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FULL PAPER

Study of some physicochemical, microbial and sensory properties of low-fat butter produced by titanium dioxide (TiO_2) nano particles

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This research study was carried out to assess the influence of using various concentrations of TiO_2– nanoparticles 0.75, 0.50, 0.25% as T1, T2, and T3 treatments, and controlling the treatment to produce four different low-fat butter treatments (70, 60, 50, and 40%) of fat. The results revealed a significant effect ($P \leq 0.05$) of fat% and nano-TiO_2 addition on butter formation temperature. The formation time of butter types was longer at butter that contains low-fat content of 40% and low concentration of TiO_2, and it needs around 9 min. Compared with butter type of 50% fat and the same concentration of TiO_2. Fluorescence Microscope Test (FMT) showed the water and fat drops are in homogenized distribution, and there was no secession between water and fat in all samples. Texture analysis shows that the Hardness, Cohesiveness, and Springing were positively affected by the addition of nano-TiO_2 in all treatments. It is noticed that there were significant effects ($P \leq 0.05$) for Harding and melting point for all samples due to a decrease in fat percentage. Nano-TiO_2 also inhibits the growth of coliform bacteria, yeast, and mold, and Psychrotrophic bacteria in the butter samples compared to the control treatment. The sensory properties were decreased when the fat content was decreased, but it was still acceptable in the treated samples. From the results, it is clear to notice that there was a significant effect ($P \leq 0.05$) of different levels of additions of nano-TiO_2 (T1 0.75%, T2 0.50%, T3 0.25%) on the mixing temperature and butter formation time for each treatment. In contrast, there were no effects of T1, T2, and T3 on the other physical, microbial and sensory tests of each sample of treatments.

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KEYWORDS

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Introduction

In general, butter can be defined as a product produced from cow's milk with at least 80% as a mass fraction of fat according to international standard CXS279–1971, which were later amended in 2010 and 2018 under the Codex standard for butter. In other words, it can be defined as a concentrated fat dispersed in the milk plasma. The structure, texture, rheological and physicochemical properties, consumption areas, and flavor benefits all these parameters are predetermined based on the composition, distribution, and ration of the butter in milk. [1-3]. Low-fat dairy products provide a solid nutritional base and improve weight loss [4]. Consumption of low-fat dairy products also improves blood pressure and could be associated with lower risk in people who are not suffering from diabetes and showed improvements in glycemic control, weight loss, lipids, and blood pressure [5]. Low-fat dairy products were also used to increase the calcium content of the diets; Calcium has been reported to have an inverse relationship with blood pressure [6]. Generally, these products can be classified into two types, and the first one is called classic butter. This type always retains its properties during transportation but under a controlled temperature of less than 5 ºC. Therefore it is also called a strategic product. The second type is milk spreads, this type contains low-fat ranging from 50 to 79%, which is considered the most widespread type, and it can be easily stored under normal conditions. This type is the most popular and preferred by the population. In addition to previous types, there is a product called butter paste. This type contains fat ranging from 40 to 49%. They put very low stress on human in terms of cholesterol, saturated fatty acids, energy, and calories [7,8]. However, the comparison of butter depends on the production method. Some of the methods synthesize the butter basis on the aggregation states of the fat according to [9-11]. This aggravation determines the framework of the structure connection. Some of them produced a crystalline product, while other connections produced coagulation. Recently, food nanotechnology has been applied in dairy products to fortify and enrich dairy food products. Nanotechnology in food has provided a great opportunity to increase bioavailability, improving the solubility of the active ingredients and health effects. For example, Omega -3, one of the most bioactive compounds that contained highly unsaturated fatty acids, can oxid and lose its bioactivity. The oxidation of the Omega-3 can be easily avoided if the Omega-3 is encapsulated at the nanoscale. The nanoscale, considered a food nanotechnology application, can increase the product's stability. The nanoscale, which is considered a food nanotechnology application, can increase the product's stability and control the release of nutrients [12]. Another nanotechnology in food is to enhance the nutritional status based on [13]. More than half of children's deaths contribute to malnutrition due to inexpensive food technology. Therefore, the enhancement of food such as milk with minerals, vitamins, and other active ingredients has recently gained a lot of importance. The texture of foods can be improved using nanotechnology, for example, the consistency of some dairy products such as butter, ice cream, and yogurt. In this sense, nanotechnology applications played a key role in solving these problems. In terms of food's dimensional structure, recently, many food types have a consequence of nanostructures. The processing of milk is the most practiced worldwide. This process exploits different physical and chemical properties of the milk's ability to produce a wide range of dairy foods, including 1000 types of butter, cheeses, and ice cream. E171 is sometimes used as a whitener or as an anti-caking agent to prevent the food from clumping and food packaging materials in the food industry. E171 also gives some food products texture; one common example is to give the chocolate a smooth texture. It can also be used in doughnuts to provide color and texture. On the other hand, the literature search showed that these materials affect microbial activity and TiO_2 nanoparticle inhibits the growth of some pathogenic microorganism [14]. An anti-microbial packaging system incorporating nanoparticles (TiO_2) could maintain cheese quality and prolong its shelf life [15]. E171 is most commonly found among food products in candies, chewing gums, and some dairy products such as cottage and mozzarella cheeses and cream. Titanium dioxide Nano-particle (nano-TiO_2, E171) is used as additives in many personal cares, food, painting, and other products. Through food processing, nanoparticles have been applied to improve nutritional quality, flavor, color, and stability or increase shelf life. They might help develop healthier food with lower fat, sugar, and salts

