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Effect of Replacing Vegetable Oil with Anhydrous Milk Fat on the Quality Properties of Laboratory-Produced Pistachio Cream: Implications for Nutritional Enhancement and Food Product Development

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ABSTRACT

The objective of this work was to formulate pistachio cream by partially replacing vegetable oil with anhydrous milk fat (animal ghee) at 15, 10 and 5% levels to get more nutritious cream. Chemical composition, fatty acid profile, content of fat-soluble vitamins and sensory property were evaluated of the products produced in the laboratory when the replacements used. All of the chemical analysis indicated a highly significant difference between all of the treatments ($P \leq 0.05$). The fat and unsaturated fatty acid content, especially oleic and linoleic acid, increased and carbohydrate and moisture content decreased as the substitution level increased. Of particular interest, with the exception of vitamin E, there were significant increases in fat soluble vitamins A, D, E and K which were provided by the anhydrous milk fat, with vitamin A increasing from 59.8 mg/100g in the control to 70.3 mg/100g in the 15% substitution treatment, and vitamin E from 145.9 mg/100g to 164.6 mg/100g in the 15% substitution treatment. However, sensory evaluation result showed that substituted treatments exhibited greater difference in flavor, texture, consistency, and appearance characteristics as compared to the control, but the color characteristic did not interestly move away from the control. Most of the sensory acceptance scores (91.38 total score), and the best scores for most of the quality parameters were obtained with the 15% substitution treatment. These results suggest partial vegetable oil substitution with anhydrous milk fat is a feasible option to obtain higher nutritional value, desirable FA profile, higher amounts of fat-soluble vitamins and higher sensorial attributes of pistachio cream, which is beneficial for nut exploitation in value added nut butters in the food industry.

1- INTRODUCTION

Pistachio spread is a relatively new food product, which has proven to be very popular in the world market owing to its unique sensory characteristics and high nutritional content of having abundant amount of fats, proteins, minerals, and bioactive compounds [1]. Pistachios have specific unsaturated fatty acids such as oleic and linoleic acids, which have been linked to a variety of health benefits including decreased risk of cardiovascular diseases [2]. In a food science context, the novel readily growing consumer demand for more nutritious and healthier foods has encouraged the food industry to seek opportunities for modifying ingredients that will provide a nutritious or healthier food product while preserving the desired food sensory properties [3].

Fat is also an important ingredient in spreadable products, including pistachio cream, and is crucial to their product texture, viscosity, physical stability, spreadability, and flavor. Many vegetable oils (sunflower oil) contain greater percentage of unsaturated fatty acid content than saturated fatty acid content which is why they are very popular in vegetable oil-based products, however some problems pose with these oils are their tendency to turn into oxidative rancidity, and limited storage stability. To solve these problems, the research trends of recent years have been aimed at using other fat sources instead of vegetal fats to enhance functional and nutritional characteristics of food products [6].

From the present context, anhydrous milk fat (AMF), popularly called animal ghee is a potential substitute, since it has a high amount of saturated and monounsaturated fatty acids and contains fat soluble vitamins such as vitamins A, D, E and K [7]. AMF is the result of the removal of water and non-fat solids from milk or cream resulting in a highly concentrated fat product that is stable at high temperatures and has a distinctive flavor. The study has shown that this ghee contains bioactive compounds that can help aid digestion and decrease inflammation in addition to its energy source [8].

Rheological parameters of food products are extremely affected by the fat phase composition, and this is important from food technology's point of view. Increased melting points and increased viscosity with higher content of saturated fatty acids helps to improve the texture, stability of fat, and spreadability [9]. The flavor contribution and improvement of sensory attributes of products is also one of the significant functions of fats [10]. Various investigations have been made on fat sources used in food products; however, not many studies have examined the use of anhydrous milk fat in the formulation of pistachio cream, which this study aims to fill.

