Using of red palm oil as milk fat healthy replacer in ice milk

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ABSTRACT

This research was performed to throw the light on the use of fresh red palm oil as milk fat substitute in formula of ice milk, and to investigate the effect of this replacement on the quality characteristics at different concentrations. Ice milk samples were prepared by substituting 25, 50, 75 and 100% of milk fat in control mix (5%) with red palm oil. We investigated physico-chemical properties of red palm oil (refractive index, color, acid value, peroxide value, iodine number, saponification number and unsaponifiable matter), total phenols, tocopherol content, fatty acid composition and oxidative stability. Using of red palm oil at different concentrations led to increase the content of carotenoid and vitamin E and caused either improvement or retention of physiochemical quality criteria (pH value, acidity, overrun, melting rate, fatty acids, color values, sensory, carotenoid and vitamin E). The appearance of ice milk was affected by the amount of red palm oil. Incorporation was positively correlated to yellowness intensity, when the ratio of red palm oil to whipping cream increased from 25% to 100% treatments. Also, ice milk produced with red palm oil containing 25 and 50% showed similar or even better-quality characteristics with respect to samples made with milk fat. In conclusion, the combination of red palm oil contributes to more intensity in yellowness as beta carotene, vitamin E, viscosity and percentage of overrun of formulation.

Keywords: Red palm oil, ice milk, physico-chemical properties, fatty acid, phytonutrients.

INTRODUCTION

Palm oil is becoming increasingly important worldwide. Palm oil and its fractions (olein and stearin) are used in different food applications, such as cooking oil for various type of dishes, frying oil and manufacturing shortening and margarine (Siew, 2005 and Nor Aini and Miskandar 2007).

The characteristic red color of red palm oil is due to the multi-carotenoids present in the oil, totaling about 575 ppm with 90% as the provitamin A carotenoid, especially b-carotene and a-carotene. Meanwhile, tocopherols (vitamin E) and tocotrienols (provitamin E) are powerful antioxidants that confer oxidative stability to RPO as well as help to keep the carotenoids and other quality parametersn of the oil stable (El-Hadad *et al.,* 2010).

Red palm oil (RPO) is an antioxidant rich oil which contains approximately 50% saturated and 50% unsaturated fatty acids. Carotenoids and vitamin E (75% of which is tocotrienol) are the most abundant antioxidants in this oil. Both of these antioxidants are contained at a level of at least 500 ppm in RPO .The cocktail of antioxidants within RPO is believed to have synergistic effects (Szucs *et al.,* 2011).Red palm oil supplementation has been used successfully to elevate vitamin A content in human diet, such as utilizing RPO in cakes, biscuits, bread, cookies, rusks and red shortening (Butt *et al.*, 2006).

In today's world, consumers are more and more conscious about the very strong relationships between health and nutrition. That has fueled the interest on the development and commercialization of healthier and improved foods with better nutritional value; in order to not only offer a benefit to the health-conscious consumer but also to fight against potentially damaging nutritional deficiencies. Functional foods are those containing biologically active components, offering health benefits, and reducing the risk to suffer several common diseases (Santillan-Urquiza *et al.*, 2017).

Ice cream is a frozen product consumed all over the world in dairy products. After the first and general definition, ice creams have been defined as food systems called polyphasic. These daily products include ice crystals, air bubbles, protein-hydrocolloid structures, a cry concentrated aqueous phase, emulsified fat, proteins and salts. In this regard, ice creams may be evaluated as oil-in-water emulsions (Cruz *et al.*, 2009).

In ice cream, fat and fat structure development tissue has a critical prescription for many features. These properties include stability, optimal structure and physical properties as an example. Also, fat network governs many desirable quality properties. It produces a smooth characteristic, increases the richness of flavor in ice cream, a good carrier and synergist for added flavor compounds, helps to stabilize the foam, largely responsible for the creamy texture, contributes good melting properties, helps to provide ice cream structure, aids in lubricating the freezer barrel while the ice cream is being frozen (Fox, 2013).

In Egypt and according to Egyptian standards (2005) the fat content of ice milk must not less than 3%. Australia and New Zealand require not more than 3 g fat per 100 g of ice cream. In Canada, this product with 3–5% fat by weight is labeled ice milk (Goff and Hartel 2013).

In Malaysia and other countries, palm oils are often used in ice cream manufacturing, selected to take into account physical characteristics, flavour, availability, stability during storage and cost. Palm mid-fraction, palm olein, palm kernel oil, red palm olein and blends of this oil in appropriate proportions can be used. Palm oils as a fat source in ice cream have the advantage that they can be used without modifying processes such as esterification and hydrogenation, which can produce trans- acids, which are not good for health. Furthermore, the cholesterol content of palm oil is lower than that of milk fat, and it can be consumed by those who are lactose intolerant (Nazaruddin *et al.*, 2008).

This paper aims to use red palm oil as fat substitute in formula of ice milk, and investigate the effect of this replacement on the quality characteristics at different concentrations. Ice milk was prepared by substituting 25, 50, 75 and 100 % of milk fat in control mix (5%) with red palm oil.

MATERIALS AND METHOD

Materials

Red palm oil

Elais guineensis was obtained from processing units at ogbomoso in the western region of Nigeria.

Fresh buffalo's milk (6% fat) supplied by the farm of Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. The Fresh buffalo's milk was separated to obtained fresh skim milk and fresh cream (50% fat), cremodan obtained from Danisco, Cairo, Egypt.

Skim milk powder (S.M.P) (34% protein, and 4% moisture) was obtained from (The Nile Commercial CO.), Cairo, Egypt.

Mango (*Mangifera indica)* was obtained from local market at Giza, Egypt.

