Assessment of Nutritional Composition, Water Activity and Oxidative Stability in Imported Cheeses Sold in Babylon Governorate, Iraq

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Abstract
The ingredients and preparation methods influence the safety and quality of cheese. Imports of Iraqi cheeses increase on year, but there are no data presented in scientific publications about the safety and quality of these cheeses. This research has analyzed three types of cheeses (soft, semi-hard, hard) obtained from Iraqi markets of Babylon but produced in Iran, Saudi Arabia and Turkey. Nine different brands from each country of origin (n = 27), with three replications per sample, were considered. Moisture, ash, fat, proteins, fiber, water activity, and peroxide value were considered. The results of the statistical analysis showed that there is a significant effect of the variables "type of cheese" and "country" or their first-order interaction impacted all the nutritional factors. In addition, the protein content declared on the labels differed from the values determined analytically in the laboratory. The extent of this difference was almost similar to that observed for the fat content, with the highest difference of 22%, which was observed in the sample CHH2-I. The lowest water activity value was in CHR3-S samples, which was 0.793 ± 0.003, while the highest water activity value was found in CHS2-S and CHS3-S samples, which was (0.977±0.003,0.977± 0.004), respectively. The results also showed that the peroxide value in the CHH1-I sample was 0.61 ± 0.04 mEq/kg, which was higher than the peroxide values of other samples that contain similar percentages of unsaturated fatty acids

Keywords: Cheese, soft cheese, peroxide value, water activity, oxidation

Introduction

Cheese is a widely consumed dairy product with diverse culinary applications and can be produced from the milk of various animals, including buffalo, cattle, goats, and sheep [1]. Statistics indicated the possibility of producing approximately more than 500 different types of cheeses around the world [2]. Cheese producers seek to maintain the quality of raw materials in a uniform and homogeneous manner [3] as the production of fresh cheese, its flavor, texture and appearance are affected by several factors including the composition of milk and changes in consistency due to seasonal effects that result in changes in the diet

.[4] The main steps in fresh cheese production are the collection of raw milk, the addition of coagulating enzymes, and the production and formulation of curds, which can be used to make many different varieties and types of cheese [5.[

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The local production of cheese in the Iraqi local market is about 13,327 thousand tons per year AtlasBig (n.d) which is a relatively small production volume compared to the volume of demand for cheese in the local market. Iraq relies heavily on imports to meet its cheese needs, as large quantities are imported from neighboring countries and European countries. The import volume of fresh and heat-treated cheeses from countries like Iran, Saudi Arabia, and Jordan is significant. In particular, fresh cheese imports from Iran alone surpass $40 million annually, while heat-treated cheese imports from Iran exceed $2.5 million [6.[

Cheese preservation is a critical factor for maintaining food quality and food safety [7, 8]. Hence, much focus has been given to analyze the various methods of preservation in order to attain maximum outcomes. Traditional methods such as freezing have been widely analyzed to determine their ability to extend cheese shelf life without affecting its sensory characteristics [9,10.[

The objective of this research was to contrast various imported cheeses available in the markets of Babil Governorate. The main aim was to identify significant factors of quality through the verification of their nutritional content, water activity, and peroxide value.

Materials and methods

Samples collections

A total of 27 cheese samples were collected, with three replicates for each sample, bringing the total number to 81 samples, including all types of cheese used in the study. The selected cheeses represent products from different companies and are commercially available in the markets and shops in Babil Governorate, Iraq, for the period from November 2024 to February 2025. The samples studied were produced in three countries: Iran, Turkey, and Saudi Arabia. Cheeses were classified into three main categories of cheese: soft cheese, semi-hard cheese, and hard cheese.

