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Nutrient Composition of 'Taifi' Pomegranate (*Punica granatum L.*) Fragments and Their Suitability for the Production of Jam

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ABSTRACT. A study was designed to contrast the proximate, physical nad elemental composition of 'Taifi' pomegranate fragments and to prepare jam from the edible portion (pulp and seeds) of the fruit. This cultivar is grown on a commercial level in the South-Western regions of Saudi Arabia. Proximate analysis indicated that, moisture, protein, fiber and ash contents of the edible portion and juice of 'Taifi' pomegranates found in this study were in agreement with the literature values (FAO 1982, Paul and Southgate 1978). The edible portion of the fruit was rich in potassium and phosphorus, but poor in sodium, calcium, iron and magnesium. Optimum character-istics of 'Taifi' pomegranate jam resulted from formulations containing 3 parts edible portion and 2 parts sugar combined with citric acid and pectin at 0.20 and 1.24% (w/w) of the primary components, respectively. Sensory evaluation confirmed that jam manufactured from the edible portion (pulp and seeds) was highly acceptable with and without adding flavors. However, flavored products containing cinnamon, ginger, vanilla, cardamom and clove at concentration of 0.11%, 0.09%, 0.05%, 0.12% and 0.06% respectively were also very acceptable.

Pomegranate (*Punica oranatum* L.) is native to Iran, but is cultivated extensively in Saudi Arabia and other Arab countries (Singh *et al.* 1967). Fruit of 'Taifi' pomegranate, a highly popular locally-grown cultivar named after the city of Taif (Bacha 1986), is produced on a commercial scale in the south-western regions of Saudi Arabia. Accurate estimation about the annual production of 'Taifi' are not available. However, it is presumed that 'Taifi' ranks third, following dates and water-melon, in the quantity of locally-produced fruits. Harvesting of 'Taifi' begins in the middle of September and continues until the beginning of November. Fruits are large, rounded, green to light red in color, and contain an edible portion (seeds and pulp) which is juicy and sweet. Typically, they are eaten fresh or are processed for their juice. Seeds of 'Taifi' are soft and palatable and there may be nutritional advantages to the consumption of the entire edible portion of the fruit.

Investigations of pomegranate quality have been concerned with the interaction of growth regulating substances and the post-harvest physiology of the fruit (Bacha and Ibrahim 1981, Kadar *et al.* 1984, Al-Mughrabi and Bacha 1986). However, few studies have been conducted which explore the formulation or resulting quality of potential industrial uses of pomegranate such as juice and jelly processing. Also, information concerning nutritional characteristics of 'Taifi' or of the quality of processed 'Taifi' products is currently unavailable. The major objectives of this study were to compare the proximate, physical and elemental composition of 'Taifi' pomegranate fractions and to prepare a nutritional and organoleptically suitable jam from the entire edible portion of the fruit.

Materials and Methods

The Preparation of Samples

Representative fruits of 'Taifi' pomegranate were obtained from the Taif (south western) region of Saudi Arabia during the 1985 and 1986 harvest season. Ripe fruits were transferred to our laboratory at K.S.U. by refrigerated trucks on the same day of harvest and stored at 5°C till the following day when analyses were initiated. Six random samples, each approximately 35 Kg. were used in this study. To prepare samples for analyses, about 10 Kg. of fruits were selected, cleaned, weighed, peeled and the edible portion was separated. Half of the edible portion from each sample (5 Kg.) was homogenized for 3 minutes at high speed in a blender (Braun, KM 32) whereas the other half of each sample was used for the expression of juice using an electric extractor (Moulinex, type 140.6.03). The fresh juice was strained through three layers of cheese-cloth.

Moisture, sugar and vitamin C contents of samples were determined immediately after their preparation. The remainder of the samples were placed in well-sealed glass jars and stored at 2°C for further analysis. To determine the levels of each parameter studied, five or six samples were analyzed in duplicate.

Chemical and Physical Analyses

Moisture, protein (Kjeldahl, NX6.25), crude fiber, and Vit. C were assayed according to A.O.A.C. (1980) procedures. Fat was determined by hexane extraction in a Soxhlet apparatus (Osborne and Voogt 1978). A muffle furnace operated at 550°C was used to determine the ash content of all samples. Reducing and total sugars (as invert sugars) were determined by the Lane-Eynon volumeteric method described in the A.O.A.C (1980). The nonreducing sugar (sucrose) was calculated from the diference between the percentage of reducing and total sugars multiplied 0.95 (A.O.A.C. 1980). Pectin was analyzed as calcium pectate according to the Pearson method (1970). The acidity was determined by titrating

samples with 0.1 N NaOH and was expressed as percent citric acid (A.O.A.C. 1980).