Reagents:

All chemical and reagents of the analytical methods used in present study was at analytical grade. All chemical (chloroform, petroleum ether and ethyl alcohol) were purchased from El- Gamhouria Trading Chemicals and Drugs Company, Egypt. Pure standards of fatty acids methyl esters were produced by Koch light Laboratories, Ltd, England. All solvents ware distilled.

Methods:

Separation of fresh buffalo's milk:

The Fresh buffalo's milk was separated to obtained fresh skim milk and fresh cream (50% fat), this method according to Li *et al.,* (2016).

Preparation of mango pulp:

Mango were sorted, cleaned, washed, processed and homogenized by ultra truxx for 5min until obtaining a homogenous mass, then treated in steam jacketed vessel at 80°C for 1 minute, pulp was extracted by means of a fine pulper in order to get homogenous textured pulp and then cooled at room temperature. The citric acid 0.08 % was added to the pulp.The resultant pulp were filled and placed into 200 mL sterilized vessels glass can, which was then stored in a frozen condition at -18±2 °C for later use according to Kumar and Mishra (2003).

Technological methods:

Ice milk production:

The different formulations of ice milk prepared as shown in Table (1). The control ice milk formula consisted of 49.86% fresh skim milk, 5% fat, 9.44% skim milk powder, 15% sugars, 0.7% Cremodan Se 734 Veg and 15% mango pulp. This formulation was estimated according to Goof and Hartel (2013). The other treatments of ice milk formulation were prepared by partial replacement of milk fat with ascending levels of RPO (25, 50, 75 and 100%) as shown in Table (1).

Ingredients were mixed together, mixes preheated up to $70C^0$ and homogenized by ultra truxx for 5min, pasteurization at 83 °C for 15 s, cooled to 5 °C and aged at 5 °C overnight, fruit's pulp 15% were added into the chilled mixes. The mixes were frozen in an ice cream machine then filled into plastic cups 80 cm^3, covered and hardened in a deep freezer at –30°C for 24 h before analysis. Three replicates were made from each treatment.

Physico-chemical properties:

Refractive Index (RI), specific gravity, melting point, relative viscosity value, smoke point, acidity %, peroxide value, iodine number, saponification number and Unsaponifiable matter for RPO and ice milk were determined according to the methods of A.O.A.C. (2016). The color of RPO and ice milk was measured with a Minolta CR-400 colorimeter (Minolta Model CR-400, Camera Company, Osaka /JAPAN). As described by Balthazar *et al.*,(2015).The pH values were measured using a digital pH meter according to the method described in A.O.A.C (2016).Overrun of ice milk was calculated using a standard 100 ml cup according to Marshall *et al.*, (2003).Melting rate of ice milk was determined according to (Kumar, 2013).The malonaldehyde compound content (mg/kg oil) was determined by using the procedure of Hoyland and Taylor (1991).

Oxidative stability by Rancimat method:

The oxidative stability of red palm oil was determined using an automated Rancimat device (Metrohm Ud.CH-9100 Herisau, Switzeland, model 679) according to Farhoosh and Moosavi (2007).

Determination of fatty acid profile:

The fatty acid profile for RPO and ice milk were determined as methyl ester by gas liquid chromatography. Methyl ester was prepared using BF_3 in methanol as methylating agent according to the A.O.A.C. (2016).

Determination of phytonutrients:

Total phenolics content in RPO was determined by the Folin- Ciocalteu method as modified by Neo *et al*., (2008). Total carotenes and vitamin E, A and lycopene were determined in sample according to Dauqan *et al.*, (2011).

Sensory evaluation:

Ice milk was sensory to evaluate flavor, body and texture, melting quality**,** appearance and overall acceptability of the resultant panelists; members of Dairy and Food science Departments, faculty of Agric., Al-Azhar Univ., Cairo, Egypt, by twenty panelists according to Lebesi and Tzia (2011).

Statistical Analysis:

Results other sensory evaluation was analyzed using one way analyze the Variance (ANOVA) using (SPSS 20.0 for Windows, SPSS Inc., Chicago, IL, USA). Duncan's Multiple Range Test ($P \leq 0.05$) was to compare ice milk means.

RESULTS AND DISCUSSION

Physico-chemical characteristics of fresh red palm oil:

The physico-chemical properties of edible oils play an important role in assessing their quality, palatability and consumer acceptability, as well as they are related with the healthy safe quality criteria of these lipids and foodstuffs cooked or processed by using them (Coultate,2009). The physico-chemical properties of tested red palm oil are presented in Table (2).

The physical properties of tested red palm oil included that color (lightness, redness and yellowness color), Density, refractive index, smoke point, viscosity, and slip melting point were illustrated in Table (2).The color in red palm oil is light yellow to orange-red, depending on its carotenoid content according to Rossi *et al.,* (2007) who reported that the L*a*b* value of Indonesian palm oil as 39.03, 47.35 and 67.26, respectively. The red palm oil showed a higher a* value (57.12), b* value (63.26) and lower L* value (44.34). The chromatic color compound a* indicates +red to −green. The increased positive value of a* indicates an increased value of red. The redness of samples correlated well with the carotenoid content. The color component b* indicates yellow to blue. These observations are in agreement with the results reported by Mba *et al.*, (2015) who reported that the red palm oil is rich in minor components which include carotenoids (500-700 ppm). The density is an important parameter from the commercial point of view, since it is used for volume to weight conversions. The density of most edible oils is less than that of water. In general, the density of an oil decreases with molecular weight and increases with unsaturation. Also, it can be used as a purity indicator as shown in Table (2). It was found that the density of red palm oil was 0.9062. These results are in agreement with those found by Gibon *et al.,* (2007). The refractive index is related to the degree of saturation and to the ratio of *cis* and *Trans* double bonds as well as influenced by oxidation damage to the oil. Refractive index at 25 °C of red palm oil was 1.4552. These may be due to the presence of high levels of saturated fatty acids in red palm oil as reported by Ebong and Isong (1999).