[16]. Nano-particles are easier to be absorbed by the body. Therefore nano-TiO_2 is commonly used as a food additive, and they are graded as a generally recognized as safe (GRAS) substance by the US Food and Drug Administration [17], and have been permitted as food additives [18]. To the best of our knowledge, no studies have been conducted to investigate the effect of using TiO_2 nanoparticles on the physicochemical and sensory properties of the butter. Therefore, this study has synthesized low-fat butter from the milk using TiO_2 nanoparticles and examined its structure, texture, rheological and physicochemical properties, consumption areas, and flavor.

Materials and methods

Materials

TiO_2 powder (30-50 nm, 99%, white powder, surface treatment TiO_2 nano powder-hydrophilic, hydrophobic) was obtained from (Hongwu International Group Ltd - China). While, the Cow's milk was obtained from the dairy factory of Food Science Department, College of Agricultural Engineering Sciences, University of Baghdad.

Methods

Manufacturing of butter

Butter (82% fat) was manufactured by separating whole milk to obtain cream (38%). After that, the cream was pasteurized by flash pasteurization at 85 °C for 15 seconds, then cooled and kept under 15 °C for 24 hours to self-fermentation, which is the method used to manufacture butter in the dairy factory, College of the Agriculture/University of Baghdad. The cream was churned at 8 °C. Butter grains were washed by cold water and put in sterilized containers after the cultured butter-milk was removed. The produced butter (82%) was used to prepare four different butter treatments in different concentration (70%, 60%, 50%, and 40%) by mixing with sterilized water under appropriateness conditions (Butter Temperature 35 °C, Water temperature 35 °C, and mixing speed 10 X 1000 rpm. Finally, the titanium dioxide TiO_2 was added to each butter treatment in three concentrations (0.75%, 0.50%, and 0.25%) by weight. All samples were left in the refrigerator (5-7 °C) for the next day to do the other tests.

Determination of acid degree value (ADV) & cholesterol value

The value of an acid degree in the cream and butter sample was estimated as in method [19], and the ADV was calculated from the following equations (1 & 2).

$$ADV\% = \frac{(\text{Ml of NaOH(sample)} - \text{Ml of NaOH(blank)}) \text{ X N}}{\text{Weight of sample (g)}} \text{ X } 100 \qquad (1)$$

The cholesterol value is estimated according to the colorimetric method after reacting (0.2 g) of butter with alkali potassium hydroxide, and the absorption of the solutions was measured at a wavelength (580 nm) [20].

$$\text{Cholesterol (mg/100 g)} = \frac{\text{Sample absorption} - \text{blank solution absorption}}{\text{Standard solution absorption} - \text{blank solution absorption}} \text{ X } 100 \qquad (2)$$

Moisture content

The moisture content in the cream and butter sample was determined using drying methods by using the oven. The % moisture was calculated after evaporation of the water and stability of the weight of the sample according to the following equation (3) [21].

$$\text{Moisture \%} = \frac{\text{Dry weight (g)}}{\text{Sample weight (g)}} \times 100 \qquad (3)$$

pH

The pH of cream and butter samples was measured using pH meter. The butter samples were taken in a beaker; the pH meter electrode was immersed in the sample to determine pH. The PH values were recorded directly from the pH meter screen [22].

Titratable acidity determination

Acidity of cream and butter sample, expressed as a percentage of lactic acid, by titration with 0.1 N NaOH using phenolphthalein as an indicator to the end-point of the faint pink color following identify standard method [23] and [24] according to the following equation.

$$\text{Lactic Acid\%} = \frac{\text{Ml of NaOH X 0.1N X 0.009}}{\text{Weight of sample (g)}} \times 100 \qquad (4)$$

Determination of fat

Cream fat percentage in the samples was determined by the Gerber method according to [25], and the fat percentage was recorded directly from Gerber cylinder. In contrast, % fat in butter was determined by the soxhlet method by extracting the fat from the sample by using a diethyl ether solvent [26] according to the following equation (5).

$$\text{Fat\%} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100 \qquad (5)$$

Total Protein determination

The nitrogen content in the cream and butter sample was estimated by Kjeldahl's method by digesting the sample using (concentrated sulfuric acid, digestion salts, and heat), then distilling the liberated ammonia with sodium hydroxide 40% [27] and [28].

Texture determination

Textural properties (hardness, cohesiveness, and springing) were conducted using a texture analyzer (CT3 (4500), Brookfield engineering lab). The hardness, cohesiveness, and springing of samples were measured. The operation conditions were a probe (TA 17) was inserted into each sample to deformation of 5.0 mm with 10.0 g trigger and speed of 1.0 mm/s [29].