Levels of pH were measured using a digital pH meter (Jenway, Model PHM 10) standarized with both pH2 buffer and pH7 buffer. Total soluble solids were measured using Abbe refractometer. Viscosity was measured with a Brookfield Viscometer (Model LVT, Brookfield Engineering Lab., Stoughton, MA) using UL adapter, 60 rpm at ambient temperature (25°C).

Elemental Analysis

Minerals were extracted by the wet ashing method (Osborne and Voogt 1978) and determined by Atomic Absorption spectrophotometry (Insturmentation Laboratory, Mod. 252). Levels of K and Mg were determined using a flame photometer (Eppendorf, No. 0700). Phosphorus contents was analyzed colorimetrically (A.O.A.C. 1980) using a digital spectrophotometer (Spectronic 21, Bausch and Lomb).

Preparation of Jams

The edible portion of 'Taifi' pomegranate fruit used for the preparation of jam was separated from other components as described above and then was mixed in a blender (Braun, KM 32) at high speed for 3-4 minutes. Unground seeds (Iess than 1% of the edible portion) were then removed from the mixture using a 0.8 mm screen. The prepared mixture was then placed in a stainless steel, double jacketed, steam kettle system. Half of the quantity of sugar, and a small quantity of water were added to the mixer and then, the suspension was heated for 4-5 minutes under continuous stirring. Steam was shut off and the remaining sugar was added to the formulation. Then, the heating was resumed until the total soluble solids value reached approximately 60 Brix. At this solids level, pectin and citric acid, dissolved in a small amount of water, were added while the mixture was stirred continuously. Cooking was terminated when the total soluble solids value reached 70 Brix (Ewaidah and Arafa 1986, Lopez 1975 and Pearson 1973). Finally, the various natural flavors were added individually to batches of the mixture at levels of 0.11, 0.09, 0.05 and 0.12% respectively. (*i. e.*cinnamom, ginger, vanilla, cardamon, and clove). The flavors were blended well with the mixture before the jam was poured hot into glass jars. The glass jars were then cooled, covered, turned upside down, and stored at room temperature (25°C) for further studies.

Before preparing suitable product for sensory evaluation, several variables and parameters of jam making were studied to determine the optimum conditions for the sugar-pulp ratio, type and quantity of flavoring agents, pectin concentration as well as, the type and quantity of acidifying agents for the adjustment of pH. The different levels of sugar/edible portion ratio tested were 35:65, 40:60, 45:55, 50:50,

55:45 and 60:40 whereas fruit pectin was supplemented at rates of 1.0, 1.5, 1.9, 2.5, 3.1 and 3.5% on the basis of sugar weight. Citric acid was added to control pH at concentrations of 0.10, 0.15, 0.20, 0.25 and 0.30% on the basis of the weight of the mixture (sugar + edible portion). Optimum levels of flavorings were determined empirically. These trials resulted in the recommendation of the final formula for jam preparation from the edible portion (pulp & seeds) of 'Taifi' pomegranate (Table 1).

Table 1. 'Taifi' pomegranate jam formulation

Ingredient	%	Quantity (g)
Pomegranate (edible portion)	~60	22.45
Sugar	~40	14.95
Citric acid	0.20	7.48
Pectin	1.24	46.34
Flavors (one of the following)		
Cinnamon	0.11	4.17
Ginger	0.09	3.41
Vanilla	0.05	1.99
Cardamom	0.12	4.55
Clove	0.06	2.28

Organoleptic Evaluation

Sensory evaluation was performed on 'Taifi' pomegranate jams prepared with and without added flavoring according to the recommended final formula shown in Table 1. The quality attributes of jams (*i.e.* texture, odor, color, taste, flavor and overall acceptability) were evaluated by a group of twenty experienced panelists selected from the K.S.U., Food Science Department staff.

