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## Research Article

# Preparation of a Novel Processed Cheese Sauce Flavored with Essential Oils

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## Abstract

**Background and Objective:** Sauces from cheese are highly used in prepared and pre-prepared meals in the food sector. Besides submitting good flavor, often cheese sauces are desired to present functional and visible roles, i.e., color, texture and mouth-feel. This study aimed to prepare novel natural sauces from processed cheese flavored with essential oils. Essential oils (EOs) that contribute to its antioxidant, antimicrobial, flavor and color properties. **Materials and Methods:** Plain processed cheese sauces were manufactured from whey protein concentrate 75% and acid casein curd 25%. Cheese sauces were flavored with 2% of some essential oils turnip, shallots, *Capsicum* and cardamom and 1% sugar. The base blends were standardized to contain 65% moisture and 29% fat in dry matter in the resultant cheese sauces. Plain cheese sauces were evaluated for chemical, texture, color parameters and sensory properties during storage at 7°C. **Results:** The values of total solids, fat, ash and lactose were decreased significantly by increasing of addition of WPC and decreasing of AC curd. The protein was only compounds that increased significantly ( $p \leq 0.05$ ) by the addition of WPC to the blend cheese. The pH values also significantly increased by increasing the ratios of WPC to the cheese blends. No chemical changes in the flavored cheese sauces. The lightness ( $L^*$ -values) of PC sauces made with different EOs had the lowest values, as follow: Turnip, shallots, *Capsicum* and cardamom, respectively. Moreover, PC sauces were made with *Capsicum* and cardamom oils (light orange and pink colors, respectively) had the highest  $a^*$  and  $b^*$ -values (light yellowish color) than the others. The flavors of PC sauces were generally better and preferable by the panelists. Also, the body, texture, appearance and color were accepted. Generally, PCs manufactured with cardamom and turnip oils gained the highest scores. **Conclusion:** According to the obtained results, it can be produce processed cheese sauces with high quality and acceptability from easy and cheap materials and flavored with essential oils, which had many benefits in human health.

**Key words:** Processed cheese sauces, essential oils, chemical properties, color parameters, organoleptic properties

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**Data Availability:** All relevant data are within the paper and its supporting information files.

## **INTRODUCTION**

Sauces from cheese are novel cheese products in our era, not only for being desirable appetizers but also for being characterized as a side dish and rather as an ingredient entire, intended to stand by itself. Cheese sauces are widely used in the food sectors in prepared and pre-prepared meals. In addition to introducing flavor, cheese sauces are also required to progress functional and visual roles, i.e., texture, mouth-feel and color. Sauces are often where likely flavor comes from in a meal and may decide why consumer like or dislike a product<sup>1</sup>. Cheese sauces commercially can come in many forms including frozen, semi-liquid, shelf-stable or as dry mixtures. There are no standards of identity or definitional legal for cheese sauce so it can be formulated by using many varieties of cheese ingredients such as natural cheese, cheese powder, processed cheeses and other dried dairy ingredients<sup>2</sup>. The deepness of flavor can be increased by the addition of flavors and concentrated flavors that can be added to imitative the developed flavors through traditional cooking methods of cheese sauce texture can be important also, the texture of commercial sauces is modified by industrial texturizing ingredients such as xanthan gum or other mixed hydrocolloids. These ingredients are useful in the control of viscosity, suspend particles, emulsify, prevent separation and provide qualities such as body and staple.

Essential Oils (Eos), which also called volatile odoriferous oil are aromatic oily liquids extracted from various parts of plants, such as flowers, bark, roots, peel, leaves, seeds, fruits, wood and whole plant. They can be extracted from plant materials by many methods for example, steam distillation method has been widely used, especially for commercial scale production<sup>3,4</sup>. Essential oils have been used for centuries in medicine, perfumery and cosmetic have been added to foods as part of spices or herbs. Their initial application was in medicine, but in the 19th century their use as aroma and flavor ingredients increased and became their major employment<sup>5</sup>.

