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Comparative evaluation of fatty acid profiles and lipid nutritional indexes in Egyptian fresh cow, buffalo, goat soft cheeses and their mixtures

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Abstract

Fresh white soft cheese is considered a prime dish in Egyptians' daily diet. However, recent inquiries focused on the relation between full-fat cheeses and heart diseases. Therefore, this study was designed to evaluate white soft cheeses manufactured from various milk species, focusing on the fatty acid profile of their lipid content and their health indicators. Results revealed that goat's milk and cow-goat mix cheeses were significantly different compared to other examined cheese samples, with higher saturated fatty acids (SFAs%) and lower mono-unsaturated fatty acids (MUFAs%) in a percentage of 73.80-75.19 and 23.04-20.92, respectively. Moreover, they are also characterized by a high proportion of short-chain fatty acids (SCFAs, 9.31-10.42%), and medium-chain fatty acids (MCFAs, 29.62-31.61%) but low content of long-chain fatty acids (LCFAs, 59.07-59.95%). Palmitic acid was the dominant fatty acid in all evaluated cheeses, ranging from (26.48-32.02%) followed by oleic acid (15.42–24.15%). The best values for conjugated linoleic acid (CLA), P/S (Poly-unsaturated fatty acids (PUFAs)/SFAs), and n6/n3 (omega6/omega3) were obtained from buffalo's cheese. The desirable hypo-cholesterolemic fatty acids (DFAs) were higher in cheeses made from cow's, buffalo's milk, and their mixtures. This study concluded that the FA composition and lipid health indices of cheese are mainly affected by the species of milk used. In addition, buffalo cheeses sold in Egypt had superior nutritional lipid quality indices.

Keywords: white soft cheese; fatty acid profile; buffalo; goat; cow; CLA; lipid indices

1. INTRODUCTION

Milk and dairy products, involving cheese, are one of the main consumer diets that have an effective function in reaching the human body's nutritive needs [1]. There are variant categories of cheese; however, fresh white soft cheese is considered almost the highest popular cheese type that consumed in Egypt as well as all over the world. The higher acceptance of fresh white soft cheese is mainly attributed to its rapid production, flexibility, and broad range of textures and flavors [2-5]. Cheese is an important dairy product supply within the human daily diet with several nutritional components; it is considered a significant source of milk fats that are presented in an elevated ratio of digestibility with flavor enhancing [1, 6, 7].

Cheese dairy fat is mainly composed of saturated fatty acids as well as a notable amount of short-chain fatty acids that contribute to its higher digestibility [8]. The main dangerous issue is that consumption of excessive and huge percentages of SFAs could lead to elevated levels of blood cholesterol, that increase the probability of cardiovascular diseases, which are mainly affected by the length of the SFAs' carbon chain [9]. On the other hand, cheeses are believed to be an essential source of conjugated linoleic acid that has a prospectively positive impact on health as well as favorable effects by the amount of oleic acid, butyric acid, omega 3 and omega 6 polyunsaturated fatty acids [10, 11]. In addition, conjugated linoleic acid (CLA) was proven by several studies to have anti-inflammatory, antioxidative, anti-carcinogenic, and anti-atherosclerotic effective health characteristics [12-14].

Health and nutritional indexes of cheese are markedly affected by the species and composition of milk as well

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as the technology and processing of cheese manufacture [15]. The highest percentage of fresh white soft cheese sold in the third-world markets is primarily made from cow's milk, followed by buffalo's then goat's milk. Furthermore, the manufacture of white-soft cheese from a mixture of two different milk species as these mixtures were principally produced to improve the sensory or chemical properties of final cheese products and may be attributed to low cost-effective [16-18].

One of the distinct features of cheese produced from goats' milk is that it contains a high percentage of SCFAs, which are regarded as components of healthy food. However, few studies in recent decades have investigated the fatty acid profiles of full-fat soft cheeses in a comparative manner of milk species [6, 15]. Although, researchers have focused on the detailed fatty acid profiles of different milk kinds by studying their negative effects on human healthiness only [19]. Therefore, the current study was planned to analyze and compare the fatty acid profiles of different white soft cheeses sold in Egyptian markets that are produced from various kinds of milk with special reference to their CLA content, besides the determination of their health indices.

