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Research Article
Chemical and Nutritional Evaluation of Novel White Soft Cheese Prepared by Nano-Fortified Interesterified Olein: Stearin Vegetable Butter

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Abstract

Background and Objective: Many of cheese consumers are concerned about milk fat's saturated fatty acid and cholesterol contents, which lead to limit their cheese consumption. Replacing milk fat by other fat replacers to produce special (non-traditional) cheese is a good solution for those consumers. This research work aimed to study the chemical, nutritional and sensory properties of new soft cheese fortified by different vegetable butter prepared by nanotechnology. **Materials and Methods:** The zero trans-fatty acids vegetable butter based on the interesterified olein: stearin fat blend (70:30 w/w) were fortified by omega fatty acids, natural minerals, natural vitamins and natural antioxidants from plant extracts. then using both high-speed homogenizer (HS-VB) and high-pressure homogenizers for six cycles (Nano -VB). The produced vegetable butter (22%) compared to market vegetable butter (the control) have applied to prepare novel white cheese. The quality and nano-fortification of the fresh novel cheeses were studied, in addition to their nutrition evaluation and sensory properties. **Results:** Vegetable butter types had no significant effects on the total solids of white cheese, while both high speed and nano vegetable butter decreased serum liver functions and had significant effects on serum minerals in rats. Also, both high speed and nano vegetable butter got the highest appearance, body and texture and taste scores with significant differences compared to Market- VB. **Conclusion:** Thus it could be concluded that soft white cheese containing either high speed or nano vegetable butter is safe to the feeding rats.

Key words: Nanotechnology, nano-fortified, vegetable butter, high-speed vegetable butter, white soft cheese

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

Replacing milk fat by other fat replacers to produce non-traditional cheese is a good solution for cheese industries due to many cheese consumers are concern about milk fat's saturated fatty acid and cholesterol contents which lead to limit their cheese consumption[1]. Milk fat can be more nutritionally desirable by altering the fat in the cow's feed but current markets give producers little incentive to feed such diets[2]. Non-traditional cheese production is growing because of its readily controllable characteristics, especially for developing countries. In such cheese, milk fat is replaced by vegetable oils to reduce the capital cost of the production and/or for healthy use[3]. Natural fats and oils are a combination of monounsaturated, polyunsaturated and saturated fatty acids, while, Trans Fatty Acids (TFAs) are unsaturated fatty acids that contain at least one double bond in the trans configuration, which could be formed during industrial partial, hydrogenation of vegetable oil, a process widely commercialized to produce solid fats[4]. Trans fatty acids have a strong and direct connection with cardiovascular diseases, breast cancer, disorders of the nervous system and vision in infants, colon cancer, diabetes, obesity and allergy was proven[5]. According to these new findings trans fatty acids should be zero in all food products.

However, Chemical interesterification is an important technological process to fats targeting various commercial applications due to modifies the physical properties and crystallization behavior of fats by altering the original specific triglyceride composition of the blend components without the formation of trans fatty acids[6]. The versatile composition in fatty acids and triacylglycerols in palm stearin and palm olein fractions caused their suitability for interesterification and producing a variety of products such as margarine, shortenings cookies, ice cream, chocolates, cakes and others[7].

Shattory *et al.*[8] have subjected olein: stearin (70 : 30 w/w) fat blend to chemical interesterification process under different conditions of temperature, catalysts and time until reaching the optimal condition order to obtain zero trans-fatty blends. They found that interesterification using NaOH: glycerol: H_2O (1:2:3 w/w) as a catalyst gave better results than using sodium methoxide catalyst regarding the product stability, melting point, triglyceride structure and solid fat content. Fortified vegetable butter samples were managed to be prepared in the nano-size form. Also, Shatory *et al.*[9], have confirmed that chemical interesterification is a safe way to modify the physical properties and glyceride structure of a fat blend with no formation of trans acids. According to the results of triglyceride structure and solid fat content, an interesterified sample was chosen to prepare two fortified vegetable butter samples (speed only and 6-cycles) to be applied in biscuits preparation. The particle size of 6-cycles vegetable butter was found to lie in the nano-range. The vegetable butter as a diet significantly decreased total lipids profile, serum phospholipids, triglyceride, total cholesterol, LDL-cholesterol and VLDL-cholesterol.