With increased consumer awareness about the health consequences of dietary fats, the food industry is looking for alternatives to the fats they use today that could be improved in terms of nutritional value without affecting sensory properties [11]. It is now known that the ratios of individual types of fatty acids are more important than the amount of fat, and milk fat, a source of naturally-occurring fats, appears to have a positive effect on overall health [12]. The aim of the present work was thus to assess the effect of partial replacement of the vegetable oil by anhydrous milk fat (AMF) on chemical composition, fatty acid profile, fat-soluble vitamin profile and sensory properties of laboratory-made pistachio cream.

Specifically, this study aimed to assess the chemical composition and the fatty acid profile of pistachio cream formulations containing different percentages of AMF; quantify the levels of fat-soluble vitamins

A, D, E and K in the formulated products; study the sensory properties and the acceptance of the modified formulations; and establish the optimum level of AMF to obtain the best formulated product for food applications.

2- MATERIALS AND METHODS

2.1 Raw Materials

The raw materials used in the preparation of pistachio cream which are green pistachios, sunflower oil, anhydrous milk fat (animal ghee), milk powder, sugar and salt, were bought from the local markets of Baghdad in the state of Iraq.The used raw materials in the preparation of pistachio cream were green pistachio, sunflower oil, anhydrous milk fat (animal ghee), milk powder, sugar and salt, all of which were obtained in the local markets of Baghdad city in the state of Iraq. The changes were done in the standard recipe found in Kılıç et al. [13]. The ingredients used to make the simple recipe are given in Table 1.

Table 1. Standard Pistachio Cream Ingredients

Percentage (%)	Raw Material
50.00	Green pistachios
25.00	Sugar
9.00	Milk powder
1.00	Lecithin
0.50	Salt
0.50	Vanilla

2.2 Preparation of Pistachio Cream Treatments

Four treatments were prepared for pistachio cream as follows:

- **Treatment A (Control):** Standard pistachio cream recipe (100% sunflower oil)
- **Treatment B:** 5% substitution of sunflower oil with anhydrous milk fat
- **Treatment C:** 10% substitution of sunflower oil with anhydrous milk fat

- **Treatment D:** 15% substitution of sunflower oil with anhydrous milk fat

Pistachio cream was prepared by using the method described by Kılıç et al. [13] with changes. The green pistachios, sugar, milk powder, salt, and vanilla were thoroughly mixed together as dry ingredients. This mixture was then transferred to an electric mixer, and vegetable oil and the lecithin then gradually added to achieve the desired consistency. The final product was stored in sterile, airtight glass bottles and then at room temperature for subsequent analysis. Every analysis had three replications of all the treatments.

2.3 Chemical Analysis

2.3.1 Moisture Content

The moisture content was measured with the oven-drying method as specified in AOAC [14]. About 3 g was taken and put into a weighed crucible and was dried in an electric oven until constant weight at 105°C for 8 hours. Moisture percentage was obtained from the following formula:

The moisture percentage is calculated as outlined below: (Sample before drying − Sample after drying) / Sample before drying * 100

2.3.2 Ash Content

Ash Content in sample was analysed by incineration following the method of AOAC [14]. The sample was put in a ceramic crucible of known weight and burnt at about 525C for 3 hours. Ash content was determined as the percentage of the weight of ash which was obtained after burning the ash fraction.

Ash(%) = {(Weigh of the crucible having the ash – Weight of the empty crucible) / Weight of the sample} × 100

2.3.3 Protein Content

The protein content was measured using the Kjeldahl procedure as described by van Dijk and Houba [15]. Sample (~ 5 g) was digested with concentrated sulphuric acid and catalyst mixture of potassium sulfate and copper sulfate. The digested sample was distilled with 40% sodium hydroxide and the ammonia molecules that are released are trapped in boric acid solution with the presence of indicators of methyl red and bromocresol green. Condensed distillate was titrated by using the acid of normality 1.0 N HCl. The percentage of protein was determined and calculated as:

Protein (%) = (Volume of HCl consumed × N × 0.014 × 6.25) / Sample weight × 100

2.3.4 Fat Content

Fat content was measured by the Soxhlet method AOAC [16] was followed. Ten grams of dried sample was extracted with hexane, for about 5 hours. Fat extracted was weighed and the solvent was evaporated. Fat percentage was calculated as:

Fat (%) = (Weight of fat extracted) / (Weight of sample) × 100

2.3.5 Fatty Acid Analysis

The lipid esterification was done following the method of AOAC [16] and fatty acid composition was determined by gas chromatography. The extraction of fat from samples was performed by Soxhlet method and the esterification was carried out with methanolic KOH. A sample of one gram of lipid was added to 8 mL of methanolic potassium hydroxide (2.11 g KOH in 100 mL of MeOH) and 5 mL of hexane. Shaken vigorously for 30 seconds and upper hexane portion with FAMEs collected.

Fatty acid methyl esters were analysed with Shimadzu gas chromatograph GC-2010 and ZB-1 capillary column (30m×0.25mm). The injection temperature was 280 °C, the detector temperature was 340 °C, and

column temperature was programmed from 100 ° C to 300 ° C at 10 ° C/ min and the flow rate of the carrier gas was measured as 100 kPa.

2.3.6 Fat-Soluble Vitamins (A, D, E, K)

The fat soluble vitamin content was analysed according to standard method using high performance liquid chromatography (HPLC) [17]. Samples were processed to extract vitamins, these were separated by applying an C18 reversed-phase HPLC column to a UV-Vis detection at selected wavelengths for each vitamin. The quantification of the samples was carried out by using the external calibration curves obtained from the authentic standard samples.

2.4 Sensory Evaluation

Sensory evaluation was carried out by A 10 members trained panel, and it was conducted by applying a sensory evaluation form containing the following sections: Physical, chemical, organoleptic and instrumental evaluation.Sensory evaluation was performed by a ten trained panel members in the Department of Home Economics – College of Education for Women – University of Baghdad, by a sensory evaluation form prepared according to a standard form [18, 19] which include the following three sections: Physical, chemical, organoleptic and instrumental evaluation. The samples were evaluated against pre-established criteria for flavor (taste and aroma), texture and consistency, color, appearance and overall acceptability. Panelists were shown the samples in a random order.

2.5 Statistical Analysis

All the data was analysed by using the Statistical Package for Social Science (SPSS) version 26 [20] using the completely randomized design. Three replicates (n=3) were made and expressed as mean ± S.D. Significant difference was tested between the treatment means by the analysis of variance (ANOVA) and the means were then compared by the Least Significant Difference (LSD) test at the least value of P≤0.05 [21].

3- RESULTS AND DISCUSSION

3.1 Fat-Soluble Vitamin Content

Table 2 shows the difference between the fat-soluble vitamin content of pistachio cream with ANFW and VOF.The fat-soluble vitamin content of pistachio cream and its difference following the replacement of VOF by ANFW are presented in Table 2. Significant statistical differences (P≤0.05) were found between the different treatments for all the vitamins analyzed. Higher concentrations of all fat-soluble vitamins were found as the anhydrous milk fat imitation increased.

Table 2. Effect of treatment on fat-soluble vitamin content (mg/100 g)

Treatment	Vitamin A	Vitamin E	Vitamin D	Vitamin K
A (Control)	59.8 ± 2.27 c	145.9 ± 6.52 c	32.0 ± 1.08 c	74.5 ± 2.97 c
B (5%)	62.4 ± 2.65 bc	152.3 ± 6.77 bc	35.8 ± 1.29 b	81.4 ± 3.74 b

Treatment	Vitamin A	Vitamin E	Vitamin D	Vitamin K
C (10%)	65.7 ± 3.19 ab	158.7 ± 8.02 ab	38.7 ± 2.10 ab	86.3 ± 3.82 ab
D (15%)	70.3 ± 3.47 a	164.6 ± 8.35 a	42.6 ± 2.38 a	89.7 ± 3.94 a
LSD	**5.016 ***	**8.934 ***	**3.652 ***	**6.209 ***

Values with different letters within the same column are significantly different (P≤0.05).