2. MATERIALS AND METHODS

2.1. Collection of cheese samples:

Seventy-five samples (100 g. per sample) were purchased from different Egyptian supermarkets in Giza governorate. The selection of samples was dependent on the salable soft cheeses that were prepared from natural milk fat only and various ruminant kinds of milk as follows (fifteen samples from each kind): cow's milk, buffalo's milk, goat's milk, a mixture of cow-buffalo's milk, and a mixture of cow-goat's milk. All cheeses were gathered in the form of a vacuum package and stored in the refrigerator at 40°F.

2.2. Fatty matter extraction from white cheese:

The cold extraction method was used that involves separating the fat content from the rest of the cheese using a solvent without the need for heating, *n*-hexane was added to the cheese and allowed to stand for 15 minutes in a sonicated water bath (Grant ultrasonic 3L bath, Nottingham, UK). The dissolved fat content was separated from the rest of the cheese using filtration (Whatman paper No.1, diameter 10 cm) and then the extracted fat was processed and purified for use in identifying fatty acids by gas chromatography [20].

2.3. Identification of fatty acids by Gas Chromatography- Flame Ionization Detector (GC-FID):

The fatty acid makeup was analyzed using the modified methods of Zahran and Tawfeuk [20]. This involved converting the fatty chains to fatty acid methyl esters (FAMEs) through trans-methylation. The FAMEs were then separated using an HP 6890 plus gas chromatography with a Supelco™ SP-2380 capillary column and detected with a flame ionization detector (FID). The injector and detector temperatures were set at 250°C while the column temperature started at 140°C and increased at a rate of 4°C/min until it reached 240°C, where it was held for 10 minutes. The carrier gas used was helium at a flow rate of 1.2 mL/min, and a sample volume of 1 µL in (n-hexane) was injected through a split injector at a splitting ratio of 100:20. The FAMEs were identified by comparing their retention times with those of authentic FAME standards. The fatty acid composition was expressed as a relative percentage of the total peak area.

2.4. Determination of cheese's fatty acid compositions and its health indexes:

The data were calculated as g/100 g relative to total FAs, and the summation was done as follows: total unsaturated fatty acids (UFA), mono-unsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), and conjugated linoleic acid (CLA). As well as the calculation of short, medium, and long-chain fatty acids (SCFAs, MCFAs, and LCFAs), was done. While the nutritional lipid indexes were estimated by using the following equations based on Santos-Silva et al. [21]; Osmari et al. [22]; Medeiros et al. [23]:

2.4.1 P/S ratio (poly-unsaturated fatty acids/saturated fatty acids).

2.4.2 n6/n3 ratio (omega6/omega3 FAs ratio)

2.4.3 Atherogenicity Index (AI) = (C12:0 + 4(C14:0) + C16:0)/(∑MUFA + ∑(n-6) PUFA + ∑(n-3) PUFA)

2.4.4 Thrombogenicity Index (TI) = (C14:0 + C16:0 + C18:0)/((0.5 X ∑MUFA) + (0.5 X ∑(n-6)) + (3 X ∑(n-3)) + (n3/n6)).

2.4.5 DFA (Hypo-cholesterolaemic fatty acids) = C18:0 + total UFA.

2.4.6 OFA (Hyper-cholesterolemic Fatty Acids) = C12:0 + C14:0 + C16:0.

2.4.7 H/H (Hypo-cholesterolaemic/ Hyper-cholesterolemic FAs) = (C18:1n9 + ∑PUFA)/OFA.

2.5. Statistical Analysis

The evaluation of the obtained data was attained in triplicates, and results were expressed in mean ± SE (Standard Error). The statistical analysis was achieved by using one-way (ANOVA) for estimating the Least Significant Difference (LSD) with a statistical significance value of $P<0.05$ in the SPSS program V23**.**