Determination of Moisture

The moisture content was estimated by drying the cheese samples in the oven at 90 °C until the weight was constant. The moisture content was calculated by the resulting weight loss according to the method mentioned by Cebeci et al.[11.[

Determination of Ash

Ash content is determined by the method of incinerating samples in a muffle furnace for four hours at 530 °C [11.[

Determination of Carbohydrates

Carbohydrates were estimated for cheese samples according to the method mentioned in Cebeci et al.[11]. The following equation was used in order to calculate the carbohydrate values:

Total carbohydrate content = 100- (moisture + ash + protein + fat(

Determination of Fat

Cheese fat content was established using the Van Gulik method in which protein is dissolved in sulfuric acid. Separation of the fat is carried out in a Van Gulik butyrometer through centrifugation, and a small amount of amyl alcohol is added to isolate it. The fat percentage is directly read from the butyrometer scale [12.[

Determination of protein

Total nitrogen of cheese samples was estimated using the Kjeldahl method and multiplying the result by the protein coefficient 6.38 to obtain the percentage of protein [11.[

Protein (%)=Total Nitrogen (%)×6.38

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Determination of Water activity

The water activity of cheese samples was determined using relative humidity sensors (Shinyei Technologies, Kobe, Japan). The cheese samples were dried in an oven at 90 °C, and after the samples reached constant weight, the water activity was calculated by dividing the equilibrium relative humidity by 100 [13.[

Peroxide value determination

The peroxide value was determined according to the method of Saad et al.[14] where 5 g of cheese was dissolved in 30 ml of glacial acetic acid/chloroform mixture (3:2), then 1 ml of saturated potassium iodide solution and 40 ml of distilled water were added, and it was titrated with 0.1 N of Na2S2O3 solution until the yellow color disappeared. After that, 0.5 ml of 1% starch solution was added and titration continued until the blue color disappeared. The peroxide value was calculated using the following equation

Peroxide value (mEq/kg sample= (

S x N x l000/W

where as : S: solution of Na2S2O3 (ml(

N: molarity of Na2S2O3 solution

W: Sample weigh

Statistical analysis

The results were statistically analyzed using two-way ANOVA at a significance level of α = 0.05, followed by Tukey's Honestly Significant Differences (HSD) test for multiple comparisons, to estimate the effect of the two variables cheese type and country of manufacture, as well as the effect of their first-order interaction, using SPSS version 13 (SPSS Inc., Chicago, Illinois, USA .(

Results and discussion

Proximate composition

Table 1 shows the chemical composition of different types of cheese collected from local markets in Babylon Governorate, Iraq and manufactured in Iran, Saudi Arabia and Turkey. cheeses were classified into three categories: soft, semi-hard and hard cheese.

The results indicated that the average moisture content values were (64.52 □3.71, 48.75 □2.95 , 36.77□3.30) % for soft cheeses, semi-hard cheeses and hard cheeses, respectively. The average moisture content values were (51.15 □12.09, 47.97□12.61, 50.92 □11.67) % for each of the cheeses produced in Iran, Saudi Arabia and Turkey, respectively. The results of the statistical analysis showed that there is a significant effect of the variables "type of cheese" and "country" or their first-order interaction. These results were consistent with Osaili et al.[15] who explained that the moisture content ranges between (60–62%) and (60–62%) for soft and semi-hard cheeses respectively, while the maximum moisture content is 45% in hard cheeses according to the UAE specification.

Table 1 also showed the ash values in soft, semi-hard, and hard cheeses. The average ash values were (2.90□1.16) % in Iranian samples, (3.06□1.11) % in Saudi samples, and (3.26□1.60) % in Turkish samples. For soft cheeses, the average ash values were (1.71□0.23) %, while for semi-hard cheeses, the average ash values were (2.96□0.56) %, while for hard cheeses, the average ash values were (4.55□0.58) %. The results of the statistical analysis showed that there were significant differences for the variables of

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"cheese type" and "country" or their first-order interaction. These results were close to those reached by Ghada et al.[16], who indicated that the ash percentage in Kareish soft cheeses ranged between (1.00-2.80.% (

Table 1 indicated the percentages of carbohydrates in the different types of cheeses studied. The average carbohydrate content in Iranian samples was (1.99±0.93) %, and in Saudi samples (2.09±0.65) %, while Turkish samples recorded an average of (2.32±0.99) %. For soft cheeses, the average carbohydrate percentage was (2.90±0.86) %, while semi-hard cheeses recorded an average of (1.73±0.32) %. As for hard cheeses, the average carbohydrate content was (1.78±0.72) %. The differences in carbohydrate content, which were calculated by the difference method, were due to the differences recorded in the contents of other nutrients. Statistical analyses showed the presence of significant differences associated with the two variables "type of cheese" and "country of origin", in addition to the first-degree interaction between them. The results were consistent with Ghazal et al.[17] who found that the carbohydrate content was 1.66±0.05 in soft cheeses.