So, The objective of this research paper was to introduce novel white cheese, made by special functional vegetable butter (zero trans fatty acids) after studied its chemical composition, texture analysis, nutrition effects and sensory properties, to the consumers by cheese industries.

MATERIALS AND METHODS

The research study was done at Fats and Oils laboratory and Dairy Science laboratory at the National Research Centre, Cairo, Egypt from January 2019 to February 2020.

Vegetable butter preparation: Zero trans fatty acids vegetable butter, fortified by omega fatty acids, natural minerals, natural vitamins and natural antioxidants from plant extracts, were donated by Prof. Yousef El-Shatory, Fats and Oils Department, National Research Centre, Cairo, Egypt. The vegetable butter was prepared according to El-Shatory *et al.*[8] based on the interesterified olein: stearin fat (70 : 30 w/w) as follow: High-Speed Homogenizer was used to prepare vegetable butter named HS-Vegetable Butter (HS-VB), while, Nano-Vegetable Butter (Nano-VB) was prepared using both High-Speed Homogenizer followed by High-Pressure Homogenizer for 6 cycles. Market vegetable butter (Market-VB) was purchased from Cairo local market. Buffalos' skim milk retentate was obtained from Animal Production Research Institute, Agriculture Research Center, Dokki, Egypt. Microbial rennet, Mucormehiei, was obtained from Novo, Denmark. All used chemicals were highly pure grade.

Cheese preparation: White soft cheese was prepared according to Foda *et al.*[10] as follows: Buffalos' skim milk retentate contained 29.2% total solids and 10.5% total protein was divided into 3 portions and the three different types of vegetable butter (22%) were added. The mixtures were homogenized using a homogenizer Lab. for 10 min, then salted with 3% NaCl and pasteurized at 73°C for 15 sec. the curds were held at 40°C for 30 min after adding the rennet (0.09 g). Cheese samples were taken fresh for different chemical, rheological and nutrition analysis and sensory properties.

Determination of the gross chemical composition: Total solids and total fat contents were determined according to the method described by Ling[11] and total protein by Kjeldahl method according to AOAC[12]. Water Soluble Nitrogen (WSN) was determined and the ripening index (%) was calculated using to the equation as described by Coskun and Tuncturk[13].

$$\text{Ripening index (\%)} = \frac{\text{Water soluble Nitrogen (WSN)}}{\text{Total nitrogen (TN)}} \times 100$$

Free fatty acids: Free Fatty acid was determined according to AOAC[12]. Peroxide Value (PV), Acid Value (AV) and Iodine Value (IV) were determined according to Official Methods, AOCS[14], Cd 3d-63, Cc 18-80 and Cd 8-53, respectively.

Rheological properties: Rheological properties of cheese samples were determined using the Texture Profile Analysis (TPA): The Texture Profile Analysis (TPA) technique (being the most commonly used method for the assessment of cheese texture, as reported by Kaminarides and Stachtiaris[15], the speed of the crosshead was set at 25 mm/min in both upward and downward direction. The Texture Profile apparatus contains the Instron Universal Testing Machine model 4302 (Instron Ltd., High Wycombe HP12 35Y, UK), equipped with a flat plunger 6 mm in diameter attached to the cross-head and a 100 N (10 kg) load cell. The cheese sample was placed on a flat holding plate at 25°C and the pluger inserted 20 mm below the cheese surface. Each sample was compressed twice by the compression load cell.

Nutritional experiment: Experimental diets were prepared according to the method described by Reeves *et al.*[16], vitamin mixture was prepared according to Campbell[17], while, the salt mixture was prepared according to Hegseted *et al.*[18]. The diet formula ingredients were prepared to make the final ratio of protein 12% and fat 10% after adding tested white cheese samples. The experimental diets' contents are shown in Table 1.