Melting and hardining point

The Melting Point in the butter sample was estimated according to [30]. In contrast, the Hardining Point was estimated according to [31] where capillary tubes were used in which the butter samples were placed and then placed in hot water to record the melting temperature of the butter or in cold water to record the hardining temperature of the butter.

Microbial tests and sensory evaluation

The Standard Plate Count (SPC) [32] method was used in these tests. Psychrotrophic Bacteria Test was conducted using the Nutrient Agar Media (N.A) at refrigeration temperature for 7-10 days. Mold and Yeast Test was conducted using the Potato Dextrose Agar Media (P.D.A) at 22 ˚C for 5 days. Coliform Bacteria Test was conducted using the Macconkey agar Media (M.A) at 37 °C for 24 hours. The sensory evaluation tests of the Butter samples were conducted in the Department of Food Science, College of Agricultural Engineering Sciences, University of Baghdad, by several specialist professors according to the sensory evaluation format, which included the characteristics of Color, Taste, Odor, and Texture [33].

Fluorescence microscope (FM)

Butter samples were prepared according to [34]. The Fluorescence Microscope test was conducted by measuring the light passing through the sample, which appears as images that can be viewed directly by a unique computer screen connected to the device.

Statistical analysis

The statistical analysis system (SAS, 2012) program was employed to assess the effect of different factors on studied parameters. The least significant difference (LSD) test was used to significantly compare between means in this study [35].

Results and discussion

Chemical composition of cream

Table 1 shows the chemical composition and pH value of the cream that has been used in the production of butter, form this values. It can be noticed that the cream used in the butter production was in the acceptable ranges of standard specification that allow in the butter production, and it was in agreement with [36].

TABLE 1 Chemical composition of the cream

% Fat	% Protein	% Moisture	ADV M.mq/100g fat	% Total Acidity	pH
38.50	1.10	60.40	1.62	0.17	5.70

Chemical Composition of Produced Butter

Table 2 that the fat% of produced butter was (fat 81.70%) produced from the cream with self-fermentation at 15 °C for 24 h. From this value, it can also be noticed that the butter was in the acceptable ranges of Iraqi standard specification, and it was in agreement with [37] and [38].

TABLE 2 Chemical composition of processed butter

% Fat	% Protein	% Moisture	ADV Mm/100 g fat	% Acidity	pH
81.70	1.00	17.30	1.42	0.20	5.34

Mixing temperature

Figure 1 presents the mixing temperature for butter samples after mixed with water at different concentrations (70%,60%,50%,40% fat) and adding TiO_2 nanoparticles at three different level (T1 0.75%, T2 0.50%, T30.25%) for each treatment separately.

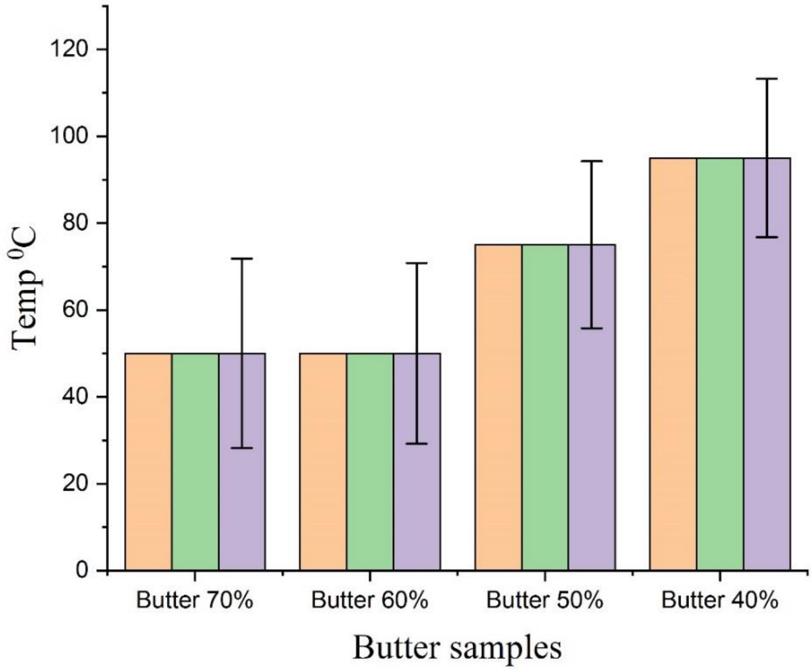

FIGURE 1 Effect of mixing temperature on butter samples formation

Figure 1 shows that there was no significant difference during the use of temperature (50 °C) for treatments samples (70%) and (60%) for all additions of TiO_2 nanoparticles (T1, T2, T3), this fact confirms that the high ability of TiO_2 to form a stable emulsion in the presence of heating, and the mixture of fat and water. The hydrophilic head of TiO_2 is surrounded by water drops allowing dispersion of the medium, which leads to the homogenized emulsion. The same results have been obtained by [28]. When water's content increases in the butter sample (50%), it is found that the fat will spread from water in the samples (Figure 2). Therefore the mixing temperature must be increased to (75 °C), when the temperature increase, the efficiency of TiO_2 will increase in terms of combining fat and water to form a stable emulsion, as shown in Figure 2. These results are in excellent agreement with previous studies [39].