3. Results and Discussion

Traditionally, bovine milk is the major milk consumed and used by cheese manufacturers, although the involvement of milk of other species is recommended due to their nutritional importance based on their lipid profiles [24, 25]. In this work, the lipid profile of different commercial cheese samples made from different milk species was analyzed with the determination of variations between cheese species for the declaration to how extent the used milk kind may affect the fatty acid structure and composition. The data represented in (Table 1) showed the percentages of saturated fatty acids in the examined cheeses. The percentage of butyric fatty acid was significantly higher in cow-goat mix cheese, followed by buffalo's milk cheese (4.20 and 4.10 %), respectively, while cow's milk cheese samples recorded the lowest butyric fatty acid content of 1.79 %. This fatty acid C4:0, was noted to have a valuable effect with the action of intestinal flora, act as an anti-inflammatory agent especially in chronic gastrointestinal tract complications and help in preventing breast and colorectal cancer evolutions [26-28].

Table 1. Saturated fatty acid content (%) of examined cheese samples.

Fatty acids	Cow's milk cheese	Cow-buffalo mix cheese	Goat's milk cheese	Buffalo's milk cheese	Cow-goat mix cheese
C4:0	$1.97^{a*} \pm 0.22$	$3.74^{a,b} \pm 0.26$	$2.29^{a,c} \pm 0.54$	$4.10^{b,c} \pm 0.79$	$4.20^{b} \pm 0.87$
C6:0	$1.59^{a} \pm 0.21$	$1.94^{a} \pm 0.12$	$3.10^{a,b} \pm 0.67$	$2.35^{a,b} \pm 0.10$	$3.68^{b} \pm 0.83$
C8:0	$1.13^{a} \pm 0.19$	$1.00^{a} \pm 0.22$	$3.93^{b} \pm 0.91$	$1.30^{a} \pm 0.03$	$2.55^{a,b} \pm 0.54$
C10:0	$2.75^{a} \pm 0.55$	$2.54^{a} \pm 0.36$	$11.18^{b} \pm 1.37$	$2.35^{a} \pm 0.10$	$5.65^{c} \pm 1.06$
C12:0	$3.56^{a} \pm 0.59$	$3.47^{a} \pm 0.31$	$5.92^{b} \pm 0.66$	$2.90^{a} \pm 0.25$	$5.50^{b} \pm 0.78$
C13:0	$0.00^{a} \pm 0.00$	$0.11^{a} \pm 0.05$	$0.00^{a} \pm 0.00$	$0.15^{a} \pm 0.08$	$0.22^{a} \pm 0.13$
C14:0	$8.91^{a} \pm 0.78$	$10.87^{a,b} \pm 0.63$	$11.40^{b,c} \pm 0.47$	$10.10^{a,b} \pm 0.56$	$13.50^{c} \pm 0.92$
C15:0	$1.36^{a} \pm 0.17$	$1.66^{a} \pm 0.19$	$1.42^{a} \pm 0.35$	$1.65^{a} \pm 0.29$	$1.57^{a} \pm 0.13$
C16:0	$32.02^{a} \pm 1.27$	$28.07^{b,c} \pm 0.53$	$26.54^{b} \pm 1.53$	$26.48^{b} \pm 0.87$	$30.92^{a,c} \pm 0.94$
C17:0	$0.92^{a} \pm 0.25$	$1.08^{a} \pm 0.34$	$0.70^{a} \pm 0.06$	$1.31^{a} \pm 0.24$	$0.80^{a} \pm 0.13$
C18:0	$10.63^{a} \pm 1.63$	$11.69^{a} \pm 0.40$	$7.40^{b} \pm 0.92$	$11.14^{a} \pm 0.53$	$6.55^{b} \pm 0.64$
C20:0	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.24^{a} \pm 0.06$	$0.00^{a} \pm 0.00$	$0.09^{a} \pm 0.05$

* a-c values with different superscripts within the same row are significantly ($P < 0.05$) different.; Data represent mean ± standard error.