3.2.1 Protein Content

The amount of Vitamin A was found to have increased considerably from control (A) 59.8 mg/100g to D (15% substitution) 70.3 mg/100 g (17.6% increase). This improvement may be due to the higher natural sources of vitamin A in anhydrous milk fat than vegetable oils [7, 17]. The fat content also helps preserve this vitamin in the making and storage of these products, leading to its higher level in treatments, alongside the multiple steps involved in making the substitute. The findings are in agreement with Antony et al. [7] who revealed that the ghee has a great amount of fat soluble vitamins, and with Ulambayar et al., [17] who found a higher level of vitamins in animal fats than in vegetable oils.

The vitamin E content increased considerably from 145.9 mg/100 g (control) to 164.6 mg/100 g (treatment D) (12.8 % increase). The rise is due to the fact that all pistachios are natural sources of tocopherols and anhydrous milk fat contains extra natural fat-soluble antioxidants. Vitamin E is an important natural antioxidant which protects unsaturated fat from oxidation and prevents deterioration during storage [22]. This can especially be of benefit to foods with lots of unsaturated fatty acids because they boost oxidative stability and improve shelf life.

The higher content of anhydrous milk fat by 0.2% in treatment D, than the same in vegetable oils gave rise to higher vitamin D content, that is 42.6 mg/100 g treatment D, whereas the content in the control was 32.0 mg/100 g. Vitamin D is key to calcium and phosphorus absorption, and bone health. So, the additional vitamin fortification gives another positive effect to the nutritional and functional properties of pistachio cream when it is fortified by physical substitution with AMF [23].

Increasing substitution with the increasing substitution rates did also significantly increase vitamin K, from 74.5 mg/100 g in the control to 89.7 mg/100 g in treatment D (20.4%). Natural animal fats with a high content of fat-soluble vitamin K will be incorporated; also, the fat content in the product will give a good solubility setting for this vitamin in the food matrix [17, 10].

As can be seen from these results, there is a direct relationship between percentage of substitution of anhydrous milk fat and the level of fat soluble vitamins with the highest values for all vitamins studied in treatment D. The study has been confirmed and validated that anhydrous milk fat can help to enrich the nutritional value of pistachio cream with fat soluble vitamins, which can improve the nutritional value of the final product.

3.3 Nutritional Value

The chemical composition and fatty acid profile of pistachio cream after substituting with vegetable oil to anhydrous milk fat (AMF) were shown in Table 3. The statistical analysis showed significant differences (P\leq0.05) for all the parameters studied when the substitution level was incremented, thus giving an insightful demonstration that there is an effect to increase the levels of substitution in the product in regard to its nutritional and fatty acid profile.

It is seen that the protein content has decreased in all the treatments when compared to the control treatment but it has reduced gradually from the control treatment to treatment D which has 16.58% protein content, which is 15.3% less as compared to the control. The lower levels were due to the greater contribution of anhydrous milk fat in the formulation which had an impact on other solids in the formula, which, when expressed as a percentage of the total weight, decreased in comparison [24]. The main protein source in the product is pistachios and the anhydrous milk fat contains very little protein due to the fact that the majority of the non-fat solids are taken out during the manufacture.