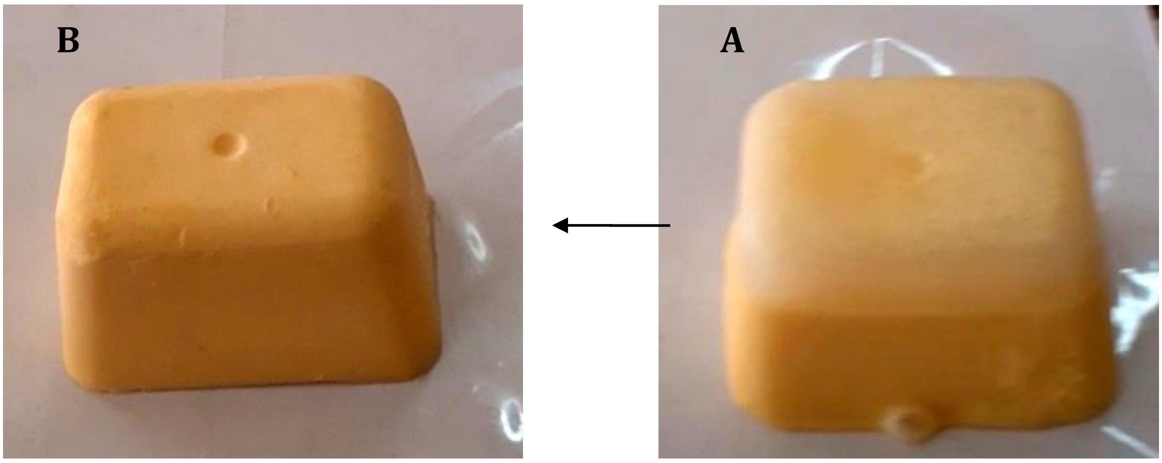

FIGURE 2 Effect of mixing temperature on the butter samples; A- butter sample 50% at 50 °C, B- butter sample 50% at 75°C

In butter sample of 40% fat, there is also a separation of fat from water, as shown in Figure 3. Therefore, it should increase the temperature to 95 °C for all additions (T1, T2, T3) as the temperature was needed to stabilize the emulsion (Figure 3). When water content increases, the capacity of TiO_2 will decrease to form a stable emulsion; hence, there was a need to increase the temperature. These findings were agreed with [40] and [41].

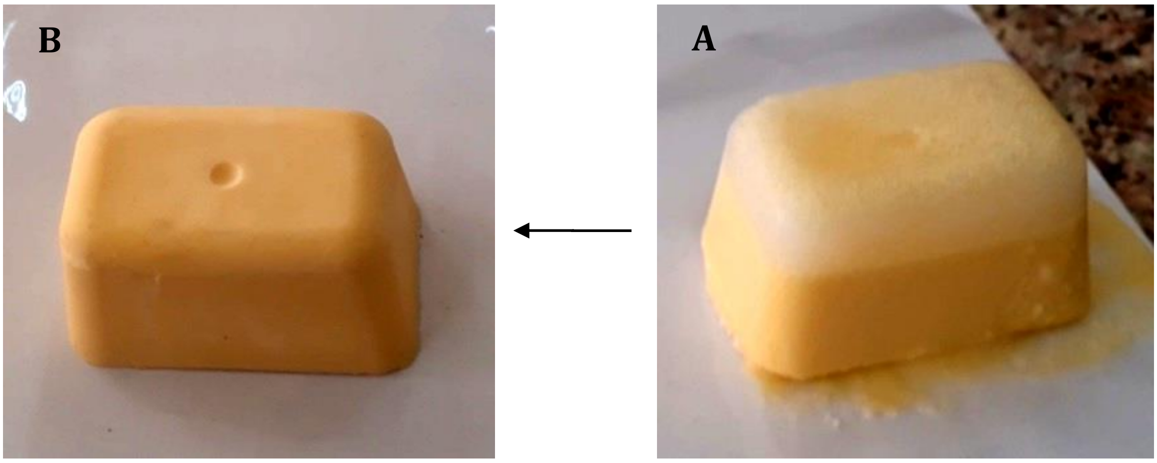

FIGURE 3 Effect of mixing temperature on the butter samples; A- butter sample 40% at 50 °C, B- butter sample 40% at 95 °C

Butter formation time

Figure 4 explains the time (minutes) needed for butter formation at different levels of fat (70%, 60%, 50%, 40%) after addition of TiO_2 nanoparticles at three levels (T1 0.75%, T2 0.50%, T3 0.25%) for each treatment separately. It can be noticed that the formation time of butter sample 70% fat was 2 min for T1 and T2; meanwhile, there was a significant difference ($P \leq 0.05$) information time needed for T3 compared with T1 and T2, which was 3 min, it can say that when the fat and TiO_2 levels are high the time needed for butter forming will be less. Increasing the TiO_2 levels will improve its capacity to bind with the fat faster, accelerating the emulsion formation [42] [43].