Essential oils from aromatic plants vary in flavor and odor, which are governed by the amount and types of constituents present in oils. So essential oils have been widely used as flavors in food products<sup>6</sup>. Moreover, the amount of essential oil obtained from different plants is different and this decides the price of essential oil. Beside the aromatic compounds, originally intended pigments which contribute to varying colors of essential oil. This can affect the applications as the ingredient in some food products.

Due to the increasing attention in natural additives, essential oils have been known to have antimicrobial and

antioxidant activities, so serving as natural additives in food products, especially in combination with other preservations under concept of "Hurdle technology." Therefore, essential oils can be as the processing aid or alternative additives as green technology<sup>7</sup>.

Essential oils have several compounds in their structure simulate the well-known plant phenols in the antioxidant activity. it have several modes of actions as antioxidant, such as prevention of chain initiation, reducing agents, free radical scavengers, termination of peroxides, quenchers of singlet oxygen formation and binding of transition metal ion catalysts as well as prevention of continued hydrogen abstraction<sup>8,9</sup>. Due to those functions, essential oils can work as the potential natural antioxidants, which can be used to prevent fat or lipid oxidation in food systems. The capability of plant essential oils to protect foods against spoilage and pathogenic microorganisms has been reported<sup>10,11</sup>.

The cheese sauce is more than just melted cheese. It can serve as a flavor enhancer or a dipping sauce, act as the main attractiveness in many dishes or help intensify or round out an appetizer flavor profile. Probably, the high cost of the manufacture of cheese sauce make it not well known in Egyptian market even it can be a very good appetizer. Effective method of lowering the costs of manufacturing cheese sauces is to reduce the levels of cheese solids. There are number of patents relating to the use of starches and thickening agents as casein substitutes in imitation cheese have been published<sup>12</sup>. Today there are many options available for the manufacturing of sauce cheeses that have improved flavor, texture and taste. Out of such an approach have come several new ingredients to replace natural cheeses for use in the development of new processed cheese sauces. The nutritive value and functionality of dairy based ingredients can help to enhance the value of sauces as well as increase the development of future products. Milk proteins provide a number of main functions that facilitate successful manufacture of milk products<sup>13</sup>.

The objectives of this study were planned to successfully preparing low cost, obtainable and favorable processed cheese sauces formulations. In addition to document using of some of essential oils in producing of processed cheese sauces with new flavor, new color, shelf stable and highly acceptable quality attributes to be suitable for Egyptian consumers.

## **MATERIALS AND METHODS**

**Materials:** The used essential oils were obtained from Department of Medicinal and Aromatic Plants, National Research Center, Egypt and shown in Table 1. Whey protein

Table 1: Plant essential oils used in the preparation of cheese sauces

Name of plant oil	Arabic name	Botanical name	References	Health benefits of oil
Turnip rapeseed	Left	<i>Brassica rapa</i> var., <i>rapa</i>	Pekkarinen <i>et al.</i> <sup>35</sup>	Rapeseed oil is favorable nutritional profiles in terms of its fatty acid composition. It is lower in saturates than all other vegetable oils, high in monounsaturates and has a high alpha-linolenic acid. Rapeseed oil can help maintain healthy cholesterol levels, beneficial for heart health <sup>36</sup>
Shallots	Koraat	<i>Allium ascalonicum</i> L.	Rattanachai-kunsopon and Phumkha-chorn <sup>37</sup>	It has been used as folk medicine since ancient time. Shallot is recognized for its hypoglycemic <sup>38</sup> , hypocholesterolemic <sup>39</sup> and antioxidant <sup>40</sup> effects. It was also reported to have anti bacteria and antifungal activity <sup>41</sup>
<i>Capsicum</i>	Felfel ahmer	<i>Capsicum annuum</i> L.	Baser and Buchbauer <sup>42</sup>	Peppers are a good source of vitamins C and E. Red pepper and capsaicinoid decrease blood cholesterol has potential beneficial effect on the human cardiovascular system. Capsaicinoids have been shown to possess antitumor activity and antioxidant activity <sup>43</sup>
Cardamom	Habahan	<i>Elettaria cardamomum</i> var., <i>cardamomum</i>	Baser and Buchbauer <sup>42</sup>	The essential oil of cardamom is having remarkable antioxidant and antimicrobial properties <sup>44</sup> . Also is reported to have anti-inflammatory and hepatoprotective activity <sup>45</sup>