Table 1: The experimental diets

Ingredients	g kg^{-1}
Skim milk powder	300.0
Sucrose	100.0
Cheese	250.0
Salt mix.	40.0
Vitamins mix.	10.0
Cellulose	50.0
Choline chloride	0.25
L-cystine	0.18
Corn starch	249.57
Total	1000.0

The nutritional experiments were performed in compliance with the appropriate laws and institutional guidelines of the National Research Center. Eighteen normal male and female (Sprague Dowally strain) rats with an average weight of 130±10 g were obtained from animal house, National Research Center, Cairo, Egypt. Rats were divided into 3 groups (6 each) and housed in galvanized metal cages. All rats were adapted for three days to the control diet before starting the experiment, then, food and water and *ad libtum* were supplied for 6 weeks. After that, the experimental rats were fasted overnight (12 h) and anesthetized with diethyl ether for blood analysis. Blood samples were collected in clean dry centrifuge tubes from hepatic portal vein then centrifuged for 15 min at 3000 rpm to separate the serum, which carefully transferred into dry clean tubes and kept frozen at (-20°C) till analysis[19].

Biochemical analyses: Total lipids of blood samples were determined according to the method described by Knight *et al.*[20], phospholipids according to Trinder[21], triacylglycerides according to Bucolo and David[22], total cholesterol according to Richmond[23]. The HDL-cholesterol according to Lopes-Virella *et al.*[24], LDL-cholesterol according to Friedewald *et al.*[25], lipid peroxide and Serum VLDL-cholesterol was calculated according to the following equation: according to Ohkawa *et al.*[26]:

$$\text{VLDL} - \text{cholestrol} = \frac{\text{Triglicerides}}{5}$$

Liver and kidney functions were determined according to Henry *et al.*[27], Young *et al.*[28] and Patton[29], respectively.

Sensory analysis: Cheese samples were evaluated (after the nutritional experiment) by fifteen panelists, staff members of Dairy Department, Food Industries and Nutrition Division, National Research Center, Dokki, Egypt. Panel members were also instructed to report any defects or unpleasant flavor. Water and no salted crackers were provided to clean their palates between tasting samples.

Statistical analysis: The experimented data were expressed as the mean values and standard error for three replicates and statistically analyzed by performing analysis of variance technique (ANOVA) using SAS[30]. Differences among means were identified using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The gross chemical composition of fresh white cheese is shown in Table 2, It could be noticed that vegetable butter types had no significant effects on the total solids of white cheese, while, Nano-VB caused a significant decrease in the fat and protein contents compared to other vegetable butter. Market-VB significantly increased the soluble nitrogen, while the ripening index was decreased significantly by HS-VB only.

These results partially in agreement with those obtained by Ismail *et al.*[31], who reported that total solid contents of fifty-eight of different non-traditional white soft cheeses samples collected randomly from local Market were ranged from 35.44 to 49.64% and the fat content was ranged from 24.50 to 40.00%. Also, Abo-Elwafa *et al.*[32] found that collected supermarkets white soft cheese had fat contents ranged (18.8 to 38.3%), while cheese factories its fat ranged between 14.8 to 30.5%. The difference of fat content could be related to the use of extra vegetable oils and /or cheaper fat in cheese manufacture to replace milk fat to reduce the cost of cheese making.

Free fatty acids: Analysis of the short and medium-chain FFA profile has been suggested as an index for characterizing cheeses over the ripening period. Data presented in Table 3 shows that HS-VB increased the free fatty acids (0.186) in the fresh cheese significantly compared to Market -VB and Nano-VB, which did not show any differences.

Mallatou *et al.*[33] reported that low concentrations of fatty acids in cheese indicate a young, un-ripened cheese and excessive concentrations of some FFAs perceive off-flavors.

Effect of vegetable butter types on the Peroxide, Iodine and Acid values of fresh white cheese: Table 4 showed that vegetable butter types had a significant effect on the peroxide value of white cheese samples. HS-VB caused the highest peroxide value followed by Nano-VB compared to Market-VB, this indicated that a breaking down may happen to the peroxides resulting in the formation of aldehydes and ketones.

Regarding the degree of unsaturation in fat (Iodine Value), the types of vegetable butter showed a significant effect on white cheese samples. HS-VB caused the highest iodine value followed by Nano-VB compared to Market-VB. These results are in agreement with those obtained by Abo-Elwafa *et al.*[32] who found that the iodine values in white soft cheese collected from small producers ranged (39.9-47.7), cheese factories ranged (33.1-49.5) and vendors ranged (38.1-46.9).