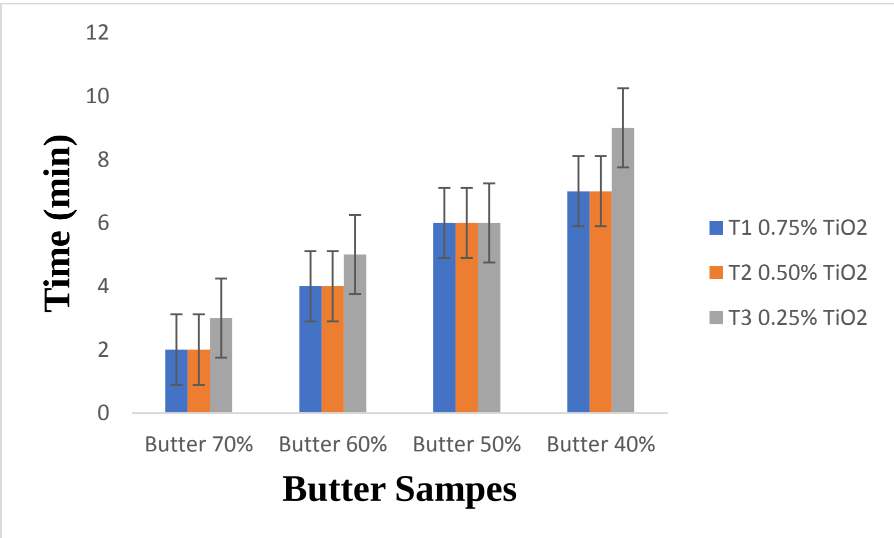

FIGURE 4 Butter formation time (min.)

As seen in Figure 4, there is a significant difference (P≤0.05) in the needed time for butter formation to other treatments, the time were 4, 4, and 5 min for 60% butter; 6 minutes for 50% butter and 7, 7 and 9 min for 40% for (T1, T2, and T3) respectively, it can say here when fat content decrease and water level increase there is a more time needed for TiO_2 to form the butter in the treatments. Also there were significant differences (P≤0.05) in the formation time for T3 in comparison with T1 and T2 in samples treatments 60% and 40%, meanwhile there were no significant differences (P≤0.05) in the timing among treatments T1, T2 and T3 in treatment sample 50% this is maybe due to sudden increase of mixing temperature from 50 °C to 75 °C which eliminate the impact on the time of butter formation at treatment 50% as it did not affect the addition of TiO_2 nanoparticles at different levels [2].

Physiochemical analysis & chemical composition

All tests were done the next day after butter processing with the addition of TiO_2-nanoparticles. Table 3 show the chemical composition for butter treatments samples. There was a significant difference (P≤0.05) in the values among all samples. This is due to an increase in the water content in the butter samples, which can affect the chemical composition.

TABLE 3 Chemical Composition of Butter Treatment Samples

Samples		% Fat	% Protein	% Moisture	ADV M.mq/100g fat	% Acidity	pH
Control		81.70	1.00	17.30	1.42	0.20	5.34
Butter Fat 70%	Ti 1	70.00	0.92	29.08	1.33	0.28	5.22
	Ti 2	69.50	0.94	29.56	1.33	0.25	5.21
	Ti 3	70.00	0.96	29.04	1.33	0.25	5.21
Butter Fat 60%	Ti 1	60.00	0.79	39.21	1.28	0.19	5.25
	Ti 2	60.00	0.76	39.24	1.27	0.18	5.25
	Ti 3	60.00	0.78	39.22	1.28	0.17	5.25
Butter Fat 50%	Ti 1	50.00	0.57	49.43	0.91	0.15	5.33
	Ti 2	50.00	0.55	49.45	0.90	0.15	5.30
	Ti 3	49.40	0.55	50.05	0.90	0.13	5.31
Butter Fat 40%	Ti 1	40.00	0.41	59.59	0.66	0.11	5.72
	Ti 2	39.80	0.40	59.80	0.66	0.11	5.55
	Ti 3	39.88	0.40	59.72	0.66	0.10	5.55
LSD value		8.415 *	0.379 *	6.752 *	0.384 *	0.117 *	0.544 ns

* (P≤0.05).
Ti 1= 0.75% titanium, Ti 2=0.50% titanium, Ti 3=0.25% titanium.

From Table 3, there is a rise in the pH value of butter in all samples compared with the control. However it did not reach a significant difference among treatments samples. This is due to the water's role to decrease the acidity as the pH was raised.

Cholesterol value

Figure 5 show the cholesterol percentage in treatment samples of butter and control samples. Cholesterol ratio in the control sample was (236 mg/100 g butter) which is in a normal range and the acceptable range of standard specification in the produced butter [31].