Table 3. Chemical composition and fatty acid profile of pistachio cream treatments

Parameter (%)	A (Control)	B (5%)	C (10%)	D (15%)	LSD
Protein	19.58 ± 0.83 a	18.89 ± 1.04 ab	18.00 ± 0.79 b	16.58 ± 0.72 c	1.384 *
Lipid	44.12 ± 2.16 c	48.77 ± 2.54 bc	54.16 ± 2.52 b	60.25 ± 2.86 a	4.952 *
Ash	2.98 ± 0.14 a	2.32 ± 0.10 b	2.11 ± 0.08 b	2.01 ± 0.09 b	0.522 *
Moisture	4.23 ± 0.18 a	3.11 ± 0.14 ab	2.89 ± 0.13 ab	2.32 ± 0.11 b	1.877 *
Carbohydrates	29.09 ± 1.08 a	26.91 ± 1.27 ab	22.83 ± 1.19 bc	18.84 ± 0.95 c	4.376 *
Palmitic acid	8.55 ± 0.47 a	8.00 ± 0.57 ab	7.85 ± 0.37 b	7.11 ± 0.33 c	0.668 *
Stearic acid	3.65 ± 0.19 a	3.57 ± 0.14 a	3.35 ± 0.16 ab	3.00 ± 0.14 b	0.372 *
Oleic acid	44.08 ± 2.37 c	47.52 ± 2.61 bc	49.77 ± 2.65 ab	52.05 ± 2.48 a	3.461 *
Linoleic acid	26.22 ± 1.16 c	29.87 ± 1.30 bc	32.00 ± 1.44 b	36.07 ± 1.69 a	3.519 *
Linolenic acid	0.53 ± 0.04 c	1.05 ± 0.08 b	1.33 ± 0.11 ab	1.70 ± 0.13 a	0.508 *

Values with different letters within the same row are significantly different (P≤0.05).

3.2.2 Lipid Content

There was a significant increase in lipid content with 60.25% in the treatment D against 44.12% in the control (36.6% increment). This increase has been put down to the high fat content of anhydrous milk fat, being more than 99% fat, hence higher substitution levels inevitably result in higher overall fat content [22, 7]. This is an expected outcome in line with what would be anticipated as the more fat added, the more the final product will change/sucrose consumption will decrease.

3.2.3. Ash And Moisture Content

With greater substitution (the mineral-rich constituents are proportionately reduced with the increasing fat content) the amount of ash has reduced from 2.98% to 2.01% (32.6% decrease). The moisture content was decreased from 4.23% to 2.32% due to the removal of almost all the water from the butter or cream to prepare anhydrous milk fat [10]. It also makes products less water retaining due to the higher fat content.

3.2.4 Carbohydrate Content

The water content also increased rapidly, from 37.84% to 47.08% (25.14% increase), as the substitution increased; carbohydrate content rapidly decreased from 29.09% to 18.84% (35.2% decrease) as substitution was increased. This is because of the proportional decrease in the other constituents, such as carbohydrates, as the fat content increased and the lack of any other nutrients in anhydrous milk fat [25].

3.2.5 Fatty Acid Profile

Palmitic acid (C16:0) reduced with going up in substitution, by 16.8% from 8.55 % to 7.11 % of total. This could be attributed to the varying compositions of the ingredients and changes in the relative ratios of fatty acids by the factor of the increased amount of anhydrous milk fat [26].

Stearic acid (C18:0) also had a downward trend from 3.65% to 3.00% (V 17.8%); this was related to the relative balance of fatty acids in the product as well as the increase of unsaturated fatty acid in favor of some saturated fatty acids.

Oleic acid (C18:1) showed a marked increase from 44.08% to 52.05% (18.1% increase). One of the more crucial monounsaturates in the body, it correlates with many health benefits for cardiovascular health [2]. This increase is due to the high oleic acid content of pistachios and anhydrous milk fat which is added giving rise to the final product [27].

Linoleic acid (C18:2) increased from 26.22% to 36.07% (37.6% increase). This is an essential fatty acid which cannot be synthesized by the human endogenic metabolism and cannot be synthesized in the body and therefore has to be ingested in the diet [28]. The improvement is indicated by this increase, which represents an improvement in the nutritional value of the product, due to the fact that linoleic acid forms a crucial component of the structure and function of cell membranes and participates in the regulation of metabolic pathways.