Jam samples were placed in individual white plastic containers, coded with a three-digit randomized number and served in a randomized order for sensory evaluation. The sample without added flavoring was used as the control. Other samples contained the different flavoring agents. The panelists were provided with water for mouth rinsing between samples. Samples were judged in a room under difused light at room temperature. Individual judges were asked to evaluate 3 samples each session. A hedonic rating scale was used employing a scale-range from 9 to 1 with extreme scores of 9 and 1 indicating the respective attitudes of like extremely and dislike extremely (Larmond 1970).

Statistical Analysis

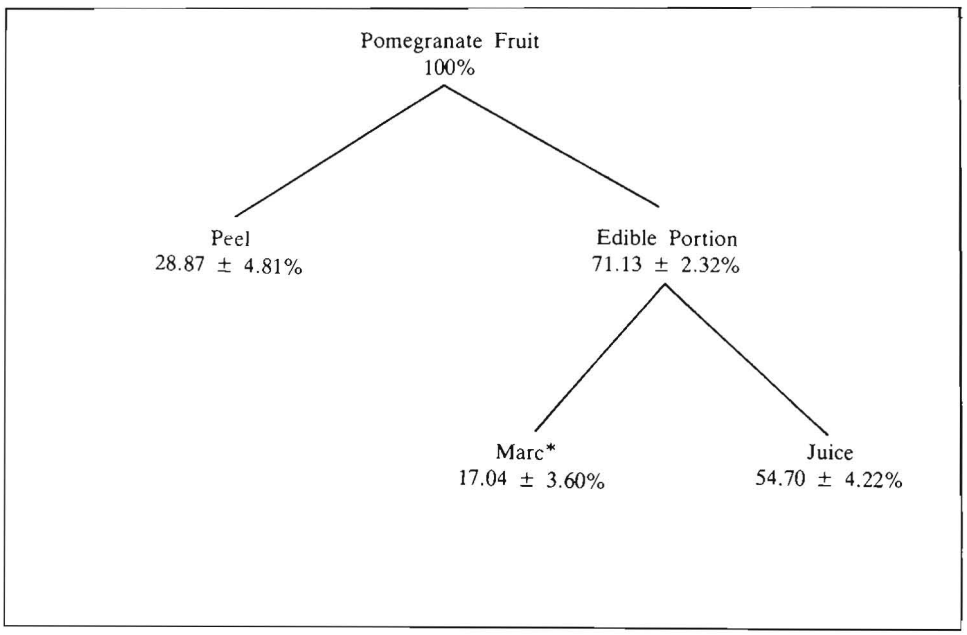
Sensory data was subjected to analysis of variance (Steel and Torrie 1980) with significant differences among the means determined using Duncan's New Multiple Range Test. The analyses was performed using SAS computer programs.

Results and Discussions

Composition

The fragmentation of 'Taifi' pomegranate constituents is shown in Figure 1. The peel and edible portions constituted 28.87 and 71.13% of fresh fruit weight respectively. The edible portion was subdivided into juice and marc (seeds and skins). Over three-fourths of the edible fraction (54.70% of the fresh fruit weight) could be expressed as juice whereas the remaining material (marc) was composed of approximately 45-55% seeds. The seed contained in the marc accounted for 6.8 to 8.9% of the fresh fruit weight. The marc and peel fractions (approximately 45% of the fresh fruit weight), are considered by-products which could be used as an animal fodder.

Figure 1. Fragmenation of 'Taifi' Pomegranate Fruit



Each values is the mean and standard deviation of calculation of five randomized samples.
* The residue after the extraction of the juice which consists of seeds and skin.

Acidity (expressed as citric acid), pH, total solids, total soluble solids and viscosity of the edible portion and juice of 'Taifi' pomegranate are shown in Table 2. The juice and the edible portion displayed titratable acidity levels of 0.37 and 0.35% respectively; their pH values were 3.83 and 4.12 respectively. The acidity of 'Taifi' (edible portion or juice) was comparable to the acidity of banana, but was higher than the acidity of fig and was lower than the acidity of the most other

Table 2. Levels of acidity, pH, total solids, total soluble solids and viscosity of the edible portion and juice of the 'Taifi' pomegranate.