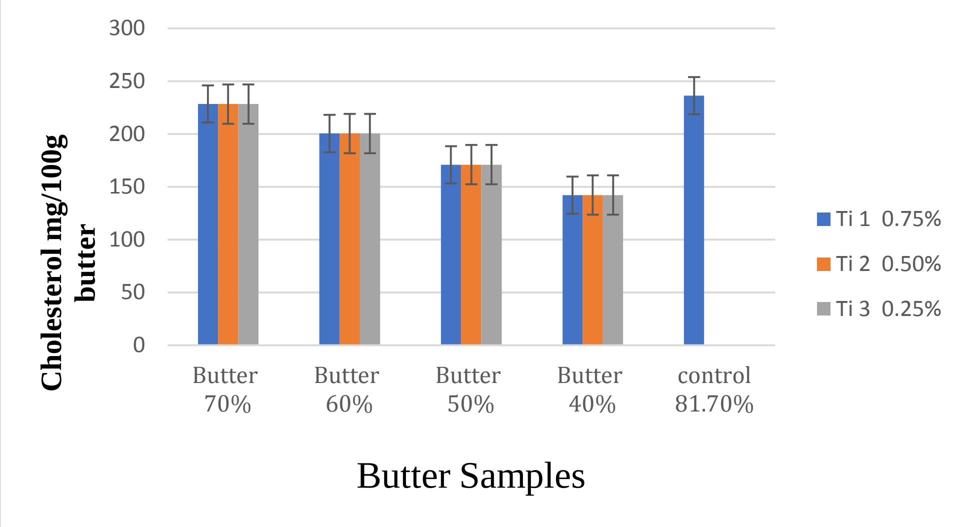

FIGURE 5 Cholesterol tests of butter treatment samples (P≤0.05).

In the rest of the samples, it was found that there is a drop in the cholesterol ratio for all additions of TiO_2 which because of degradation in total fat and rise in the water content in butter samples which in turn led to decrease the cholesterol, which is desired in the butter. Also, it can see in this figure there are no significant effects (P≤0.05) of the additions (T1, T2, T3) on the cholesterol ratio in all treatments.

Texture analysis

Table (4) shows the texture properties (Hardness, Cohesiveness, and Springing) for the butter samples. There was a clear significant (P≤0.05) difference in hardness among all treatments and control, as the highest value was at 70%, which due to the addition of TiO_2 as it binds the fat and produces the stables emulsion more than in control, as it is claimed that when the binding strong will lead to more hardness [32] they claim that adding TiO_2 to the dairy products can improve the texture and increase the hardness of the product. Samples of butter treatments 60%, 50%, and 40% hardness value were less of control because of high content of water in the butter samples, which cause the degradation in the total fat content that binds with TiO_2 that lowering the total fat ratio and saturated fatty acid which is responsible for the butter hardness that made the samples less solid [33].

Cohesiveness in the samples as the table shows no significant effects among all treatments and control. This is because proper mixing allows the TiO_2 and butter samples component to distribute appropriately, producing a consistent and homogenized butter. Table 4 reveals there is a significant difference in the springing among all samples and control, which again may be because of the high content of water that decrease the total fat ratio to bind TiO_2, which in turn make the butter samples fragile emulsion contrast control butter hence will affect the springing of produce butter. Also, in this Table 4, it appears that there are no significant effects (P≤0.05) of different levels of additions (T1, T2, and T3) on the texture properties of all samples.

TABLE 4 Texture analysis of butter producing by TiO_2 nanoparticles additions

Samples		Hardness (g↓)	Cohesiveness	Springing (mm)
Control		288.6	0.13	1.20
Butter Fat 70%	Ti 1	469.1	0.14	1.20
	Ti 2	440.5	0.13	1.20
	Ti 3	435.4	0.12	1.10
Butter Fat 60%	Ti 1	271.2	0.12	0.10
	Ti 2	270.1	0.12	0.10
	Ti 3	266.3	0.11	0.10
Butter Fat 50%	Ti 1	260.9	0.11	0.10
	Ti 2	253.1	0.11	0.90
	Ti 3	250.1	0.11	0.90
Butter Fat 40%	Ti 1	236.8	0.11	0.80
	Ti 2	235.2	0.10	0.80
	Ti 3	230.9	0.10	0.80
LSD value		52.338 *	0.0466 NS	0.271 *

* ($P \leq 0.05$).

Ti 1= 0.75% Titanium, Ti 2=0.50% Titanium, Ti 3=0.25% Titanium.

Hardening and melting point of butter

Table 5 shows the Hardening and Melting Point for all butter samples treatments and control in the acceptable ranges of standard specification in the produced butter [34]. They claimed that Hardening and Melting Point should be between 19-26 °C and 22-31 °C, respectively.

TABLE 5 Hardening & melting point of produced butter with TiO_2 nanoparticles

Samples		Hardening Degree (°C)	Melting Point (°C)
Control		25.9	24.2
Butter Fat 70%	Ti 1	25.6	25.9
	Ti 2	25.1	25.9
	Ti 3	25.0	25.4
Butter Fat 60%	Ti 1	23.7	26.3
	Ti 2	23.5	26.1
	Ti 3	22.4	26.1
Butter Fat 50%	Ti 1	21.6	30.7
	Ti 2	21.5	30.7
	Ti 3	20.9	30.2
Butter Fat 40%	Ti 1	20.3	33.6
	Ti 2	19.7	33.1
	Ti 3	19.6	33.8
LSD value		2.177 *	3.836 *

* ($P \leq 0.05$).