Linolenic acid (C18:3) increased from 0.53% to 1.70% (220.8% increase). The omega-3 fatty acid has great nutritional and health value, it is important for the function of the heart and brain, and it decreases inflammatory reactions [29]. The increase can be explained by the increased substitution level and the accompanying change in fatty acid composition of the final product.

The results showed that partial replacement of pistola chichi with anhydrous milk fat significantly induces fatty acid changes in pistachio cream where the levels of desirable unsaturated fatty acids increase, whereas the amount of saturated fatty acid decreases. In terms of food science, the consequence of this is that it makes the food

healthier, since the proportions of different fatty acids is now known to be the factor more significant for health than total fat [11].

3.3 Sensory Evaluation

The results in Table 4 show that replacing the VEO with AMF affects various sensory parameters of pistachio cream.Table 4 shows that changing VEO with AMF affects various sensory parameters of pistachio cream. Means significantly different (P≤0.05) were found for flavor, texture, consistency, appearance, and overall quality; and color was found to be no different.

Table 4. Effect of treatment on sensory evaluation scores

Treatment	Flavor	Texture & Consistency	Color	Appearance	Total
A (Control)	30.63 ± 1.82 b	24.38 ± 1.26 b	9.13 ± 0.62	7.50 ± 0.36 b	71.63 ± 2.91 c
B (5%)	38.13 ± 2.37 a	29.13 ± 1.75 a	9.25 ± 0.77	7.75 ± 0.41 b	84.25 ± 3.83 b
C (10%)	42.63 ± 2.57 a	28.75 ± 1.83 a	9.13 ± 0.67	9.50 ± 0.62 a	90.00 ± 3.89 a
D (15%)	41.00 ± 2.33 a	32.25 ± 2.17 a	9.00 ± 0.58	9.13 ± 0.57 a	91.38 ± 3.74 a
LSD	**4.815 ***	**3.028 ***	0.305 NS	**1.637 ***	**6.287 ***

Values with different letters within the same column are significantly different (P≤0.05). NS = not significant.

3.3.1 Flavor (Taste and Aroma)

The flavors of the treatments C and D were higher than the control (30.63, 42.63 and 41.00, respectively). This enhancement is due to its content of natural flavour compounds that are produced during butter and ghee production which makes anhydrous milk fat less bland and less greasy compared to vegetable oils [10, 7]. Fats also serve to transport aromatic compounds and slowly release them during consumption to improve their taste perception and consumer acceptance [30]. Desirable sensory properties were obtained for the pistachio natural flavor (NF) and the anhydrous milk fat (AMF) flavor, which is responsible for the higher ratings for the substituted treatments than for the control.

3.3.2 Texture and Consistency

Texture score was improved and increased in the solution used in the treatment D with score of 32.25 compared to the control with score 24.38. This improvement is said to be

as a result of the higher percentage of saturated fatty acids within the anhydrous milk fat which has a higher melting point than vegetable oils, giving a more cohesive fat network within the product [22]. The enhanced fat percentage also led to a better separation from the oil and better spreadability, which are important characteristics of spreadable products such as producing pistachio cream.

3.3.3 Color

There was no difference between scores for color of the treatments ranging from 9.00 to 9.25. This is probably because the main color of pistachio cream is due to the color of the pistachios and other ingredients and the substitution rates used were too small to effect the color significantly [18]. Further, the colour of the anhydrous milk fat is light yellow and very similar to the original product, resulting in minimal colour differences between treatment.

3.3.4 Appearance

Appearance scores of the 2 treatments were higher as compared to the control and treatments C and D had scores of 9.50 and 9.13, respectively. The improvement is attributed to the improvement in the homogeneity and the smoothness of the surface, which was achieved by increasing the fat content in the product and refining the distribution of the ingredients among the product [19]. The product also looked more uniform and shiny and had less oil separation during storage, which had a positive effect on the consumers.