	Edible Portion	Juice
Acidity (expressed as citricacid, %)	0.35 ± 0.05*	0.37 ± 0.09
pH	4.12 ± 0.09	3.83 ± 0.14
Total solids (%)	18.46 ± 0.38	15.12 ± 0.75
Total soluble solids (Brix)	16.36 ± 0.49	15.22 ± 0.42
Viscosity (centipoises)	---**	1.67 ± 0.05

* Each value is the mean and standard deviation of five samples each analyzed in duplicate. Values are expressed on a fresh weight basis.

** Not measured.

known fruits such as grape, guava, lemon, peach and pineapple (Jacobs 1958). The pH value for pomegranate juice reported by Kader *et al.* (1984) was lower than the value in this study while the acidity value stated by the same author was higher than the one attained in this work. The percent dry matter for the edible portion and juice of 'Taifi' were 18.46 and 15.42 respectively. The levels of total soluble solids contained in the juice or edible portion (15.22 and 16.46 Brix respectively) were higher than that of many other fruits which are commonly utilized in the manufacturing of jams such as strawberry, raspberry, cherry, plum, apple and blackberry (Rauch, 1965).

Moisture, protein (N × 6.25), fat (hexane extract), ash, crude fiber, sugar, Vit C and pectin contents of 'Taifi' pomegranate are presented on a fresh weight basis in Table 3. The moisture content of the edible portion and juice of the fruit were found to be 81.54% and 84.58% respectively. Contents of protein (1.03%) and fat (0.75%) found in the edible portion of the fruits were higher than the protein (0.09%) and fat (0.19%) contents found in the juice. This may be due to the presence of seeds in the edible portion which are presumed to contain higher levels of these constituents than are found in the juice. Conversely, the juice of 'Taifi' fruits contained higher amounts of reducing sugars, total sugars and ascorbic acid than did the edible portion. However, 'Taifi' is not considered as a rich source of vitamin C. Ash content in the edible portion of the pomegranates was 0.47%.

Table 3. Proximate composition of the edible portion and juice of 'Taifi' pomegranate.

Constituents	Edible Portion	Juice
Moisture (%)	81.54 ± 0.21*	84.58 ± 0.75
Protein (NX6.25) (%)	1.03 ± 0.41	0.09 ± 0.11
Fat (ether ext.) (%)	0.75 ± 0.08	0.19 ± 0.03
Ash (%)	0.47 ± 0.04	0.32 ± 0.05
Crude-fiber (%)	3.00 ± 0.24	**
Reducing sugar (%)	11.79 ± 0.95	12.92 ± 0.03
Non-reducing sugar (%)	0.79 ± 0.04	0.80 ± 1.52
Total sugar (%)	11.89 ± 0.43	13.84 ± 0.51
Vit. C (mg / 100g)	1.70 ± 0.01	2.74 ± 1.01
Pectin (%)	0.51 ± 0.10	**

* Each value is the mean and standard deviation of five randomized samples, each analyzed in duplicate. Values are expressed on a fresh weight basis.
** Below detectable limits.

The moisture, protein, fiber and ash content of the edible portion of the fruits were in agreement with literature values (FAO 1982; Pellet and Shadarevian 1970) but the content of fat was higher than the values reported in the same literature. The moisture, fat, ash and crude fiber contents of pomegranate juice found in this study were also in good agreement with the values from literature (FAO 1982, Paul and Southgate 1978) but the total sugar content in the juice (13.84) was higher than the value reported by Paul and Southgate (1978).

Elemental analyses of 'Taifi' pomegranate fractions revealed substantial differences between the mineral content of the edible portion and that of the juice (Table 4). Of the two fractions, the edible portion displayed a greater mineral content which suggested that substantial elemental reserves remained in association with (and perhaps bound in) the marc after the juice was expressed. Minerals which appeared to be the least soluble were phosphorus, manganese, magnesium and calcium; these minerals were present in the juice at levels which were only 12, 16, 35 and 45% of the original concentrations found in the edible portion, respectively. Sodium levels were similar in both the edible portion and juice whereas iron appeared to be concentrated in the latter fraction. However, the apparent concentration of iron during juice expression may be artifactual as replicated values were extremely variable (as shown by standard deviations equal to or in excess of 100% of the mean).