Caproic C6:0 and caprylic C8:0 fatty acids were significantly higher in cheeses containing goat milk than in other cheeses. Moreover, goat's milk cheese samples were found to have the highest value of capric fatty acid C10:0 (11.18%) followed by cow-goat mix cheese (5.65%); these two types were significantly different ($P < 0.05$) from other cheeses. Myristic acid C14:0 was statistically significantly higher in cow-goat mix cheese samples (13.50%), while stearic fatty acid was higher in cow, buffalo, and their mixed cheeses than goat and cow-goat mix cheeses. The main SFA in milk fat of the majority of mammals is palmitic acid C16:0; it fluctuated from 26.48 – 32.02 %, cow's cheese had the highest value, while the minimum value was recorded in goat's cheese (Table 1). The data represented in this study for SFA% were nearly identical to Cossignani et al. [25] for goat's cheese samples. Chilliard et al. [29] and Aguilar et al. [30]; also stated that cheese produced from goat milk constituted higher percentages of C6:0, C8:0, and C10:0 than cow milk.

Lauric acid C12:0 in (Table 1); ranged from 2.90 to 5.92%, where buffalo's cheese recorded the lowest value while goat and cow-goat cheeses had significantly uppermost values. Lauric acid is distinctive by antimicrobial effect, and it was determined to be high in cheese containing goat milk, similarly stated by Aguilar et al. [30] and Adamska et al. [31]. Almost all saturated fatty acids represented in lauric, myristic, and palmitic acids are well-known to be implicated in raising levels of cholesterols in the body and so associating in elevating the likelihood of coronary heart disease with atherosclerosis complications [9, 32].

Non-significant differences ($P > 0.05$) among examined cheeses were defined for pentadecanoic acid C15:0 and heptadecanoic acid C17:0 in a range of 1.36-1.66% and 0.70-1.31%, respectively. However, the greatest concentrations of C15:0 and C17:0 fatty acids were revealed in buffalo cheese and cow-buffalo mix cheese (Table 1). These fatty acids, as part of the odd-chain fatty acids (OCFAs), are accompanied by a lowering in the complications of cardiac diseases with mortality reduction. Apparently, they are found to be involved in diminishing anemia, fibrosis, inflammation, cardiovascular disease, obesity, and the possibility of chronic diseases such as pancreatic cancer. Therefore, its dietary supplementation is recommended, as announced by recent studies [33-35]. Consequently, among the odd-chain SFAs, C15:0, and C17:0 were the major considerable fatty acids in ruminant cheese, in conformity with other studies [36, 37].

Table 2. Unsaturated fatty acid content (%) of examined cheese samples.

Fatty acids	Cow's milk cheese	Cow-buffalo mix cheese	Goat's milk cheese	Buffalo's milk cheese	Cow-goat mix cheese
C10:1	$0.47^{a*} \pm 0.23$	$0.37^{a} \pm 0.12$	$0.54^{a} \pm 0.13$	$0.18^{a} \pm 0.00$	$0.56^{a} \pm 0.10$
C13:1	$0.05^{a} \pm 0.00$	$0.38^{a,b} \pm 0.14$	$0.05^{a} \pm 0.00$	$0.56^{b} \pm 0.17$	$0.20^{a,b} \pm 0.11$
C14:1	$1.23^{a} \pm 0.22$	$1.17^{a} \pm 0.13$	$0.50^{b} \pm 0.12$	$1.08^{a} \pm 0.20$	$1.22^{a} \pm 0.14$
C 14:2	$0.88^{a,b} \pm 0.20$	$1.17^{a} \pm 0.19$	$0.34^{b} \pm 0.18$	$1.18^{a} \pm 0.22$	$0.85^{a,b} \pm 0.12$
C15:1, c10	$0.41^{a,b} \pm 0.20$	$0.84^{a,b} \pm 0.18$	$0.25^{a} \pm 0.12$	$1.06^{b} \pm 0.26$	$0.35^{a} \pm 0.20$
C16:1, n9	$1.74^{a} \pm 0.22$	$2.18^{a} \pm 0.74$	$1.77^{a} \pm 0.25$	$2.95^{a} \pm 0.27$	$1.91^{a} \pm 0.12$
C16:1, n7	$0.80^{a,b} \pm 0.20$	$0.87^{a,b} \pm 0.13$	$0.38^{b} \pm 0.19$	$1.29^{a} \pm 0.35$	$0.71^{a,b} \pm 0.10$
C17:1, c10	$0.62^{a} \pm 0.14$	$0.39^{a} \pm 0.17$	$0.29^{a} \pm 0.15$	$0.27^{a} \pm 0.14$	$0.54^{a} \pm 0.19$
C18:1, n9c	$24.15^{a} \pm 0.75$	$23.34^{a} \pm 1.74$	$19.24^{a,b} \pm 2.99$	$22.80^{a} \pm 1.90$	$15.42^{b} \pm 1.81$
C18:2, n6c	$3.57^{a} \pm 0.38$	$2.06^{b} \pm 0.06$	$1.88^{b} \pm 0.10$	$2.14^{b} \pm 0.22$	$1.98^{b} \pm 0.29$
C18:2,c9t11 (CLA)**	$0.33^{a} \pm 0.08$	$0.29^{a} \pm 0.10$	$0.27^{a} \pm 0.01$	$1.28^{b} \pm 0.11$	$0.41^{a} \pm 0.15$
C18:3, n3	$0.88^{a} \pm 0.28$	$0.79^{a} \pm 0.36$	$0.66^{a} \pm 0.06$	$1.32^{a} \pm 0.13$	$0.63^{a} \pm 0.27$