Table 2: Fat and total solids contents (%) of the ingredients used in manufacture of processed cheese sauces

Ingredients	Total solids (%)	Fat (%)
Acid curd	30.0	10.5
Whey protein concentrate	95.0	0.7
Skim milk powder	96.0	0.1
Butter	84.0	82.0

Table 3: Formulas of blends used in manufacture of processed cheese sauce

Materials	T1	T2	T3	T4	T5
Acid curd	56.82	35.61	19.90	8.50	-
Whey protein concentrate	-	9.87	17.90	23.50	30.08
Skim milk powder	6.06	4.69	3.78	3.08	2.60
Butter	16.18	13.06	10.95	9.35	8.27
Sugar	1.00	1.00	1.00	1.00	1.00
Emulsifier salts	2.06	1.66	1.39	1.19	1.06
Water	17.88	34.11	45.08	53.38	56.99
Total	100.00	100.00	100.00	100.00	100.00

T1: 100% acid casein curd, T2: 75% acid casein curd+25% whey protein concentrate, T3: 50% acid casein curd+50% whey protein concentrate, T4: 25% acid casein curd+75% whey protein concentrate, T5: 100% whey protein concentrate

concentrate was obtained from CHR-Hansen's Laboratory, Denmark. Skim milk powder and unsalted butter were obtained from Dina farmer, Egypt. Kasomelas emulsifying salt (K-2394-Rhone-Poulenc Chimie, France) were obtained from Green Land (International Dairy and Food Co.), 10th Ramadan city, Egypt. Sugar was purchased from local market, Egypt. Fresh raw buffalo's milk was gained from the National Research Centre, Giza.

## Methods

**Experimental 1:** Preparation of processed cheese sauce from acid casein curd and whey protein concentrate. The goal of this experiment is to get better and cheaper cheese blend to be used later in the second experiment. That is preparing of processed cheese sauce flavored by essential oils.

**Preparation of acid curd:** Acid casein curd used in this study was prepared as described by Mohamed *et al.*<sup>14</sup>. Fresh skim milk (fat content less than 0.5%) was pasteurized and cooled to 37°C. About 1.0 M hydrochloric acid solution was added to the milk as coagulant and the precipitation was carried out at 37°C to pH 4.6-4.7. At once the curd was settled, the whey was removed and the curd was washed with wormed water at 41°C then pressed. The fat and total solids contents of acid curd and the used ingredients are shown in Table 2.

**Preparation of plain processed cheese sauce:** Plain processed cheese sauces were prepared from mixture with different ratios of acid casein curd and whey protein concentrate (Table 3) to get the best blend of cheese sauce to use in the next part of this study. That is preparing of processed cheese sauces flavored with essential oils. Plain Processed Cheese Sauces (PCS) were prepared as described by Abdel-Hamid *et al.*<sup>15</sup>. The ingredients were mixed for about 1 min before processing. The mixture was cooked at 85°C/15 min in pilot machine locally at National Research Center using indirect heated steam at pressure of 1.5-2.0 kg cm<sup>-2</sup>. Resulted processed cheese sauces were purred into glass jars (150 g) and capped directly after filling. The resultant cheese sauces were cooled at room temperature before storage at room temperature.

## Experimental 2

**Manufacturing of processed cheese sauces flavored with essential oils:** Flavored Processed Cheese Sauces (PCS) were prepared as described before in experimental 1, except that 2 mL of every essential oil (Table 4) was added at the blends before cooking. The resultant cheese sauces were cooled at room temperature before storage at room temperature and at 5±2°C for 3 months.