The amounts of free fatty acids liberated in fat which correspond to the rancidity (Acid Value) of different white soft cheese samples are shown in Table 4. HS-VB caused a significant increase in the Acid Value followed by Market -VB and Nano-VB. These results are in agreement with those obtained by Abo-Elwafa *et al.*[32] who found the acids values of white cheese collected from the vendors ranged (0.29-2.52), small producers ranged (0.18-1.72), supermarkets ranged (1.12-1.7) and factories cheese ranged (0.35-0.57). it is well known that the lower acid value expresses better product[34].

Rheological properties of white soft cheese: Rheological characterization is important as a means of determining body and texture characteristics affected by cheese composition, processing techniques and storage conditions. Cheese texture may vary with a change in the physical state of cheese fats[35]. Data in the Table 5 shows that vegetable butter types had a significant effect on the hardness of the white soft cheese as HS-VB increased the cheese hardness and cohesiveness significantly compared with the Nano-VB and the Market-VB. These results are in agreement with those obtained by Weech *et al.*[36] who found that the reduction of the fat content of Iranian white cheese from 23 to 6 % has affected the texture, functionality, cheese-making yield and sensory characteristics of white cheese.

Nutritional experiments

Effect of a diet containing cheese on serum lipid profile and serum malondialdehyde (MDA): The effects of feeding rats with white cheese made by two types of vegetable butter on serum Total Lipid (TL), triglycerides (T.G.), Total Cholesterol

Table 2: Effect of vegetable butter types on the chemical composition of white soft cheese

Cheese samples made by	Chemical composition (%)				
	Total solids	Fat	Protein	Water-soluble nitrogen (WSN)	Repining index
Market-VB	37.62±0.21	18.00±0.11^{A}	14.10±0.29^{A}	0.23±0.21^{A}	10.41±0.21^{A}
HS-VB	38.04±0.15	17.50±0.18^{A}	13.44±0.19^{B}	0.19±0.19^{C}	9.04±0.12^{B}
Nano-VB	37.53±0.11	16.00±0.18^{B}	12.59±0.15^{B}	0.20±0.15^{B}	9.98±0.19^{A}

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

(TC), High-Density Lipoprotein (HDL), low-density lipoprotein (LDL), Very-Low-Density Lipoprotein (VLDL), phospholipids and malondialdehyde (MDA) compared to market vegetable butter as control were shown in Table 6.

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

As shown in Table 6 Nano-VB had reduced the serum total lipid and phospholipid of rats significantly followed by HS-VB compared to Market-VB. This reduction may be due to the presence of different bioactive components as polyunsaturated fatty acid oils (PUFAs) and monounsaturated fatty acid oils (MUFAs) and other minor components, as sterols and vitamin E. The healthy oils are principally characterized by their high fatty acid concentrations in the form of a-linolenic acid (C18:3, n-3, ALA) and Vitamin E in form of tocopherols[37].

Table 3: Effect of vegetable butter types on the free fatty acids of fresh white cheese

Cheese samples	FFA (%)
Market-VB	0.096 ± 0.11^B
HS-VB	0.186 ± 0.38^A
Nano-VB	0.096 ± 0.01^B

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

Table 4: Effect of different types of vegetable butter on the Peroxide, iodine and acid values of fresh white cheese

Cheese samples	Peroxide Value (meq. O_2 Kg oil^{-1})	Iodine value (g 100g^{-1})	Acid value (mg KOH gm oil^{-1})
Market-VB	5.616 ± 1.2^C	41.060 ± 0^B	0.193 ± 0.02^B
HS-VB	20.386 ± 1.9^A	46.247 ± 0.20^A	0.373 ± 0.03^A
Nano-VB	17.206 ± 2.1^B	45.916 ± 0^A	0.190 ± 0.03^B

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

Table 5: Rheological properties of white soft cheese made by three different vegetable butter

	Rheological properties	
Cheese samples	Hardness (N)	Cohesiveness (%)
Market-VB	0.769 ± 0.11^B	1.873 ± 0.09^B
HS-VB	1.433 ± 0.06^A	2.320 ± 0.11^A
Nano-VB	0.763 ± 0.09^B	1.423 ± 0.118^C

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

Also, it could be noticed that no significant changes in other parameters (TG, TC, LDL, VLDL and MDA) of rats fed cheese prepared by HS-VB or Nano-VB compared with the market-VB (control group). Nevertheless, the obtained values of lipid profile remained within the normal range. These results illustrated that the dietary intake of oils, which are rich in unsaturated fatty acids is an important factor for preventing the early development of atherosclerosis. In accordance with the observation, Bays *et al.*[37] demonstrated that the consumption of linoleic acid stimulates reverse cholesterol transport and increases the clearance of cholesterol in bile. Rabar *et al.*[38] concluded that rich polyunsaturated fatty acid oils (PUFAs) and monounsaturated fatty acid oils (MUFAs) are associated with the prevention of cardiovascular risk (CVR).