** Conjugated linolic acid (CLA)

* a-b values with different superscripts within the same row are significantly ($P < 0.05$) different.; Data represent mean ± standard error.

Oleic acid C18:1, cis9 was recorded to have anti-atherogenic and anti-cancer features. The same previous characteristics were reported for omega 3 (linolenic acid) plus enhanced immune reactions and restrained heart disorders [38]. While omega 6 supported the minimizing of diabetes 2 illnesses by boosting the sensitivity toward insulin with cardiovascular disease prevention [39, 40]. Oleic acid was found to be the highest unsaturated fatty acid; it ranged from 15.42– 24.15%. Cheeses containing goat milk recorded the lowest oleic acid (15.42%) in cow-goat mix and 19.24% in goat's cheese among other milk species (Table 2). The results were nearly similar to Prandini et al. [41]; who reported that the oleic acid % in fresh goat's cheese was 19.31%.

Cow's milk cheese had the highest value of omega 6 (3.57%), while omega 3 was not significantly different ($P > 0.05$) between different kinds, with a minimum percentage of (0.63) in cow-goat mix cheese, followed by goat's milk, and a maximum of 1.32% in buffalo's cheese. CLA was significantly higher in buffalo cheese than in other cheeses (1.28%) as presented in (Table 2). However, the percentages described by Prandini et al. [41] for CLA were higher than the obtained results in the case of fresh goat's and cow's cheeses with lower proportions of omega 6 and omega 3. In addition, a higher CLA content (0.39-0.48%) was stated by Paszczyk et al. [42] in fresh cow's cheese. The fatty profile of buffalo milk is found to be high proportionally in CLA, which has the capability to behave as anti-obesity, anti-carcinoma, anti-diabetic, and anti-atherogenic [43, 44]. In addition, Ménard et al. [43] concluded that buffalo's milk was characterized by higher percentages of omega-3 compared to cow's milk.

The lowest CLA content was determined in goat's cheese (0.27%) compared to cheese produced from other milk species, which was similar to the data represented by Szterk et al. [45]. The variation of CLA concentrations in milk fat (other than milk species) is principally contributed to animal feeds, lactation stage, age, breed, as well as seasonal diversity [46-48]. There was a significant difference ($P < 0.05$) in the content of palmitoleic acid C16:1, n7 between goat's cheese with the lowest value (0.38%) and buffalo cheese with the most elevated percentage (1.29%). While other chemical structures of palmitoleic acid C16:1, n9 showed no significant difference amongst the examined cheese varieties. The palmitoleic fatty acid was identified in several prior epidemiological researches to have a possible reduction of atherogenic dyslipidemia, the minimum prevalence of diabetes type 2, and lower insulin resistance [49-51]. However, there are recent studies that suggest the importance of reevaluation and declaration of the correlation between the percentage of palmitoleic fatty acid and lowering type 2 diabetes [52-53].