Table 4: Formulations flavored processed cheese sauces

Materials	Control	Turnip sauce	Shallots sauce	<i>Capsicum</i> sauce	Cardamom sauce
Acid curd	8.50	8.50	8.50	8.50	8.50
Whey protein concentrate	23.50	23.50	23.50	23.50	23.50
Skim milk powder	3.08	3.08	3.08	3.08	3.08
Butter	9.35	9.35	9.35	9.35	9.35
Sugar	1.00	1.00	1.00	1.00	1.00
Turnip oil	-	2.00	-	-	-
Shallots oil	-	-	2.00	-	-
<i>Capsicum</i> oil	-	-	-	2.00	-
Cardamom oil	-	-	-	-	2.00
Emulsifier salts	1.19	1.19	1.19	1.19	1.19
Water	53.38	51.38	51.38	51.38	51.38
Total	100.00	100.00	100.00	100.00	100.00

### Cheese sauces analysis

**Chemical composition of processed cheese sauces:** Cheese sauces were freshly analyzed for their total solids, ash and fat contents according to AOAC<sup>16</sup>. Protein and total nitrogen contents were measured using the semi micro-Kjeldahl method according to the method described by Ling<sup>17</sup>. Lactose content was determined according to the method reported in IDF<sup>18</sup>. The pH value was determined during storage period using a digital laboratory pH meter (HI 93 1400, Hanna instruments) with glass electrode.

### Physical analysis of cheese sauces

**Color parameters:** Colors were measured according to Hunter<sup>19</sup> by using Hunter colorimeter (model D2s A-2) tri-stimulus values of the color namely L\*, a\* and b\* were measured.

Where:

- L\*: Values represent darkness from black (0) to white (100)
- a\*: Values represent color ranging from red (+) to green (-)
- b\*: Values represent color ranging from yellow (+) to blue (-)

**Textural profile measurements:** Force and torque measurements of cheese sauces samples were measured using a texturometer (model Mecmesin Emperor Lite 1.17, USA). Mechanical primary properties of cohesiveness, gumminess, springiness and hardness were determined from the deformation Emperor Lite Graph. Also the secondary characteristic of chewiness (hardness × cohesiveness × springiness) was selected because the cheese sauces showed springiness<sup>20</sup>.

**Sensory attributes evaluation:** The staff member (Dairy Science Department, National Research Center) were asked to score the cheese sauces for appearance, cheese flavor, color, mouth-feel, texture and overall acceptability on a 9-point

hedonic scale where, 1 is dislike extremely and 9 is like extremely as described by Childs *et al.*<sup>2</sup>.

**Statistical analyses:** All experiments and analyses were done in triplicate and data were expressed as mean values. The statistical analyses were performed using the SPSS 16.0 Syntax Reference Guide<sup>21</sup>. Statistically different groups were determined by the Least Significant Difference (LSD) test ( $p \leq 0.05$ ).

## RESULTS AND DISCUSSION

**Experimental 1:** The main goal of this part is to use less expensive components and easier to get the best blend of the processed cheese sauces with good chemical composition and texture properties, which can be easily applied to get processed cheese sauces with different flavor. To achieve this, Acid Casein (AC) curd and Whey Protein Concentrate (WPC) were used in different proportions and study of the chemical composition and properties of textures.

**Proximate chemical composition of plain processed cheese sauces:** The chemical composition of the main form of processed cheese sauces used in our experiments is shown in Table 5. It is interesting to note that both ingredients i.e., Acid Casein (AC) curd and Whey Protein Concentrate (WPC) significant effects on the chemical components of resultant cheese sauces. The values of total solids, fat, ash and lactose were decreased significantly ( $p \leq 0.05$ ) by increasing of addition of WPC and decreasing of AC curd. The protein was only compounds that increased significantly ( $p \leq 0.05$ ) by the addition of WPC to the blend cheese. The pH values also significantly increased by increasing the ratios of WPC to the cheese blends. The main effects on chemical composition values were associated with the different type of milk protein base, the acid curd contain almost all the components of milk,