Pure substances have sharp melting points but oils and fats are complex mixtures of triglycerides and possess a melting range. From Table (2), it was observed that the melting point of red palm oil 38°C. Red palm oil was semisolid texture at room temperature. It was relatively slow melting properties. These results are agreement with those obtained by Edem, (2002) and Nor-Aini and Miskandar (2007). The smoke point of red palm oil as indicated in Table (2) ware (235°C). According to Berger, (2007), the recommended smoke point for palm oil must be above 215°C (preferably above 220°C) and smoke point of oil is dependent on the content of some minor component especially the free fatty acids. The slip melting point of red palm oil (37.00°C). The highest temperature indicating it is more saturated. The increase in slip melting characteristics of palm oil are generally due to redistribution of the fatty acid chains within the triacylglycerol molecules (Sellami *et al.*, 2012). The viscosity of oils is positively related to its melting point, thus it increases with high saturation and decrease with unsaturation as well as chain length. Consequence of that, the highest viscosity value (400 centipois) was detected in RPO. This value was due to the arrangement of acyl chains of fatty acids on the glycerol backbone of the triglyceride molecule, also the chemical properties of the oils such as chain length and saturation/unsaturation. These observations are nearly agreed with Naghshineh *et al.*, (2010).

The chemical properties of tested red palm oil included that acidity, iodine value and saponification value were recorded in Table (2). Acidity is present in oils as a minor component and as a product of hydrolysis by lipase enzymes or by water reacting with tri acyl glycerols. Acidity is the most used criterion for determining the quality of oil. Red palm oil contains lowest amount of acidity (0.19%) These results are agreement with those obtained by Gee, (2007). The iodine value is a measure of the unsaturated of oil. It is one of the parameters used to measure the quality of the oil (Mamat *et al.*, 2005). Data showed that iodine value of red palm oil was 59.10. These obtained results indicated that the tested oil had reasonable amounts of saturated fatty acids owing to their relatively low iodine value, indicating a high resistant to oxidation which was associated with good quality and long shelf life. The values of the obtained results are in accordance to those obtained by Gee, (2007). The excellent resistance of red palm oil was an account of their lower iodine values, infrequently linoleic acid contents and the relatively higher percentages of unsaponifiable matter. The obtained results are in agreement with those of Alina *et al.*, (2012) and Beku, (2015).

As presented in the same Table (2), the highest saponification value of red palm oil (193.42) mg KOH/g oil, this observation is based on the fact that long chain fatty acids or their acyl chains have low saponification values. This result was relatively with those found by Gupta, (2017).

Concerning the unsaponifiable matter, the values of red palm oil (1.33%). These high values were due to their high concentration of vitamin E and carotenoids; this observation is closed to that of Kumar *et al.,* (2016).

Oxidative stability (Rancimat induction period) of red palm oil:

Oxidative stability is a measure of oil and fat resistance to oxidation, because the process takes place through a chain reaction, the oxidation reaction has a period when it is relatively slow, before it suddenly speeds up. The time for this to happen is called the "induction time "and it is repeatable under identical condition (temperature, air flow, etc.). There are a number of ways to measure the progress of the oxidation reaction. Oxidative stability involved that peroxide value, thiobarabituric acid and induction period (hrs) was tabulated in Table (2). The peroxide value is defined as the amount of peroxide oxygen per kilogram of oil; traditionally this was expressed in units of millieqviualnts. The peroxide value (PV) is an indicator of the primary level of oxidation. The results cited in Table (2) showed that PV of red palm oil was 0.82. These results are approximately agreement with Alina *et al.*, (2012). Thiobarbituric acid (TBA) value measures secondary lipid oxidation products, which responsible for the rancid taste developed during storage. The results in same Table showed that TBA of red palm oil was 0.08 the obtained results are in agreement with those of Kirk and Sawyer (1991) and Riuz *et al.*, (2001).

As regards the induction period (hrs) is one of the most popular methods currently in use is the rancimat method (Mariod *et al*., 2014).The data indicated that, red palm oil had the superior induction period being 71.00 hr. consequence of that, red palm oil is a potent anti-oxidant rich oil which consists of carotenoids, tocopherols, tocotrienols and lycopenes, as well as lipid fractions such as squalene, saturated and unsaturated fatty acids (which maximize absorption of these anti-oxidants).Alpha and beta-carotene account for >90% of the total carotene in red palm oil. The obtained results are nearly in agreement with Rooyen *et al.* (2008) and Leonardis *et al*., (2016).

Fatty acid composition of tested fresh red palm oil:

Results in Table (3) showed that the percentage of total saturated fatty acids, total unsaturated fatty acids and total polyunsaturated fatty acid of red palm oil were (44.75, 43.16 and 12.10%) respectively. The fatty acid composition of red palm oil which has been identified by GLC contains (37.79%) palmitic acid ($C_{16:0}$) and (42.60%) oleic acid ($C_{18:1}$).It was clearly noticed that palmitic was the most prevalent saturated fatty acid in this oil, However, low percentages of stearic acid (4.83%) were found in this oil besides inconsiderable quantities of the other saturated acids which their percentage accounted1.78 %.