Lowering effect of produced vegetable butter on serum total lipids might be due to the presence of phenolic compounds and rich diet with vegetable butter contained "linolenic acid (ALA, C18:3 n-3) could reduce hepatic lipid accumulation by stimulating $-oxidation and suppressing fatty acid synthesis[39,40].

Effect of the diet containing cheese made by different vegetable butters on liver and kidney function: Table 7 shows a significant decrease in serum liver functions both (GOT) and (GPT) of rats fed white cheese made by Nano-VB; while, HS-VB showed insignificant decrease compared to the market-VB.

These results are partially in agreement with those obtained by Salemi and Pooya[41] who found no significant effect on serum levels of GPT and GOT of rat groups fed by local margarine compared with tested groups. Regarding kidney function, it can be noticed that rats feeding cheese made by High Speed-VB or Nano-VB showed a significant decrease in serum creatinine and urea compared to market-VB. It is worth mentioning that, the obtained values of liver and kidney function for test groups within the normal range. These results proved that dietary formulas containing High speed-VB or Nano-VB are safe about the liver and kidney functions. on the other hand, Alaam *et al.*[42] noticed a slight increase in serum creatinine with no significant change in

Table 6: Serum lipid profiles and serum malondialdehyde (MDA) of rats fed diet containing cheese made by different vegetable butter

Diet containing cheese	Total lipids (mg dL^{-1})	Phospholipids (mg dL^{-1})	Triglycerides (mg dL^{-1})	Total cholesterol (mg dL^{-1})	HDL-C (mg dL^{-1})	LDL-C (mg dL^{-1})	VLDL-C (mg dL^{-1})	(MDA) (mmol dL^{-1})
Market-VB	421.23 ± 42.9^A	66.00 ± 10.2^A	42.92 ± 2.7^A	94.43 ± 2.5	53.56 ± 8.30	33.67 ± 3.40	8.97 ± 0.78	4.17 ± 0.19
HS-VB	414.57 ± 11.4^A	61.33 ± 14.77^A	42.57 ± 3.72^B	92.99 ± 3.2	51.66 ± 6.28	32.37 ± 3.62	8.46 ± 0.52	4.32 ± 0.16
Nano-VB	388.38 ± 39.2^B	54.67 ± 4.8^B	42.06 ± 2.39^B	94.27 ± 4.1	52.29 ± 9.06	32.43 ± 2.51	8.35 ± 0.51	3.93 ± 0.67

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p \geq 0.05$)

Table 7: Liver and kidney functions of rats fed white cheese made by different vegetable butter

	Liver function		Kidney function	
Diet containing cheese	GOT (U mL^{-1})	GPT (U mL^{-1})	Creatinine (mg dL^{-1})	Urea (mg dL^{-1})
Market- VB	64.42 ± 3.24^{A}	36.33 ± 3.20^{A}	1.59 ± 0.44^{A}	33.31 ± 3.98^{A}
HS- VB	64.29 ± 1.55^{A}	35.67 ± 3.83^{A}	1.36 ± 0.47^{B}	30.13 ± 1.91^{C}
Nano – VB	62.32 ± 5.59^{B}	33.33 ± 3.39^{B}	1.40 ± 0.40^{B}	31.92 ± 3.08^{B}

Means of three replicates ± Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different (P = 0.05)

Table 8: Serum minerals of rats fed white cheese made by different vegetable butters

Diet containing cheese	Ca (µg dL^{-1})	Mg (µg dL^{-1})	Fe (µg dL^{-1})	Mn (µg dL^{-1})	Zn (µg dL^{-1})
Market- VB	7.80 ± 1.33^{B}	1.72 ± 0.61^{A}	1.46 ± 0.17	0.15 ± 0.019	77.04 ± 23.63^{A}
HS-VB	7.02 ± 2.39^{C}	1.80 ± 0.41^{A}	1.54 ± 0.17	0.15 ± 0.018	78.26 ± 5.51^{A}
Nano-VB	8.78 ± 1.85^{A}	1.38 ± 0.33^{B}	1.58 ± 0.13	0.16 ± 0.020	73.8 ± 10.69^{B}