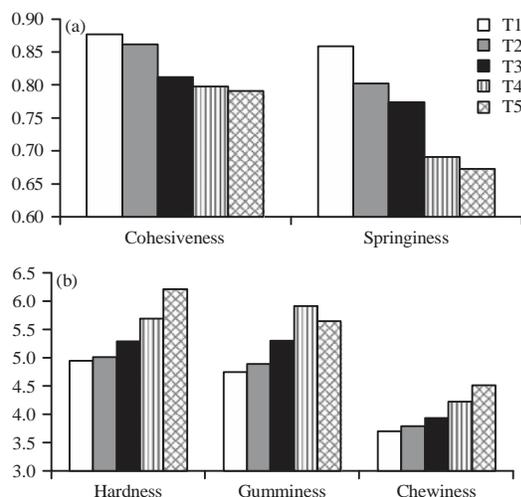


Fig. 1(a-b): Textural properties of processed cheese sauces, T1: 100% acid casein curd, T2: 75% acid casein curd+25% whey protein concentrate, T3: 50% acid casein curd+50% whey protein concentrate, T4: 25% acid casein curd+75% whey protein concentrate, T5: 100% Whey protein concentrate

Table 5: Chemical composition (%) and pH values of different blends used in of processed cheese sauces manufacture

Compounds	T1	T2	T3	T4	T5
Total solids	41.54 <sup>a</sup>	39.64 <sup>a</sup>	37.96 <sup>ab</sup>	35.58 <sup>b</sup>	32.84 <sup>b</sup>
Fat	22.00 <sup>a</sup>	16.75 <sup>b</sup>	13.00 <sup>bc</sup>	10.50 <sup>c</sup>	8.00 <sup>c</sup>
F/DM	52.96 <sup>a</sup>	42.26 <sup>b</sup>	34.25 <sup>bc</sup>	29.51 <sup>cd</sup>	24.36 <sup>d</sup>
Protein	10.46 <sup>c</sup>	15.44 <sup>b</sup>	18.95 <sup>ab</sup>	20.48 <sup>a</sup>	21.18 <sup>a</sup>
Total nitrogen	1.64 <sup>b</sup>	2.42 <sup>a</sup>	2.97 <sup>a</sup>	3.21 <sup>a</sup>	3.32 <sup>a</sup>
Lactose	5.00 <sup>a</sup>	4.25 <sup>a</sup>	3.00 <sup>ab</sup>	2.25 <sup>b</sup>	1.50 <sup>b</sup>
Ash	4.08 <sup>a</sup>	3.20 <sup>a</sup>	3.01 <sup>a</sup>	2.35 <sup>a</sup>	2.16 <sup>a</sup>
pH	5.75 <sup>b</sup>	5.79 <sup>b</sup>	5.89 <sup>ab</sup>	5.94 <sup>a</sup>	5.98 <sup>a</sup>

<sup>a,b,c</sup>Mean have the different superscripts are significantly ( $p < 0.05$ ) different, T1: 100% acid casein curd, T2: 75% acid casein curd+25% whey protein concentrate, T3: 50% acid casein curd+50% whey protein concentrate, T4: 25% acid casein curd+75% whey protein concentrate, T5: 100% whey protein concentrate, F/DM: Fat/day matter

so reflected the chemical composition of obtained cheeses. These results were in agreement with those reported by Muir *et al.*<sup>22</sup> who noted that the total solids was higher in cheese analogues and the pH values were lower in cheese prepared with acid casein than the control. By the same way, El-Neshawy *et al.*<sup>23</sup> found that a slight increase in the moisture content was observed in cheese with added WPC at the higher level.

#### Texture profile properties of plain processed cheese sauces:

Figure 1 shows the effects of acid curd, whey protein concentrate and the different in protein concentrations on the

textural properties of the processed cheese sauces such as hardness, gumminess and cohesiveness. In general, hardness and gumminess increased significantly with protein concentration which increased by increasing the ratio of WPC to the blend. On the contrary, the addition of WPC into cheese blends decreased their cohesiveness and springiness. These results are in accordance with those of Solowiej *et al.*<sup>24</sup> who reported that the addition of Whey Protein Concentrate (WPC) to processed cheese analogues resulted harder cheese than that analogues prepared from Acid Curd (AC). Also, the cohesive of cheese analogues manufactured from WPC was decreased with increasing of WPC to cheese mixtures and more gummy than that manufactured from AC. Moreover, Lobato-Calleros *et al.*<sup>20,25</sup> mentioned that, the instrumental textural characteristics of adhesiveness and hardness were negatively correlated to springiness and cohesiveness.