As for the unsaturated fatty acids, it is seen that oleic acid was the most prevalent acid in red palm oil; it contained (42.0%). Linoleic acid; it amounted 11.65%, however linolenic acid and other unsaturated fatty acids were found in negligible amounts. It could be noticed that each one at the USFA was presented in RPO in its highest percentage, these results are nearly in agreement with Naghshineh *et al*., (2010) and Kumar and Krishna (2014). Also Ong and Goh (2002) studied the fatty acid composition of palm oil, and they reported that fatty acid composition of palm oil was as follows: 0.2, 1.1, 44.3, 4.6, 39.0, 10.5, and 0.3% of C12, C14, C16, C18, C18:1, C18:2, and (C16:1, C18:3).

Phytonutrients of red palm oil:

Results in Table (4) showed that ß-carotene, vitamins E, A, Lycopene and phenolic compounds in red palm oil. It also shows their Recommended Dietary Allowance (RDA) as established by the Institute of Medicine for different population besides, the amounts in grams of red palm oil that supplies the RDA. The data indicated that red palm oil is rich sources of micro components that serve therapeutic and antioxidants roles especially β-carotene and vitamin E, besides their contents of vitamins A, Lycopene and Phenolic Compounds.

Red palm oil is the highest content of minor components it contained considerable amount of β-Carotenes 650.33ppm, vitamin E 710 ppm, vitamin E isomers consist of saturated tocopherols and unsaturated tocotrienols. There are five vitamin E isomers in red palm oil; α-and γ-tocopherol; and α - γ - and δ-tocotrienols. Approximately 70% of vitamin E in red palm oil is in the form of tocotrienols which are more potent antioxidants (Cassiday, 2017).Red palm oil contained infrequent amounts of vitamin A (1.72 ppm).These amounts are not sufficient to supply the RDA, on the authority of this, it need taking up a great amount of red palm oil being approximately 348.83 grams, in spite of this; the super abundance content of β- carotene in this oil which accounted 650.33 ppm in red palm oil is supported to meet the requirement of vitamin.

It was reported by Van Jaarsveld *et al.,* (2006) that 12 μg β-carotene can provide 1 μg retinol equivalent (RE), dependence of this, 650.33 μg β- carotene in red palm oil can provide 54.20 ug retinol, thereby the calculated amounts of red palm oil to supply the RDA of retinol (vitamin A) were 11.07 grams. By that means, 2 teaspoon (11g) of red palm oil will supply the RDA of vitamin A for adults. Consequence of that, supplementation of 1 teaspoon (5.5) of these oils will recommend to maintain sufficient vitamin A for infants and children. As shown in Table 4, red palm oil is rich in phenolic acid compounds. It was noticed that red palm oil had highest content of phenolics which were 220.34ppm. The phenolic acids are potent antioxidants and serve therapeutic role and nutritional benefits.

Physiochemical properties of ice milk and their different treatments:

As shown in Table (5) the statistical analysis of data shows that the fresh cream substitution of RPO has no significant effect ($P \leq 0.05$) on ice milk pH value and acidity. However, the pH values ranged from 6.14 to 6.20 in terms of pH values. This decrease in pH in all mixes may be due to the lower pH of fruits pulp, actually 4.9 for mango. These results are nearly in agreement with Galoburda *et al.,* (2014) and El-Sheshetawy *et al*., (2016).

The titratable acidity for formulated ice milk ranged from 0.29 to 0.33%, the apparent acidity of ice milk mixes was due to the milk proteins, mineral salts and dissolved carbon dioxide, and our results are in agreement with those reported by Marshall *et al*., (2003) and Lim *et al.,* (2010).

The obtained data from the same Table (5) showed that, the viscosity of ice milk mixes decreased as the proportion of RPO was increased, the viscosity values ranged from 22 to 27 centipois. This may be explained by the different degree of fat crystallization occurring in the milk fat and the RPO of globules at the refrigeration temperature (5˚C). It can be expected that an ice milk mix which had a higher amount of milk fat would have more fat crystals formed during aging process when compared with an ice milk. The decrease in viscosity of RPO mixes may be attributed to the higher content of total mono unsaturated fatty acids (MUFAs) and total poly unsaturated fatty acids of RPO compared to the fresh cream and the differences in melting point and fatty acid composition of the RPO used. A similar trend of result was previously found by Rosnani *et al*., (2007).

Finally, incorporation of RPO in all treatments had significant effect on the viscosity as compared to control, whereas 75% and 100% RPO substitution treatments lowered the viscosity of the mixes significantly as compared to control. These results are nearly agreement with Nazaruddin *et al*., (2008) and Al-Assar, (2009).

Overrun and melting rate of ice milk and their different treatments:

Overrun is the terms used to indicate the volume of air incorporated during the freezing operation. The more air added, the greater is the volume of ice milk produced and the higher is the overrun. From Table (6) it could be noticed that the highest overrun was for the 25% RPO ice milk then 50% RPO substitute ice milk. Also, it could be observed that the lowest overrun was for 75% and fresh cream substitution 100% with RPO. Generally, overrun decreased slightly significantly ($p \leq 0.05$) when RPO used especially at high concentrations. This result was nearly in agreement with Nazaruddin *et al*., (2008) and Corradini *et al*., (2014).

The decrease of overrun may be attributed the higher content of total mono unsaturated fatty acids (MUFAs) and total poly unsaturated fatty acids PUFAs of RPO compared to the fresh cream. The reduced aeration is reasonable for this decrease in overrun, as the oilier nature of RPO may not be enough to withstand the physical structure that support the air cells introduced during whipping. Moreover, the nature of high viscosity for fruits pulp, which had a negative effect on the overrun values, these results are nearly in agreement with those reported by Bajwa *et al*., (2003) and Guven et al., (2018).