3.3.5 Total Sensory Rating

The overall best were treatment C (90.00) and treatment D (91.38) with control being rated at 71.63. This is a good indication of the positive attributes of anhydrous milk fat on the majority of sensory properties, particularly flavor, appearance and texture. The results show that as the substitution levels got higher, consumer acceptance and treatment C and D had the highest consumer acceptance that treated the best balance of different sensory qualities.

These results suggested anhydrous milk fat can be effectively applied in the production of pistachio cream and provide a product with desirable sensory-quality and consumer acceptance characteristics as compared to the conventionally processed product [18, 19]. The 15% substitution level (Treatment D) seems to have reached the best compromise on nutritional enhancement/sensory level.

Overall Discussion and Food industry implications are discussed.

Conclusion of this research work shows that there is a significant improvement in several nutritional and sensory properties of pistachio creams by partial replacement of vegetable oil by anhydrous milk fat which can be a significant contribution in food products development.

3.4.1 Nutritional Enhancement

Effective substitution levels lead to high levels of fat-soluble vitamins (A, D, E and K), which are a big step forward in terms of nutrition. Vitamin A, vitamin E, vitamin D and vitamin K content results showed a rise of 17.6%, 12.8%, 33.1% and 20.4%, respectively in the 15% substitution treatment when compared to the control treatment. For consumers, these vitamins are of great importance for vision, immune support and bone health, as well as for antioxidant protection [7, 17].

This enhanced fatty acid profile – with higher amounts of oleic acid (18.1%), linoleic acid (37.6%) and Linolenic Acid (220.8) – is important for health benefits. It has been reported that these unsaturated fatty acids may decrease the risk of cardiovascular diseases, enhance cognitive function and have anti-inflammatory effects [2, 28, 29].

3.4.2 Food Processing and Stability

Addition of the increased saturated fatty acid content from anhydrous milk fat enhances the texture, consistency and oxidative stability. Saturated fatty acids have a higher melting point which gives

them a more stable fat network and therefore helps to prevent separation of oils and increase the spreadability [22]. This influences the production of food as products with greater stability do not need as many stabilizers and additives.

Additionally, there is the natural antioxidant level, in this case Vitamin E. Vitamin E prevents the oxidation of unsaturated fatty acids that can be achieved during storage and prolong the shelf life [31]. This is important for products high in unsaturated fatty acids which may undergo oxidative rancidity.

3.4.3 Consumer Acceptance and Market Potential

The enhanced sensory traits – in particular those of flavor, texture and appearance – suggest good consumer acceptance potential. The total sensory scores from the substituted treatments (84.25 – 91.38) significantly outscored the control (71.63) indicating that consumers will prefer the modified treatment [18, 19]. Likewise, no discernable color variation is beneficial since colors can play a major role in what consumers will buy.

Consumer demand for "clean label," natural and nutritionally improved products is escalating and creating the potential for a commercial advantage to using anhydrous milk fat as a substitution. Product development with improved nutritional and improved sensory properties are well-suited in order to occupy share of market in the very competitive food market.

3.4.4 Comparison with Previous Studies

The results of this study agree with others who have researched the use of fat substitutes in spreadable products. Ghee of various animal sources was found to have higher amount of fat soluble vitamins than vegetable oils, according to the report done by Ulambayar et al. [17] Likewise, Sharma et al. [22] proved that ghee possesses beneficial effects on lipid metabolites & more oxidatively stable. The results are also consistent with those of Barišić et al., [3] which showed that various interventions to improve the nutritional quality of chocolate spreads can be undertaken and Adeleke and Babalola [2] who reported the health benefits of unsaturated fatty acids.