The edible portion of 'Taifi' pomegranate appeared to be a good source of potassium and phosphorus and a fair source of magnesium and iron. As current recommended dietary allowances of potassium, phosphorus, magnesium and iron

Table 4. Mineral content in the edible portion and juice of 'Taifi' pomegranate

Elements	Edible Portion	Juice
Potassium (mg/100g)	222.790 ± 11.530*	152.235 ± 22.753
Sodium (mg/100g)	1.120 ± 0.349	1.017 ± 0.667
Magnesium (mg/100g)	9.595 ± 0.844	3.310 ± 0.507
Calcium (mg/100g)	2.400 ± 0.236	1.100 ± 0.270
Manganses (mg/100g)	0.103 ± 0.023	0.017 ± 0.019
Zinc (mg/100g)	0.592 ± 0.058	0.342 ± 0.059
Copper (mg/100g)	0.365 ± 0.035	0.200 ± 0.077
Iron (mg/100g)	0.233 ± 0.258	0.353 ± 0.353
Phosphorus (mg/100g)	43.350 ± 8.923	5.500 ± 0.821

* Each value is the mean and standard deviation of six randomized samples, each analyzed in duplicate. Values are expressed on a fresh weight basis.

are 3750, 800, 300 and 10 mg per day (RDA 1980), a 100 g serving of the edible portion of 'Taifi' would provide 6.0, 5.4, 3.2 and 2.3% of the adult daily requirement for these minerals. In contrast, this material is a poor source of calcium, providing only 0.3% of the current RDA of 800 mg per day. 'Taifi' juice is also a fair source of potassium and iron, providing 4.0 and 3.9% of the recommended daily intake of these elements per 100 g of liquid. However, as phosphorus levels were associated with the solid fractions of the edible portion, the expressed juice was considered to be a poor source of this nutrient (providing only 0.7% of the RDA per 100 g liquid).

Jam Preparation

In preliminary trials, different variables were studied before recommending a formulation for the 'Taifi' pomegranate jam prepared for sensory quality evaluation. Sugar/pulp ratios of 45:55, 50:50, 55:45 and 60:40 resulted in a very sweet product while the 35:65 sugar/pulp formula resulted in a product that was judged to be less sweet. Since the sugar content in 'Taifi' is high in comparison with other fruit commonly utilized in the manufacture of jam, the 40:60 sugar/pulp ratio was found to be the most preferable by the taste panel members.

Conversely, as the pectin content of 'Taifi' was found to be very low, a high level of supplemental pectin (3.1% of sugar weight) was the most suitable for obtaining an acceptable level of jam gelation.

A level of 0.20% (of mixture weight) citric acid was enough to adjust the acidity of the jam to pH of 3.1 to 3.2. With respect to flavoring agents, data indicated that cinnamon, ginger, vanilla, cardamom, and clove were very

acceptable flavors at concentrations of 0.11, 0.09, 0.05, 0.12 and 0.06% respectively.

An analysis of pomegranate jams prepared for sensory evaluation revealed the similarities among samples for their physical attributes. Soluble solids levels ranged from 69.8 to 71.3 Brix whereas values of titratable acidity and pH varied from 0.59 to 0.65 and 3.12 to 3.17 respectively (Table 5).

Table 5. Total soluble solids, acidity, and pH of flavoured and non-flavoured 'Taifi' pomegranate jam

Treatment	% Total Soluble Solids*	% Total acid**	pH
T1 - Control	70.8***	0.62	3.14
T2 - Cinnamon	70.3	0.60	3.15
T3 - Ginger	71.0	0.59	3.17
T4 - Vanilla	71.3	0.65	3.12
T4 - Vanilla	71.3	0.65	3.12
T5 - Cardamom	70.5	0.63	3.14
T6 - Clove	69.8	0.63	3.13
Mean	70.6	0.62	3.14

* As degrees brix
** Acidity expressed as % citric acid
*** Each value is the mean of 4 randomely selected glass jars.

Organoleptic Evaluation

Mean scores of the taste, color, texture, flavor and overall acceptability of the control (not-flavored) and the flavored pomegranate jams are listed in Table 6. Scores of these quality attributes ranged from 6 (like slightly) to 7 (like moderately). Control batches were not significantly different ($P < 0.05$) from the flavored jam products with respect to taste, color, texture, flavor and overall acceptability. In addition no significant differences ($P < 0.05$) were found in the quality attributes observed among the flavored jam samples. However, even though the difference in taste between the control and the favored jams lacked significance, the mean score of the control was lower than the mean scores of flavored jam samples. This result indicated perhaps, a slight bias against the naturality bland character of pomegranate flavor.