The melting resistance as loss in weight percent of the initial weight of the ice milk treatments. Results from the same table showed that, the melting resistance of ice milk produced using different levels of substitution of milk fat with RPO was decreased significantly ($p \leq 0.05$), with the increase of substitution level as compared to control. It could be observed that, 100% RPO showed the fastest melting rate, while the control ice milk treatment was the lowest. The melting percentage after 10 min. at 25 °C ± 2 being 10, 11, 13, 16 and 18% for C, 25, 50, 75 and 100% treatments respectively. In addition, both 75% and 100% ice milk treatments were full melted after 50 min, while, other treatments showed more resistance, actually 88, 90, and 100 % for control, 25 and 50% treatments respectively. These results are nearly in agreement with those reported by Nazaruddin *et al*., (2008) and Guven *et al*., (2018). This increase in melting rate were related to the increase of substitution of milk fat with RPO, which may be attributed to the lower melting point of the RPO. These results are nearly in agreement with those reported by Liew *et al*., (2001) and Rosnani *et al*., (2007).

Impact of red palm oil incorporation into ice milk formula on fatty acids profiles:

Fatty acids composition of prepared ice milk as affected by replacing milk fat with different levels (25, 50, 75 and 100%) of RPO, were determined by gas chromatography and the obtained data are recorded in Table (7).The main fatty acids in the tested ice milk control were myristic, palmitic, stearic and oleic acids which represented 10.62%, 34.96%, 11.54% and 25.91% respectively. Due to blending of RPO at different levels into ice milk, the major changes were noted in the contents of most fatty acids of the resulted ice milk treatments. Blending of RPO with ice milk leading to observably remarkable decrease in most fatty acids content except for palmitic, oleic, linoleic and arachidic acid were a considerable increased.

The fatty acids of ice milk are generally composed of both saturated and unsaturated forms. Table (7) showed that saturated fatty acids contents were 67.10, 61.63, 56.06, 50, 41 and 44.83% for control, 25, 50, 75 and 100% treatments respectively.

The total saturated fatty acids of ice milk mixes decreased with the increasing of replacement rate with RPO. This may be attributed to increase in unsaturated fatty acids compared to saturated fatty acids in 100%RPO, in addition, 25% and 50% treatments contained partial whipping cream consists of high palmitic, stearic and oleic acids composition as the milk fat component, so it could affect the fatty acids composition in final ice milk treatments. These results are in close approximately agreement with those reported by Corradini *et al*., (2014).

The present results in Table (7) showed that ice milk treatments content from unsaturated fatty acids ranged from 29.09 to 43.27 % of total fatty acids for control to 100% red palm oil treatments respectively.

Incorporation RPO into ice milk mixes during formulation exerted marked increase in the oleic acid (ω9) content from 25.91 to 42.62 % of total fatty acids for control ice milk to 100% RPO treatments respectively. Moreover, the Linoleic acid (ω6) content in ice milk treatments increased from 2.95 to 11.53% of total fatty acids, while the Palmitoleic acid content was decreased with the increase of incorporation of RPO into ice milk treatments, it ranged from 3.18 to 0.65% of total fatty acids for control, to 100% red palm oil treatments respectively. This may be due to the decrease in whipping cream quantity. Since the whipping cream was not a good source of linoleic and linoleinic acid, the incorporation of red palm oil in ice milk had boosted up the quantity of both fatty acids. These results are in close approximately agreement with those reported by Rosnani *et al.*, (2007) and Corradini *et al.*, (2014).

The importance of incorporation of red palm oil into ice milk, not only for its high content from unsaturated fatty acids, but also for improving various characteristics such as providing a good balance for omega6/omega 3 ratio. Increasing the carotenoid and omega-6 intake is essential to improve health, prevention and management of chronic disease by reducing the risk of cardiovascular disease (CVD), obesity, diabetes, inflammation, and several neurological diseases. Furthermore, the balance of omega-6 and omega-3 fatty acids is very important for homeostasis and normal development (Watson and Preedy 2012 and Mafra *et al.*, 2014).

Color values of different ice milk treatments:

The data from Table (8) showed that the results of color for ice milk produced by using 100% fresh cream as a control sample and ice milk samples which substituted with 25, 50, 75 and 100% red palm oil immediately after processing. From statistical analysis of these results, it could be observed that, there were significant differences (p≤0.05) in the color between all ice milk treatments and the control sample.

The color analysis showed that the Lightness (L*) exhibited decreasing trend, with the increasing of the percentage of red palm oil replacement in ice milk. It was noticed that the replacement of 100% red palm oil in ice milk showed the least Lightness value (94.27) respectively compared the control sample (99.36). On the other hand, the redness (**a***) and the yellowness (b*) values of ice milk treatments were increased from (6.82 and 18.55 to 8.38 and 41.12 respectively) with increasing the percentage of RPO replacement compared to the control sample (2.54 and 2.06 respectively).

As regards the chroma color and total intensity values were significant differences (p≤0.05) between all ice milk treatments and the control sample ice milk. The ice milk samples containing 25%,50,75 and 100% RPO for Chroma were (39.06),(54.73),(93.24) and (176.10) respectively compared the control sample (10.70) and total intensity between all ice milk treatments and the control sample, the ice milk samples containing 25%,50,75 and 100% RPO for total intensity were (48.12),(47.28),(46.55) and (45.16) respectively compared the control sample (49.41).However the blending of RPO with ice milk leaded to a considerable improvement in the color values of ice milk, this is could be attributed mainly to high levels beta carotenes of fresh RPO.These results are nearly in agreement with those obtained by Nazaruddin *et al.*, (2008) and Kavak and karabiyik (2019).