Nevertheless, this study is contributing research in a unique way by specifically studying the substitution of anhydrous milk fat in pistachio cream, which has limited research literature on it. Comprehensive chemical composition, fatty acid profile, vitamin profile, and sensory properties analysis give a complete picture of the effects of substitution, with useful information for food product developers.

3.4.5 Future research directions and limitations

This study is informative but it has a number of limitations, which are as follows:

Shelf-life assessment:

1. The study did not assess the oxidative stability and shelf-life of the developed products. It is recommended that further work be carried out to determine the effect of replacing anhydrous milk fat with other fats on oxidative stability in storage.
2. Characteristic 2: Oxidative stability: This was not measured directly, except for the antioxidant activity of the products in addition to vitamin E activity. Oxidative stability values such as peroxide value and free fatty acids would be beneficial to study.
3. Consumer acceptance: Sensory evaluation was done using trained panelists but more representative data can be obtained from consumer acceptance testing.
4. Textural analysis: Instrumental texture analysis of the product would complement the sensory evaluation and give quantitative data regarding the consistency of the product
5. Bioavailability: On the final product, the fat soluble vitamins'

bioavailability should be evaluated using digestion simulation tests.
6. Economic feasibility: It would be useful to do a cost benefit analysis of the substitution to make sure it makes economic sense for use in industry.

4-CONCLUSION

This research successfully confirmed that part of the vegetable oil could be replaced with anhydrous milk fat in pistachio cream without compromising several nutritional and sensory properties which would undoubtedly provide a useful guideline in food product development for the spread industry.

The following conclusions can be drawn:

1. The control product was supplemented with 15% substitution (Treatment D), which showed the greatest increases in fat soluble vitamins (A, D, E, K), 17.6%, 33.1%, 12.8% and 20.4% respectively compared to the control, providing significant nutritional benefits to the product.
2. A significant improvement in the fatty acid composition, including nutritionally beneficial unsaturated fatty acids, was obtained with an increase of oleic acid (+18.1%), linoleic acid (+37.6%) and linolenic acid (+220.8%) contributing to the contribution of health promoting properties of the product.
3. The 3 substituted treatments showed marked improvement on the sensory attribute scores, achieved the highest total score (91.38) than the control (71.63) and showed significant improvements in flavor, texture, consistency, appearance and overall acceptability. Substitution didn't affect color.
4. The formulation recommended for use in industry was 15% substitution level, due to the balance that consumes between nutritional enhancement and sensory acceptability.
5. Since consumer demand for healthier and natural food products it is found to be a useful alternative for minimizing the content of anhydrous milk fat and increasing the consumption of vegetable oil in pistachio cream to give a healthier food product being produced with desirable sensory characteristic.
6. The results in this study add to the available knowledge on fat substitution in food products while offering practical suggestions for the food industry on preparing value-added, nutrition-optimized spreadable products.

5- RECOMMENDATIONS

The study has led to the following recommendations:

1. Regarding formulations in commercial production of pistachio cream, the 15% treatment (Treatment D) appeared to be the most optimum one because of its acceptability and nutritional enhancement.
2. In future, it is suggested to try the oxidation stability and shelf-life of the developed products under various storage conditions.
3. Consumers acceptance test with larger, divers panel should be analyzed to confirm the sensory results.
4. Economic feasibility assessments need to be carried out to decide the commercial viability of the substitution strategy.
5. The final product should be subject of studies on bioavailability of the fat-soluble vitamins through digestion simulation.
6. The use of other fat sources and/or substitution level may be further investigated to optimize product formulation.

7. Anhydrous milk fat should be explored for use in other nut spreads (hazelnut, almond etc.).

Conflict of Interest

The authors declare that they have no conflict of interest.

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Data Availability

All data supporting the findings of this study are available within the manuscript.

Ethical Approval

This study did not involve human participants or animals. All experimental procedures were conducted in accordance with institutional and laboratory biosafety guidelines.

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