As illustrated in **Table 3**, goat (73.80%) and cow-goat mix (75.19%) cheeses were composed of highly saturated FAs significantly ($P < 0.05$) as compared to other examined cheeses. Consequently, they had the lowest UFA%, which was 24.81 in cow-goat mix cheese and 26.20 in goat's milk cheese. The sum of SFA and UFA in cow, cow-buffalo mix, and buffalo cheeses were 64.86 & 35.16, 66.15 & 33.87, and 63.87 & 36.13, respectively. Monounsaturated fatty acids were significantly lower in goat's cheese (23.04%) and cow-goat mix cheese (20.92%) than in other cheeses. On the other side, polyunsaturated fatty acids were significantly higher in cow and buffalo cheeses (5.66 and 5.92%, respectively). Paszczyk et al. [42]; showed nearly similar results for cheese made from cow milk in SFA and MUFA but with lower percentages of PUFA.

Table 3. Lipid quality indices of examined cheese samples.

Fatty acids	Cow's milk cheese	Cow-buffalo mix cheese	Goat's milk cheese	Buffalo's milk cheese	Cow-goat mix cheese
SFA**	$64.86^{a*} \pm 1.58$	$66.15^{a} \pm 1.07$	$73.80^{b} \pm 3.08$	$63.87^{a} \pm 1.13$	$75.19^{b} \pm 2.94$
MUFA	$29.50^{a} \pm 1.50$	$29.55^{a} \pm 0.62$	$23.04^{b} \pm 2.96$	$30.21^{a} \pm 0.63$	$20.92^{b} \pm 2.41$
PUFA	$5.66^{a} \pm 0.40$	$4.31^{a,b} \pm 0.49$	$3.16^{b} \pm 0.13$	$5.92^{a} \pm 1.70$	$3.88^{a,b} \pm 0.59$
UFA	$35.16^{a} \pm 1.56$	$33.87^{a} \pm 1.05$	$26.20^{b} \pm 3.08$	$36.13^{a} \pm 1.13$	$24.81^{b} \pm 2.94$
P/S	$0.08^{a,b} \pm 0.00$	$0.06^{a,b} \pm 0.00$	$0.04^{b} \pm 0.00$	$0.09^{a} \pm 0.02$	$0.05^{a,b} \pm 0.00$
n6/n3	$5.00^{a} \pm 0.47$	$3.78^{b} \pm 0.38$	$2.94^{b} \pm 0.48$	$1.62^{c} \pm 0.04$	$4.35^{a,b} \pm 0.85$
AI	$2.12^{a} \pm 0.22$	$2.32^{a} \pm 0.14$	$3.16^{a,b} \pm 0.47$	$2.07^{a} \pm 0.07$	$3.97^{b} \pm 0.56$
TI	$2.69^{a} \pm 0.21$	$2.76^{a} \pm 0.21$	$3.10^{a,b} \pm 0.28$	$2.30^{a} \pm 0.05$	$3.89^{b} \pm 0.54$
DFA	$45.78^{a} \pm 3.19$	$45.55^{a} \pm 1.39$	$33.60^{b} \pm 4.00$	$47.27^{a} \pm 0.92$	$31.36^{b} \pm 3.54$
OFA	$44.49^{a} \pm 2.40$	$42.40^{a} \pm 0.81$	$43.86^{a} \pm 1.80$	$39.49^{a} \pm 0.97$	$49.91^{b} \pm 1.70$
H/H	$0.64^{a} \pm 0.05$	$0.62^{a} \pm 0.05$	$0.50^{a,b} \pm 0.07$	$0.66^{a} \pm 0.04$	$0.36^{b} \pm 0.05$

** Saturated fatty acid (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), total unsaturated fatty acids (UFA) = MUFA+PUFA, polyunsaturated fatty acids / saturated fatty acids (P/S) ratio, omega 6 (n6) / omega 3 (n3), index of atherogenicity (AI), index of thrombogenicity (TI), hypo-cholesterolemic fatty acids (DFA), hyper-cholesterolemic fatty acids (OFA), hypo-cholesterolaemic/hyper-cholesterolaemic ratio (H/H)

*a-c values with different superscripts within the same row are significantly ($P < 0.05$) different.; Data represents mean ± standard error.