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p\geq0.05$)

Table 9: Sensory properties of white soft cheese made by three different vegetable butter

Cheese samples	Appearance (20 points)	Body and texture (20 points)	Color (20 points)	Taste (20 points)	Acceptability (100 points)
Market-VB	19.00 ± 0.45^{B}	17.00 ± 0.10^{B}	18.17 ± 0.40	19.50 ± 0.2^{B}	73.7 ± 1.26^{B}
HS-VB	24.00 ± 0.44^{A}	18.67 ± 0.09^{A}	18.16 ± 0.39	25.16 ± 0.21^{A}	86.0 ± 1.2^{A}
Nano-VB	23.60 ± 0.44^{A}	18.20 ± 0.11^{A}	18.80 ± 0.341	25.80 ± 0.19^{A}	86.4 ± 1.3^{A}

Means of three replicates±Standard Error (SE), means within the same column followed by the same superscripted letter are not significantly different ($p\geq0.05$)

serum urea level of rat groups fed by palm oil and its fractions (palm olein and palm stearin) compared to control group which fed corn oil.

Effect of a diet containing cheese made by different vegetable butter on serum minerals. The values of serum minerals of rats fed diet containing white cheese made by H S-VB or Nano-VB compared with market-VB are shown in Table 8.

Table 8 showed a significant increase in serum (Ca) and a significant decrease in (Mg) of rats fed cheese made by Nano-VB compared to High speed-VB the control (Market-VB). Rezq *et al.*[43] reported that increase the intake of saturated fat as butter leads to a significant decrease in serum level of calcium and a highly significant increase in serum level of Mg of rat group compared to rats fed a diet without oils. While, serum levels of Fe and Mn of rats fed cheese vegetable butter weather made by High speed-VB or Nano-VB were not significantly changed compared to market-VB. The serum level of Fe of rats was significantly decreased by fed cheese made by Nano-VB compared to High speed - VB or Market-VB. These results in agreement with those obtained by Shotton and Droke[44] who noticed that increasing saturated fat was associated with significant increases in iron absorption than corn oil. Also, Nano-VB caused a decrease in the Serum level of Zn significantly compared with other vegetable butter. Tallman and Taylor[45] reported that polyunsaturated fat may adversely affect the absorption and utilization of zinc in animals, but the mechanism of action is not known.

Effect of different types of vegetable butter on sensory evaluation of white soft cheese. Data presented in Table 9 indicated that both HS-VB and Nano-VB got the highest appearance, body and texture and taste scores with significant differences ($p\geq0.05$) compared to Market-VB, while there are no significant differences between them. The different types of vegetable butter had no significant effect on the white cheese color. In terms of total acceptability the Nano-VB increased the white cheese slightly (86.4 points) followed by HS-VB (86.0 points) with no significant differences. While the white cheese made by Market-VB got the lowest acceptability score with significant differences (73 points).

CONCLUSION

It could be concluded that vegetable butter types had no significant effects on the total solids of white cheese, while, Nano-VB caused a significant decrease in the fat and protein contents compared to other vegetable butter. The high-speed vegetable butter caused a significant increase in the peroxide value, iodine value and the acid value of white soft cheese followed by Nano-VB. The high speed and nano vegetable butter decreased serum liver functions both (GOT) and (GPT) of rats. The high speed and nano vegetable butter had significant effects on serum minerals. Both high speed and nano vegetable butter got the highest appearance, body and texture and taste scores with significant differences compared to Market-VB.

Soft white cheese containing either high speed or nano vegetable butter is safe to the feeding rats.

SIGNIFICANCE STATEMENT

This study discovers the novel way to produce zero trans-fatty acids vegetable butter which can be fortified by omega fatty acids, natural minerals, natural vitamins and natural antioxidants that can be beneficial for human health. This study will help the researcher to uncover the critical areas of food nanotechnology and milk fat replacing that many researchers were not able to explore.

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