Effect of preparation the ice milk and their different treatments on carotenoid and vitamin E contents:

The present data in Table (9) shown that carotenoid and vitamin E contents of the control sample ice milk and their different treatments containing (25,50,75 and 100% RPO were determined in ice milk mix during preparation of the mixture and after the processing of the final product ice milk to evaluate the loss and their changes during product.

As illustrated in the obtained results Table (9), there were significant (p≤0.05) in the carotenoid and vitamin E contents of various ice milk treatments and ice milk control sample affected by preparation methods (heat, pasteurization at 85˚C for 15 second).Initial carotenoids contents were (ppm): 170.37 for ice milk mix with 100 RPO compared 25.11 for control sample before production. Carotenoid contents for this sample might be duo to the carotenoid in raw materials 260 (ppm) mango pulp, 0.63 (ppm) milk and red palm oil contain the highest amount of carotenoids among the ingredients 630.33ppm (Underwood, 2000 and Ribeiro *et al.*, 2007).

After product a reduction in carotenoids (2.74% to 8.36%) occurred during product Table (9).Mean value in ice milk mix during processing of the mixture before production (25.11ppm) was significantly reduced (23.01 ppm) after the processing of the final product ice milk with the mean loss of 8.36% for the control sample. The percentage of red palm oil at 25, 50, 75 and 100% reduced the percentage loss in carotenoids 4.21, 3.98, 2.90 and 2.74% respectively. The gradual decrease of carotenoids was observed in all treatments. This result was nearly agreement with Nazaruddin *et al.*, (2008) and Brito and Pinho (2016).

The lowest of reduction in carotenoid and vitamin E content of ice milk treatments containing (25, 50, 75 and 100%) compared to ice milk control may be due to the highest amount of carotenoid and vitamin E for fresh RPO, also the RPO is thoroughly blended with other ingredients like, sugar and milk, thereby avoiding direct exposure to heat, probably the retention is higher. The present results are conformity with data obtained by Manorama and Rukomini (1991) and Debier *et al.*, (1999).

The same trend was observed with vitamin E contents the content of vitamin E were decreased from 2.16 to 2.13 ppm for ice milk mix with 100% RPO while decreased from 0.40 to 0.38 ppm for control sample ice milk before and after production respectively. After product a reduction in vitamin E (0.93% to 2.65%) occurred during product Table (9).Mean value in ice milk mix during processing of the mixture before production (0.40 ppm) was significantly reduced (0.38 ppm) after the processing of the final product ice milk with the mean loss of 2.65% for the control sample. The percentage of RPO at 25, 50, 75 and 100% reduced the percentage loss in carotenoids 2.40, 2.34, 1.74 and 0.93% respectively. The gradual decrease of vitamin E was observed in all treatments this trend results was observed by Debier *et al.*, (1999).

Sensory evaluation of ice milk affected by different levels of substitution of milk fat with red palm oil:

Organoleptic properties of food products are important monitoring method which indicate the food acceptability to consumers, sensory evaluation was carried out to evaluate flavor, body and texture, melting quality, appearance and overall acceptability of the resultant products, which achieved by twenty experienced panelists; members of Dairy and Food science Departments, faculty of Agric., Al-Azhar Univ., Cairo, Egypt.

Data presented in Table (10), declared that incorporation of red palm oil affect the flavor of the resultant ice milk significantly. The changing in flavor (from 30 point) was ranged from 28.22 to 26.62 points, for control ice milk to 100% red palm oil treatment. These low scores for both mouth feel and flavor for ice milk with red palm oil at different levels could attribute to the slight flavor of red palm oil, which found not commonly accepted by some panelists.

The obtained results revealed that sweetness for ice milk slightly decreased from control to 100% red palm oil treatments. This may be due to the presence of whipping cream, which contributes to some sweet sensation. Thus, it can be concluded that, increasing red palm oil substitution levels caused the decrease in sweetness levels substantially. This result is a proximately in agreement with those reported by Dian *et al.*, (2017) they reported that, mild increase in perceived sweetness was found with higher dairy fat content in ice cream.

Aroma acceptability showed a lower score for ice milk treatments with high red palm oil content as compared to control ice milk; this might probably due to lower content of whipping cream which responsible for release of volatile aromatic compound as compared to control sample. The degrees of flavor preference decreased as the concentration of dairy fat used decreased. These findings are in agreement with Corradini *et al*., (2014), who reported that a decrease in fat content resulted in a lower flavor release in ice milk.

The obtained results from the same Table (10), revealed that creaminess attributes was in decreasing trend when RPO levels increased into ice milk. Therefore, as the dairy fat content decreased, smoothness of the ice milk decreased. These obtained results are in agreement with the findings of Frost and Janhoj (2007) and Corradini *et al*., (2014), they reported that ice milk creaminess attribute was associated with milk fat globules in dairy products. Thus, reduction of the whipping cream from control to 100% red palm oil treatments caused the decrease of creaminess.

The melting resistances for ice milk treatments ranged from 18.09 to 17.05 for control to 100% respectively. Ice milk 25% RPO treatment firmness was not affected by incorporation of red palm oil into ice milk as compared to control, whereas, there were no significantly decreased for 50%,75% and 100% red palm oil treatments as compared to control, this may be due to the melting point of the RPO (38˚C). So, by reducing the amount of dairy fat, the firmness of resultant ice creams containing red palm oil not affected. These findings in agreement with Liew *et al.*, (2001) and Rosnani *et al*., (2007), they found that the higher proportion of palm oil used to replace dairy fat, the lower the firmness of ice milk.