The polyunsaturated fatty acids / saturated fatty acids (P/S) ratio is recommended to be over 0.45 and not less than 0.1 [54-55]. The P/S ratio was significantly higher in buffalo's milk cheese (0.09) and lower in goat's milk cheese (0.04). The ratio of n6/n3 was equal to or lower than 5 in all examined samples as recommended by WHO, 2010 [55] and Simopoulos [56], the highest ratio was found in cow's cheese (5) and the lowest one in buffalo's cheese (1.62). The results for cow's milk cheese were almost identical to the study published by Aguilar et al. [30] and Paszczyk et al. [42] for n6/n3, while Ménard et al. [43]; recorded n6/n3 for buffalo's milk as 1.3. However, higher ratios of goat's fresh cheese (n6/n3) were determined by Cossignani et al. [25]. Principally, both ratios P/S and n6/n3 are vital to be calculated in diets as they are related to withstanding cancer and heart diseases [56]. All the examined samples were within the recommended value for n6/n3 index but failed to reach the approved ratio of P/S. The raised proportions of omega 3 fatty acids with a decreased ratio of the n6/n3 are associated with restraining chronic disease pathogenesis as the excess content of n6 encourages the progression of several diseases such as autoimmune disorders, inflammation, cancer, and mainly cardiovascular system complications [57-59]. From this point of view, it was achieved perfectly in the examined buffalo's milk cheeses, which were significantly characterized by elevated n3 and low n6/n3. In accordance with data reported by Ménard et al. [43] and Ilieva et al. [60]; buffalo's milk in this regard may help in improving human health.

The higher the AI and TI indexes, the higher the risk of cardiovascular diseases, as the AI is an indicator of lipid deposition in the artery wall (atherosclerosis), while the probability of blood clot evolution is indicated by the TI index [61]. Indexes of AI and TI were significantly higher in cheeses containing goat milk, varying from 3.16-3.97 for AI and 3.10-3.89 for TI; these results were identical to those obtained by Aguilar et al. [30]. The recorded values for AI and TI in cow cheeses nearly resembled the data noticed by Aguilar et al. [30] and Hirigoyen et al. [62]. Generally, meals with recorded high levels of atherogenicity index are notable for being unhealthy for consumers [63]. Several authors stated that various examined samples of cheese were characterized by high dietary atherogenic compositions, which were indicated by increased AI indices than 2 [11, 15, 30, 64]. A study conducted by Naydenova et al. [65] deduced that cheese produced from buffalo milk had a low-risk probability for human being healthiness.

The desirable hypo-cholesterolemic fatty acids (DFAs) were higher in cow, buffalo cheeses, and their mixtures, while the undesirable hypercholesterolemic fatty acids (OFAs) were significantly higher in cow-goat mix cheese. The value of OFAs is mostly impacted by the highest percentages of saturated fatty acids (palmitic, myristic, and lauric). The hypo-cholesterolaemic / hyper-cholesterolaemic ratio (H/H) ranged from 0.36- 0.66% as presented in (Table 3). Referenced by Santos-Silva et al. [21]; it was reported that the H/H value is regarded as the functionality of fatty acids toward the lipoprotein for transferring plasma cholesterol in relation to the likelihood of congestive heart failure. In addition to, the recommendation of higher levels of H/H, it was determined at the lowest ratio in cow-goat milk cheese with a significant difference ($P < 0.05$). However, Paszczyk et al. [2]; stated lower values of the H/H ratio in cow milk cheese (0.41) and a nearly identical ratio for buffalo milk (0.70) recorded by Nie et al. [66].