From the results of experimental 1, it could be concluded that the best processed cheese sauce can be prepared from the blend contains 75% WPC and 25% AC (T4) which have desired physicochemical properties and characterized by a suitable hardness to use in the next experimental.

**Experimental 2:** The aim of this experimental is to use the best blend of experimental 1 which prepared from 25% AC and 75% WPC (T4) in preparing of processed cheese sauces with different flavors and colors by using four essential oils (turnip, shallots, *Capsicum* and cardamom). In the same time, an attempt to enhance the shelf life of cheese sauces using essential oils which have remarkable antimicrobial and antioxidant properties.

#### Chemical properties of flavored processed cheese sauces:

The chemical compositions of processed cheese sauces made with different plant Essential Oils (EOs) during storage at 7 °C for 3 months are shown in Table 6. Generally, the addition of different EOs to the base blend of cheese sauces did not significantly affect ( $p > 0.05$ ) the chemical properties of the resultant cheese sauces. Moreover, there were insignificant differences ( $p > 0.05$ ) among resultant flavored sauces made with different EOs. However, there were insignificant increased ( $p > 0.05$ ) in the pH values, this is due to the high pH values of different EOs using in the formula (pH values of different EOs ranged from 6.06-6.12). The obtained results are in the same line with those reported by Azzam<sup>26</sup> which are no significant differences among the processed cheeses treated with vegetable oils and control in the fat in dry matter, moisture and total nitrogen.

Table 6: Gross composition and pH values of flavored processed cheese sauces during storage at 7 °C for 3 months

Essential oil	Storage period (month)	Chemical composition					pH
		Total solids	Fat/dry matter	Protein	Lactose	Ash	
Control	Fresh	35.58 <sup>a</sup>	29.51 <sup>a</sup>	20.48 <sup>a</sup>	2.25 <sup>a</sup>	2.35 <sup>a</sup>	5.94 <sup>a</sup>
	1	35.60 <sup>a</sup>	29.52 <sup>a</sup>	20.51 <sup>a</sup>	2.22 <sup>a</sup>	2.35 <sup>a</sup>	5.92 <sup>a</sup>
	3	35.61 <sup>a</sup>	29.55 <sup>a</sup>	20.53 <sup>a</sup>	2.21 <sup>a</sup>	2.36 <sup>a</sup>	5.91 <sup>a</sup>
Cardamom sauce	Fresh	35.55 <sup>a</sup>	29.58 <sup>a</sup>	20.45 <sup>a</sup>	2.22 <sup>a</sup>	2.34 <sup>a</sup>	6.02 <sup>a</sup>
	1	35.56 <sup>a</sup>	29.61 <sup>a</sup>	20.45 <sup>a</sup>	2.15 <sup>a</sup>	2.36 <sup>a</sup>	5.98 <sup>a</sup>
	3	35.58 <sup>a</sup>	29.62 <sup>a</sup>	20.48 <sup>a</sup>	2.13 <sup>a</sup>	2.37 <sup>a</sup>	5.95 <sup>a</sup>
<i>Capsicum</i> sauce	Fresh	35.54 <sup>a</sup>	29.56 <sup>a</sup>	20.44 <sup>a</sup>	2.21 <sup>a</sup>	2.33 <sup>a</sup>	6.05 <sup>a</sup>
	1	35.56 <sup>a</sup>	29.59 <sup>a</sup>	20.45 <sup>a</sup>	2.19 <sup>a</sup>	2.34 <sup>a</sup>	6.04 <sup>a</sup>
	3	35.57 <sup>a</sup>	29.60 <sup>a</sup>	20.46 <sup>a</sup>	2.18 <sup>a</sup>	2.36 <sup>a</sup>	6.00 <sup>a</sup>
Shallots sauce	Fresh	35.54 <sup>a</sup>	29.57 <sup>a</sup>	20.44 <sup>a</sup>	2.23 <sup>a</sup>	2.34 <sup>a</sup>	5.99 <sup>a</sup>
	1	35.55 <sup>a</sup>	29.58 <sup>a</sup>	20.47 <sup>a</sup>	2.20 <sup>a</sup>	2.35 <sup>a</sup>	5.97 <sup>a</sup>
	3	35.57 <sup>a</sup>	29.59 <sup>a</sup>	20.49 <sup>a</sup>	2.18 <sup>a</sup>	2.38 <sup>a</sup>	5.94 <sup>a</sup>
Turnip sauce	Fresh	35.56 <sup>a</sup>	29.61 <sup>a</sup>	20.46 <sup>a</sup>	2.20 <sup>a</sup>	2.33 <sup>a</sup>	6.01 <sup>a</sup>
	1	35.57 <sup>a</sup>	29.63 <sup>a</sup>	20.47 <sup>a</sup>	2.19 <sup>a</sup>	2.35 <sup>a</sup>	5.97 <sup>a</sup>
	3	35.58 <sup>a</sup>	29.63 <sup>a</sup>	20.50 <sup>a</sup>	2.18 <sup>a</sup>	2.35 <sup>a</sup>	5.94 <sup>a</sup>