Concerning appearance, it could be noticed from the data obtained that a was positively correlated to yellowness intensity, when the ratio of RPO to whipping cream increased from 25% to 100% red palm oil treatments. These results may be attributed to contain red palm oil on large amounts of carotene strong yellow color in nature form had apparently contributed to the yellowness color of finished ice milk. This results in agreement with Wan *et al.*, (2009) who suggested that the amount of red palm oil substitution was positively correlated to yellowness intensity.

CONCLUSIONS

In conclusion, the present study has shown that mixture of formulation with red palm oil as a fat replacer gave suitable characteristics for ice milk production. This can contribute to soft and smooth in ice milk texture. Red palm oil also influences the melting resistance, which gave lower melting resistance than other formulations. The combination of red palm oil contributes to more intensity in yellowness as beta carotene, vitamin E, viscosity and percentage of overrun of formulation.

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Table 1. formulation of control ice milk and with different levels (25, 50, 75 and 100%) red palm oil as fat milk replacer.

Ingredients (g or ml)	Control	25%	50%	75%	100%
Fresh skim milk	49.86	51.11	52.37	53.61	54.86
Fresh cream (50%)	10	7.5	5	2.5	-
Skim milk powder	9.44	9.44	9.43	9.44	9.44
Sucrose	15	15	15	15	15
Mango pulp	15	15	15	15	15
Cremodan Se 734 Veg	0.7	0.7	0.7	0.7	0.7
Red palm oil	-	1.25	2.5	3.75	5
Total	100g	100g	100g	100g	100g

Table 2. Physico-chemical properties of red palm oil.

Physico-chemical properties			
Color	L*: 44.34 a*: 57.12 b*: 63.26	Acidity % (as palmitic acid)	0.192
Density	0.9063	peroxide value (meq.O_2/kg oil)	0.823
Rafractive index at 25 °C	1.4552	Iodine value (Hanus)	53.10
Melting point (°C)	38.00	T.B.A(mg malonaldehyde/kg oil)	0.08
Smoking point (°C)	235	Saponification value (mg KOH/g oil)	193.42
Slip Melting Point (°C)	37.00	Unsaponification mater %	1.33
Viscosity at 25° C centipois	400	Induction period (h)	71.00

L (lightness) a* (redness) b* (yellowness)*

Table 3. Fatty acid composition of fresh red palm oil.

Fatty acids %	Common name	Red palm oil
(C6:0)	Caproic	0.00
(C8:0)	Caprylic	0.04
(C10:0)	Capric	0.10
(C12:0)	Lauric	0.22
(C14:0)	Myristic	1.10
(C16:0)	Palmitic	37.79
(C16:1)ω 7	Palmitoleic	0.56
(C17:0)	Margaric	0.35
(C18:0)	Stearic	4.83
(C18:1)ω 9	Oleic	42.60
(C18:2)ω 6	Linoleic	11.65

Fatty acids %	Common name	Red palm oil
(C18:3)ω 3	Linolenic	0.45
(C20:0)	Arachidic	0.32
Total SFAs		44.75
Total MUFAs		43.16
Total PUFAs		12.10

Table 4. phytonutrients concentration of red palm oil and Recommended Dietary Allowance (RDA. μg/day) and grams daily intake from red palm oil.

Phytonutrients	Concentration (ppm)	RDA (μg/day)	Amount (g)that supply the RDA
β-Carotenes	650.33	2400	3.70
Vitamin E	710	10000	14.08
Vitamin A	1.72	600	348.83
Lycopene	1.62	33.39	20.61
Phenolic Compounds	220.34	863	3.80

Table 5. Physiochemical properties for ice milk and their different treatments.

Item / Treatments	Acidity %	pH	Viscosity cPs
Control	0.29^{A}	6.20^{A}	27^{A}
25%	0.29^{A}	6.18^{A}	26^{B}
50%	0.30^{A}	6.18^{A}	25^{C}
75%	0.31^{A}	6.15^{A}	23^{D}
100%	0.33^{A}	6.14^{A}	22^{E}

Means values in the same column showed the same superscript letter is not significantly different ($p \leq 0.05$).

Table 6. Overrun and melting rate of ice milk and their different treatments.

Item Treatments	Overrun%	Melting rate (g/min) at 25˚C.					
		10min	20 min	30 min	40 min	50 min	60 min
Control	70^{A}	10^{A}	23^{A}	35^{A}	57^{A}	75^{A}	88^{A}
25%	69^{B}	11^{B}	27^{B}	38^{B}	60^{B}	78^{B}	90^{B}
50%	66^{C}	13^{C}	33^{C}	44^{C}	72^{C}	88^{C}	100^{C}
75%	64^{D}	16^{D}	45^{D}	60^{D}	83^{D}	100^{D}	-
100%	62^{E}	18^{E}	55^{E}	72^{E}	89^{E}	100^{D}	-

Means values in the same column showed the same superscript letter is not significantly different ($p \leq 0.05$).