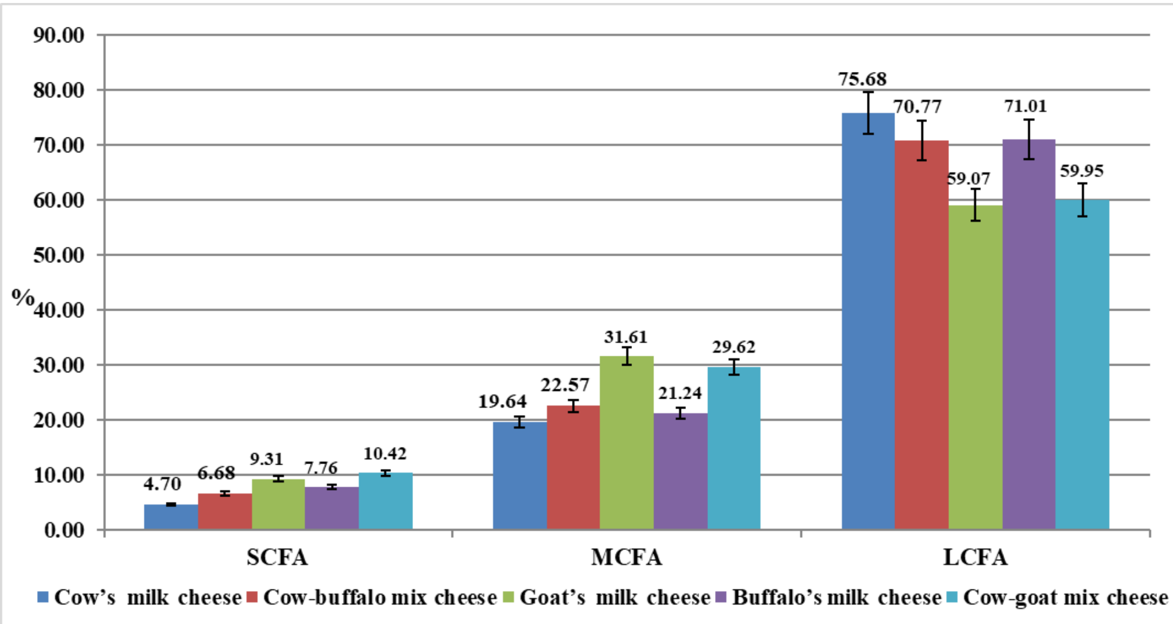

Figure 1: Fatty acids composition of examined cheese samples based on the chain length.
Short chain fatty acid (SCFA, C4:0-C9:0); Medium chain fatty acid (MCFA, C10:0-C15:1); Long chain fatty acid (LCFA, C16:0-C20:0); Data represent mean ± standard error.

According to Figure 1, the highest short-chain fatty acids (SCFAs) were found in cow-goat cheese mix (10.42%), followed by goat's milk cheese (9.31%). Medium-chain fatty acids (MCFAs) ranged between

19.64-31.61%, where goat cheese samples had the most elevated value of MCFAs and the lowest percentage of long-chain fatty acids (LCFAs, 59.07%). Nevertheless, cow's milk cheese was found to have the highest percentage of LCFAs. The study results were in accordance with data reported by Prandini et al. [41]; who stated that goat milk had higher SCFAs and MCFAs with lower LCFAs compared to fresh cow's cheese. Cheeses associated with high SCFA content are favorable for health as these FAs have valuable nutritional and biological characteristics. They act as anticarcinogenic, with potential therapeutical effects on colon disorders and growth inhibitors for pathogenic microorganisms, as well as controlling cholesterol blood levels [67, 68, 69]. The increased consumption of MCFA and LCFA has been proven to correlate with cardiovascular diseases [70].

4. CONCLUSION

The evaluation of different kinds of cheese sold in Egyptian markets revealed that there was a variation in fatty acid compositions, nutritional lipid indices, and beneficial fatty acids owed to the difference in the used milk species. The highest CLA percentage was detected in buffalo cheese. Referring to our study results; mixing cow milk with buffalo or goat milk (cow-buffalo mix cheese and cow-goat mix cheese) suppressed their health indexes more than using one milk species alone, involving an increase in their AI and TI ratios with a decrease in the H/H index. All analyzed cheeses couldn't reach the recommended level for P/S value, although they matched the healthier concentration of n6/n3. Buffalo's cheeses were identified to have excellent nutritional quality compared to other cheeses (lowest SAFs%, highest PUFAs%, minimal AI, TI, n6/n3, least OFA value, and maximal content of DFA). However, the maximal percentages of SCFAs were determined in cheese manufactured from goat's milk. It is crucial for producers to re-evaluate and improve cheese production by focusing on their lipid profiles.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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