In conclusion, the contents of protein, fat, ash, fiber and most minerals were higher in the edible portion than in the juice of 'Taifi' pomegranate, which was

Table 6. Sensory evaluation scores for quality attributes of flavored and non-flavored 'Taifi' pomegranate jams

Flavor of Jams	Quality Attributes				
	Taste	Color	Texture	Flavor	Overall accptability
Control (non-flavored)	6.80±1.40a*	7.15±1.09a	7.45±1.20a	6.90±1.77a	7.15±1.18a
Cinnamon Flavor	7.45±1.24a	7.05±1.19a	7.25±0.97a	6.90±1.71a	7.40±1.09a
Ginger Flavor	7.15±1.27a	7.05±1.14a	7.20±1.01a	6.75±1.80a	7.10±1.21a
Vanilla Flavor	7.20±1.06a	6.85±0.99a	7.60±0.60a	6.85±1.73a	7.30±1.03a
Cardamom Flavor	7.35±1.14a	6.95±1.10a	7.10±1.12a	7.30±1.42a	7.40±0.99a
Clove Flavor	7.50±1.32a	6.85±1.09a	7.10±1.25a	7.50±1.47a	7.60±1.27a

* Each value is the mean and standard deviation of twenty panalist responses. Mean scores in the same column with the same letter are not significantly different at the 5% level.
Score scale: 1=dislike extremely, 5=neither like nor dislike, 9=like extremely.

perhaps due to the presence of seeds in the edible portion. Potassium and phosphorus were the elements in greatest proportion followed by magnesium and calcium respectively.

Highly acceptable jams can be prepared from the edible portion (seeds and pulp) of pomegranates with and without adding flavors. Due to the high nutritive value of the seeds, including them as ground material in the pulp will improve the nutritive value of the jam produced.

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تركيب العناصر الغذائية وصناعة المربى لصنف الرمان الطائفي (*Punica granatum* L.)

عصام حسن عويضه

كلية الزراعة ـ جامعة الملك سعود ـ الرياض ـ المملكة العربية السعودية

صممت هذه الدراسة لتقدير الخواص الكيماوية والطبيعية والعناصر المعدنية لصنف الرمان الطائفي المزروع في المناطق الجنوبية الغربية من المملكة العربية السعودية، وأيضاً درست إمكانية تصنيع مربى من الجزء المأكول منه (اللب والبذور).

أشارت النتائج بأن قيمة البركس للمواد الصلبة الكلية في الجزء المأكول والعصير هي ١٦,٤٦ و ١٥,٢٢ على التوالي فيما كان رقم الاس الهيدروجيني ٤,١٢ و ٣,٨٣ على التوالي. كما أظهرت نتائج تحليل العناصر المعدنية بأن البوتاسيوم (K) والفوسفور (P) يوجدان بأعلى نسبة مقارنة مع بقية العناصر الأخرى بالإضافة إلى أنه يوجد اختلافات كبيرة بين الجزء المأكول والعصير في محتواها من البوتاسيوم (K) والمغنسيوم (Mg) والكالسيوم (Ca) والفوسفور. وبشكل عام وجد أن نسبة العناصر الغذائية كانت أعلى بدرجة كبيرة في الجزء المأكول من الثمرة مقارنة بالعصير وذلك يعود لوجود البذور فيها.

وقد تمت دراسة المتغيرات التالية في صناعة المربي: (١)نسبة السكر: الجزء المأكول، (٢) نوعية وكمية مكسبات النكهة (٣) نسبة البكتين (٤) كمية المادة المحمضة (حمض ستريك) وقد تم الحصول على أفضل تركيبة لتصنيع مربى الرمان الطائفي عندما كانت نسبة الخلط كالآتي: ٦٠٪ الجزء المأكول (اللب والبذور) و٤٠٪ سكر و ٠,٢٪ حمض الستريك و ١,٢٤٪ بكتين. وأكدت الاختبارات الحسية لدى المحكمين نجاح وقبول المربي المصنعة بإضافة أو بدون إضافة المنكهات واتضح أن أفضل مكسبات النكهة هي القرفة والزنجبيل والفانيليا والقرنفل بالنسب التالية ٠,١١٪ و ٠,٠٩٪ و ٠,٠٥٪ و ٠,١٢٪ و ٠,٠٦٪ على التوالي.