Table 7. Fatty acids profiles of ice milk affected by levels of red palm oil as partial milk fat**.**

Fatty acids %	Common name	Control	25%	50%	75%	100%
(C4:0)	Butyric	1.47	1.12	0.76	0.37	0
(C6:0)	Caproic	1.22	0.92	0.65	0.31	0
(C8:0)	Caprylic	0.69	0.53	0.37	0.2	0.04
(C10:0)	Capric	1.58	1.25	0.82	0.5	0.11
(C12:0)	Lauric	2.02	1.57	1.12	0.67	0.22
(C14:0)	Myristic	10.62	8.24	5.86	3.48	1.1
(C16:0)	Palmitic	34.96	35.75	36.48	37.11	37.82

Fatty acids %	Common name	Control	25%	50%	75%	100%
(C16:1)ω7	Palmitoleic	3.18	2.54	1.91	1.28	0.65
(C17:0)	Margaric	2.65	2.09	1.52	0.95	0.37
(C18:0)	Stearic	11.54	9.92	8.21	6.53	4.85
(C18:1)ω9	Oleic	25.91	30.1	34.29	38.49	42.62
(C18:2)ω6	Linoleic	2.95	4.38	6.85	9.23	11.53
(C18:3)ω3	Linolenic	0.85	0.77	0.68	0.57	0.4
(C20:0)	Arachidic	0.35	0.24	0.27	0.29	0.32
Total SFAs		67.10	61.63	56.06	50.41	44.83
Total MUFAs		29.09	32.64	36.20	39.77	43.27
Total PUFAs		3.80	5.15	7.53	9.8	11.93

Table 8. Color values of ice milk as affected by different levels of red palm oil:

Substitution %	L*	a*	b*	Chroma	Total intensity
Control	99.36^{A}	2.54^{E}	2.06^{E}	10.70^{E}	49.41^{A}
25%	96.10^{B}	6.82^{D}	18.55^{D}	39.06^{D}	48.12^{B}
50%	94.39^{C}	7.26^{C}	22.24^{C}	54.73^{C}	47.28^{C}
75%	91.53^{D}	7.96^{B}	29.48^{B}	93.24^{B}	46.55^{D}
100%	85.27^{E}	8.38^{A}	41.12^{A}	176.10^{A}	45.16^{E}

Means values in the same column showed the same superscript letter is not significantly different (p≤0.05). L*(lightness), a*(redness), b*(yellowness).

Table 9. Carotenoid and vitamin E contents of ice milk affected by different levels of substitution of milk fat with red palm oil.

Parameter (ppm)	Control	25%	50%	75%	100%
Carotene enriched ice milk mix	25.11^{E}	41.24^{D}	71.58^{C}	134.75^{B}	170.37^{A}
Carotene enriched final ice milk product	23.01^{E}	39.50^{D}	68.73^{C}	130.83^{B}	165.82^{A}
% Loos	8.36	4.21	3.98	2.90	2.74
Vitamin E in ice milk mix	0.40^{E}	0.85^{D}	1.30^{C}	1.75^{B}	2.16^{A}
Vitamin E in final ice milk product	0.38^{E}	0.81^{D}	1.25^{C}	1.69^{B}	2.13^{A}
% Loos	2.56	2.40	2.34	1.74	0.93

Means values in the same row showed the same superscript letter is not significantly different (p≤0.05).

Table 10. Sensory evaluation of ice milk as affected by different levels of red palm oil.

Properties	Control	25%	50%	75%	100%
Flavor (30)	28.22^{A}	28.30^{A}	28.09^{A}	27.89^{B}	26.62^{C}
Body and Texture (30)	29.11^{A}	28.33^{B}	28.25^{B}	27.46^{C}	26.39^{D}
Melting quality (20)	18.21^{A}	18.09^{A}	17.66^{A}	17.27^{A}	17.05^{A}
Appearance (20)	17.66^{B}	18.55^{A}	18.45^{A}	17.33^{B}	15.45^{C}
Overall acceptability (100)	91.33^{B}	93.21^{A}	91.20^{B}	87.66^{C}	82.76^{D}

Means values in the same row showed the same superscript letter is not significantly different (p≤0.05).

استخدام زيت النخيل الأحمر كبديل صحي لدهن اللبن فى المثلوجات اللبنية

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المخلص العربى

هذا البحث يلقى الضوء على استخدام زيت النخيل الأحمر كبديل لدهن اللبن فى مكونات المثلوجات اللبنية، كما يوضح تأثير نسب الإستبدال المختلفة على دلائل الجودة لهذا المنتج، حيث تم تجهيز المثلوجات اللبنية بإستبدال 25, 50, 75 و100٪ من دهن اللبن فى العينة القياسية (5 ٪) بزيت النخيل الأحمر. وتم تقدير الخصائص الطبيعية والكيميائية لزيت النخيل الأحمر (معامل الإنكسار- اللون – رقم الحموضة – رقم البيروكسيد – الرقم اليودى – المواد المتصبنة والغير قابلة للتصبن) الفينولات الكلية – التوكوفيرولات – تركيب الأحماض الدهنية – الثبات الأكسيدى . استخدام زيت النخيل الأحمر بنسب الإستبدال المختلفة أدى الى تحسين دلائل الجودة الطبيعية والكيميائية للمنتج (قيم الأس الهيدروجينى – الحموضة – الزيادة فى حجم المنتج – معدل الزوبان – الأحماض الدهنية – اللون – التقييم الحسى – محتوى الكاروتينات وفيتامين هـ). وكانت النتائج كما يلى: ادى دمج زيت النخيل الأحمر الى المثلوجات اللبنية الى حدوث زيادة ايجابية فى درجة او تركيز اللون الأصفر مع زيادة معدل الإستبدال من 25 الى 100 ٪ من دهن اللبن. ايضا اظهرت المثلوجات اللبنية المحتوية على نسب استبدال 25 و 50 ٪ من زيت النخيل الأحمر خصائص افضل او مماثلة للعينة القياسة المنتجة بدهن اللبن نستنتج من هذا أن دمج زيت النخيل الأحمر ساهم في زيادة دررجة او تركيز اللون الأصفر (بيتاكاروتين) وفيتامين هـ كما اثر على اللزوجة ونسبة الزيادة فى حجم المنتج النهائي.

الكلمات المفتاحية: زيت النخيل الاحمر، الايس كريم، الخواص الطبيعية والكيميائية، الاحماض الدهنية.