<sup>a,b,c</sup>Means have the different superscripts are significantly different at  $p < 0.05$

Table 7: Color properties of flavored processed cheese sauces during storage at 7 °C for 3 months

Color parameters	Storage period (months)	Turnip sauce	Shallots sauce	<i>Capsicum</i> sauce	Cardamom sauce
L*	Fresh	81.88 <sup>a</sup>	77.63 <sup>a</sup>	34.90 <sup>b</sup>	27.30 <sup>b</sup>
	1	80.95 <sup>a</sup>	77.36 <sup>a</sup>	34.81 <sup>b</sup>	27.27 <sup>b</sup>
	3	80.26 <sup>a</sup>	76.15 <sup>a</sup>	33.90 <sup>b</sup>	26.60 <sup>b</sup>
a*	Fresh	-1.58 <sup>b</sup>	-1.77 <sup>b</sup>	+3.79 <sup>a</sup>	+4.50 <sup>a</sup>
	1	-1.62 <sup>b</sup>	-1.80 <sup>b</sup>	+3.83 <sup>a</sup>	+4.63 <sup>a</sup>
	3	-1.79 <sup>b</sup>	-2.09 <sup>b</sup>	+3.95 <sup>a</sup>	+4.75 <sup>a</sup>
b*	Fresh	23.90 <sup>a</sup>	25.11 <sup>a</sup>	27.66 <sup>a</sup>	27.41 <sup>a</sup>
	1	23.96 <sup>a</sup>	25.21 <sup>a</sup>	27.70 <sup>a</sup>	27.76 <sup>a</sup>
	3	24.40 <sup>a</sup>	25.80 <sup>a</sup>	27.92 <sup>a</sup>	28.83 <sup>a</sup>

L\*: Lightness, a\*: Redness, b\*: Yellowness, <sup>a,b,c</sup>Mean with the different letters within the same row are significantly different at  $p < 0.05$

During the storage, the chemical composition of processed cheese sauces was very slightly changed ( $p > 0.05$ ). All the compounds were slightly increased in all treatments; except the pH values and lactose content were decreased during the storage period. The slight reduction in pH values and lactose content during the storage period could be attributed to a limitation growth and activity of resistant microflora, such as heat resistant proteinases or psychrotrophic bacteria present and enzymes in the product, which cause a hydrolysis of lactose to some acids<sup>27,28</sup>. Whereas, El-Mahdi *et al.*<sup>29</sup> reported that these changes in pH values of cheese sauces during storage could be due to the changes in soluble nitrogen and hydrolysis of polymerized phosphate present in emulsifying salts and their interaction with proteins.

**Color parameters of flavored processed cheese sauces:** Color as an issue of visual perception is an important consideration in food products evolution, because food appearance and color are usually the first impressions to record in the consumer mind. Color values of different cheese sauces for lightness (L\*), redness (a\*) and yellowness (b\*) during storage at 7 °C for 3 months are presented in Table 7. Both of Turnip and shallots sauces were significantly higher in L\*-values than *Capsicum* and cardamom sauces, which mean that more light

and less yellowness values. On the other hand, cheese sauces were made with *Capsicum* and cardamom oils (light orange and pink colors, respectively) had the highest a\* and b\*-values. However, both *Capsicum* and cardamom cheeses intended to the orange color as shown by having the highest a\* and b\*-values, while, turnip and shallots cheeses were lacked in red color and had more green in color.