Ti 1= 0.75% titanium, Ti 2=0.50% titanium, Ti 3=0.25% titanium.

From this Table 5, it can be noticed that when fat content decreases in the samples (70%, 60%, 50%, and 40%) the Hardening will be decreased, and Melting Point will be increased. Both properties depend on the triglycerides that found in the fat glycerides decreased the Hardening will be decreased, and melting point will increase in the butter [33] there were no significant differences of TiO_2 additions T1, T2, and T3 on the Hardening and Melting Point in all different fat ratio.

Microbial tests

Table 6 presents the effects of TiO_2 nanoparticles additions on some microbial tests. Count of Coliform bacteria was 6 cfu/g, mold & yeast 30 cfu/g, and Psychrotrophic bacteria $30X10^3$ cfu/g in the control samples, while there was no growth in all treatments in all additions of TiO_2. This is due to the TiO_2 capacity to inhibit the growth of these microorganisms, which then prevent them from growing and reproduction. This finding comes in line with [36], as they reported that TiO_2 has a high ability to inhibit and kill microorganisms as it is used as antimicrobial.

TABLE 6 Microbial tests of butter treatment samples

Samples		Coliform Bacteria (c.f.u/g)	Mold and Yeast (c.f.u/g)	Psychrotroph b. (c.f.u/g)
Control		6	30	$30x10^3$
Butter Fat 70%	Ti 1	0	0	0
	Ti 2	0	0	0
	Ti 3	0	0	0
Butter Fat 60%	Ti 1	0	0	0
	Ti 2	0	0	0
	Ti 3	0	0	0
Butter Fat 50%	Ti 1	0	0	0
	Ti 2	0	0	0
	Ti 3	0	0	0
Butter Fat 40%	Ti 1	0	0	0
	Ti 2	0	0	0
	Ti 3	0	0	0
LSD value		0.0162 NS	17.551 *	42.076 *

* ($P \leq 0.05$).
Ti 1= 0.75% titanium, Ti 2=0.50% titanium, Ti 3=0.25% titanium.

Fluorescence microscope test

Figure 6 present the results (FM) of butter treatments and control in which the fat appears in light color, whereas water is in dark color. Pictures (A, B, C, D) clarify that when the percentage of water is high in the samples, the dark spots (water drops) will increase. In addition, these spots were in the homogenized distribution in the samples in the form of water drops. Moreover, there was no secession between water and fat, which resulted from Tio2 in emitting them in a homogenized form despite the increment in the percentage of water in the samples [30].

Picture (F) explains the distribution of water drops in the fat, representing the diffusion phase (W/O), dark water drops appear spherical surrounded by a layer of light fat. When emulsion reversed into (O/W) as shown in the picture (J), it can be seen the opposite, that's mean the water (dark color) surrounded the fat drops (light color) while it maintains the shape of drops in spherical form. In addition, it remains in homogenizing distribution, which gives the reason behind the capability of TiO_2 to produce the homogenized emulsion of water and fat, whichever (W/O) or (O/W).

