 1D) having a negative estimate coefficient of 1.11 (Eq. 5).

$$Overall\ Sweetness = 7.00X_1 + 10.00X_2 - 1.11X_3 +19.31X_1X_2 +12.33X_1X_3 \quad [5]$$

Incorporating 16.7% SOC with dates resulted in the lowest stickiness scores. No significant difference ($P>0.05$) were reported compared to 100% dates as filling. The increase in filling stickiness scores was directly proportional (R^2=0.86, data not shown) to the increase in sugar concentration that is probably related to sugar melting down during baking. Melting of sugar occurs in some food processes or evaporation in which sugar water syrup is produced. The regression for Ma'amoul's stickiness and Mouthfeel were as follows (Eq. 6):

$$Stickiness= 4.59X_1 + 4.51X_2 + 7.51X_3 +0.90X_1X_2 -0.90X_1X_3 \quad [6]$$

Sugar has the highest estimate coefficient (7.51) compared to 4.59 and 4.51 for dates and SOC, respectively. Cubic plot of the effect of dates, SOC and sugar on Ma'amoul's filling stickiness is presented in Figure 1E. Stickiness increase during baking of sugar containing filling was related to the formation of sugar syrup and can be explained by the glass transition as presented by Lisette (2010). Our results support that SOC have significant influence in decreasing Ma'amoul stickiness; hence a very attractive consequence to the consumer degree of liking.

Conclusion

A mixture response surface was able to predict the effect of dates, SOC and sugar on consumer acceptability and liking of traditional Ma'amoul filling. Modeling the effects of studied factors (i.e., dates, sesame oil cake and sugar) presented an

experimental data equations that are used to predict the acceptability of Ma'amoul filling.

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