At the end of the storage period the whiteness values of all cheese sauces were very slightly decreased. On the other hand, a\* and b\*-colors values were very slightly increased during the refrigerator storage, which that meaning all cheese sauces became darker as the cold storage period progressed. This may be attributed to the Maillard browning reaction, which occurs during storage between lactose and cheese protein, which are responsible for the formation of the brownish color in the stored cheeses<sup>30</sup>.

Also, during storage of processed cheese the intensity of the yellow color had a pronounced increase, this could be attributed to decrease in the moisture content of cheese. These finding are in agreement with those found by Abd-Rabou *et al.*<sup>31</sup>. Furthermore, Azzam<sup>26</sup> mentioned that the increasing in the intensity of the yellow color of processed cheese treated with vegetable oils during the storage period could be attributed to decrease in the moisture content.

Table 8: Sensory liking scores of processed cheese sauces flavored with essential oils

Scores (1-9)	Turnip sauce	Shallots sauce	<i>Capsicum</i> sauce	Cardamom sauce
Appearance liking	7.5 <sup>a</sup>	7.8 <sup>a</sup>	8.5 <sup>a</sup>	8.8 <sup>a</sup>
Cheese flavor liking	8.5 <sup>a</sup>	8.4 <sup>a</sup>	6.6 <sup>b</sup>	6.8 <sup>b</sup>
Sauce texture liking	7.4 <sup>a</sup>	7.8 <sup>a</sup>	7.9 <sup>a</sup>	7.8 <sup>a</sup>
Color liking	6.6 <sup>a</sup>	6.8 <sup>a</sup>	8.5 <sup>b</sup>	8.2 <sup>b</sup>
Overall liking	7.7 <sup>a</sup>	7.4 <sup>a</sup>	7.3 <sup>a</sup>	7.9 <sup>a</sup>

<sup>a,b,c</sup>Mean have the different superscripts are significantly different at  $p < 0.05$

### Organoleptic characteristics of flored processed cheese

**saucers:** With the many flavors and textures present in the different types of cheese sauces, it is important to understand which sensory features are looked upon positively by consumers<sup>1</sup>. The best smoother texture in a processed cheese sauces and more uniform particle sizes and fluidity of end product resulted from the cheese power<sup>29</sup>. For those in the business of producing cheese sauces, understanding the key product properties that contribute to overall acceptance is decisive for success. Many recent researches have addressed the ways of liking for different cheeses<sup>32,33</sup>, but to our knowledge, no studies have examined the flavor variabilities of liking for different cheese sauces<sup>34</sup>.

The sensory evaluation of processed cheese sauces flavored with essential oils is shown in Table 8. Cheese sauces made with different EOs were generally better and preferable by the panelists. Also, the appearance, texture and color were accepted from the panelists. The significant differences ( $p < 0.05$ ) were appeared only in flavor and color attributes. The flavor of turnip and shallots was better than *Capsicum* and cardamom sauces. In contrary with color, the color of *Capsicum* and cardamom sauces was good than turnip and shallots. Cheese sauces made with cardamom and *Capsicum* oils had light orange and pink colors, respectively. While turnip and shallots sauces had light yellowish color and all sauces have creamy texture and smooth consistency. According to the overall liking, turnip and cardamom sauces gained the highest scores.

### CONCLUSION

Upon the previous results, it can be produce processed cheese sauces with high quality and acceptability from easy and cheap materials and flavored with essential oils. These oils had many benefits in human health, which had the highest contents of unsaturated fatty acids, so could be used to improve conjugated linoleic acid and omega-3 fatty acids in processed cheese fat. In the same, these oils provided new color to the cheese sauces and increased their shelf life. Therefore, it could be recommended these products for consumers as a novel and healthy appetizer.

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