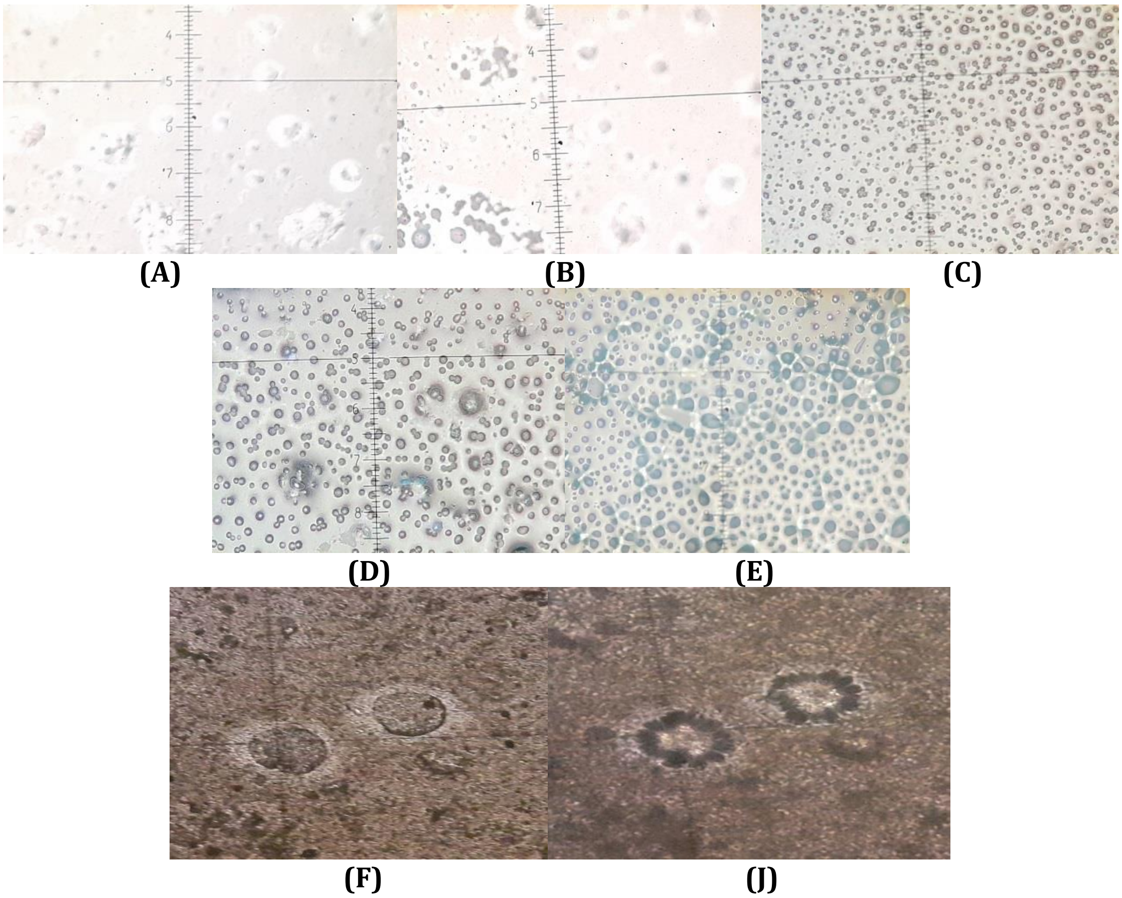

FIGURE 6 Fluorescence microscope test of butter treatment samples: A: Control 80%, B butter 70%, C butter 60%, D, butter 50%, E, butter 40%, F, butter 70%(W/O), J, 40%(o/W)

Sensory properties

Table 7 shows the sensory evaluation for all samples of butter and control. Color attribute as seen that addition of TiO_2 to the samples 70% and 60% gives homogenized yellow color which is acceptable even it brighter than control samples, this agrees with [32] who stated that addition TiO_2 to dairy products can improve the color meanwhile other samples 50% and 40% noticed that yellow color become brighter because of the high content of water and low content of fat which hence, decrease carotene pigment which responsible of the yellow color of butter. Taste and odor of butter were affected by the addition of TiO_2 as the evaluation results in the butter sample 70% and 60% were acceptable and close to the control sample. However, there was an increase in the water content in samples 50% and 40% as the taste and odor were fewer due to low-fat content.

TABLE 7 Sensory evaluation of butter treatment samples

Samples		(30) Color	(25) Taste	(15) Odor	(30) Texture	(100) Total
Control		29	23	12	26	90
Butter Fat 70%	Ti 1	24	21	11	24	80
	Ti 2	26	21	12	24	83
	Ti 3	26	22	12	24	81
Butter Fat 60%	Ti 1	23	20	11	22	76
	Ti 2	23	19	10	22	74
	Ti 3	23	16	10	20	69
Butter	Ti 1	21	17	10	20	68

Fat 50%	Ti 2	21	15	10	20	66
	Ti 3	22	15	10	20	67
Butter Fat 40%	Ti 1	17	17	9	17	60
	Ti 2	17	14	9	17	57
	Ti 3	17	14	9	15	55
LSD value		5.379 *	3.402 *	1.839 *	4.705 *	7.210 *

* ($P \leq 0.05$).

Ti 1= 0.75 % titanium, Ti 2=0.50 % titanium, Ti 3=0.25 % titanium.

To enhancement the texture of butter, it is found that the addition of TiO_2 to the butter samples 70% and 60% has improved the butter texture, which makes the firm homogenized close to the texture of the control sample, which was in agreement with [32], who claim that addition of TiO_2 to dairy products can improve the texture. Also, in the treatment of samples (50% and 40%), it was noticed that the firm and texture persisted consistently, however, only in increasing the water content, decreasing fat content and storage at 1-5 C^0, These conditions make the samples more fragile when pressing it by hand or teeth. In addition, there were no significant differences of additions (T1, T2, and T3) of TiO_2 on the color, odor, taste, and texture for each sample of treatments.

Conclusion

From the mentioned information, it can be argued that no matter that several results are promising, there is still a lot of work to do about understanding the actual beneficial effects on the physicochemical properties of using nanoparticles in the manufacturing of dairy products. The use of (nano-TiO_2) titanium dioxide played an essential role in manufacturing low-fat butter, as it acted as an emulsifier agent that binds the fat and water very well. The manufactured butter was homogeneous in texture and appearance. There was no water separation from the fat, even in low-fat concentrations in the final product. Also, the sensory and physicochemical properties were acceptable compared with control butter. In addition, the (nano-TiO_2) titanium dioxides had a positive effect in preventing the growth of microorganisms in the manufactured butter and extending the produced butter's shelf life.

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