The results exhibited that the average fat content in Iranian samples was (32.83±9.18) %, while Saudi samples recorded an average of (30.01±9.19) %, while the average in Turkish samples was (30.25±8.82) %. It was found that the average fat content in soft cheeses was (20.65±2.85) %, while semi-hard cheeses recorded an average of (34.22±7.01) %. The hard cheeses were characterized by the highest average fat content, reaching (38.22±2.02) %. According to the statistical analysis, there were statistically significant differences attributed to the type of cheese and the country of origin, in addition to the presence of a significant effect of the interaction between these two variables. The table also shows the fat content stated on the product labels. It is noteworthy that the experimental values obtained from the practical analysis were different from the values declared on the labels in most cases. It was found that the declared fat content was less than the actual content specified in 4 cases out of 27 .

This large discrepancy may be attributed to the incorrect use of food composition data when calculating nutritional information, or it may be due to the difference in the analysis methods used. In addition, the labels of two samples of Saudi soft and semi-hard cheeses and two others, a sample of Iranian semi-hard cheeses and a sample of Turkish hard cheeses, did not include this information.

The average protein values were (2.90±1.16) % in Iranian samples, (16.80±5.53) % in Saudi samples, and (13.23±3.76) % in Turkish samples. For soft cheeses, the average protein values were (10.18±2.89) %, while for semi-hard cheeses, the average protein values were (12.29±5.40) %. While for hard cheeses, the average protein values were (18.68±2.86) %. The results for soft cheeses were consistent with Lehaçani and Al-Abdullah [18], who found that the protein percentage was (12.04 ± 0.03) %. The results of the statistical analysis showed that there is Significant differences were found for the variables “type of cheese” and “country” or for their interaction of the first degree. In addition, the protein content declared on the labels differed from the values determined analytically in the laboratory. The extent of this difference was almost similar to that observed for the fat content, with the highest difference of 22%, which was observed in the sample CHH2-I

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Table 1. Amount of moisture, ash, carbohydrates, fat and protein (g/100g) in Iranian, Saudi and Turkish cheese samples

Cheese type/country of manufacture	Moisture	Ash	Carbohydrate	Fat			Protein		
				C	L	Δ	C	L	Δ
Soft cheese									
CHS1-I	62.8	1.7	3	24	38	-36.84	8.51	12	-29.08
CHS2-I	71.08	1.8	1.5	18.5	25	-26	7.15	8	-10.62
CHS3-I	67	1.53	4	20	19	5.26	7.45	6	24.16
CHS1-S	63.8	1.7	2.33	19.4	23	-15.65	12.67	22	-42.40
CHS2-S	61	1.9	2.2	20.8	27	-22.96	14.08	32	-56
CHS3-S	61	1.8	2.64	22.9	NR	-	11.56	NR	-
CHS1-T	64	1.2	2.69	25.01	26.6	-5.97	7.11	7	1.57
CHS2-T	61	1.8	3.98	19.3	30	-35.66	13.90	NR	-
CHS3-T	69	2	3.77	16	18	-11.11	9.22	NR	-
Semi-hard cheese									
CHM1-I	50.01	2.4	1.61	40	43	-6.97	5.99	NR	-
CHM2-I	46.5	2.5	1.94	40	40	0	8.96	12	-25.33
CHM3-I	49	3.4	1.04	38	38.5	-1.29	8.60	12	-28.33
CHM1-S	46	2.8	1.6	42	45	-6.66	7.4	11	-32.72
CHM2-S	50	3.2	1.79	26	30.77	-15.50	18.99	24.3	-21.85
CHM3-S	50	3.4	2.06	24	25.4	-5.51	20.53	25	-17.88
CHM1-T	55	4	1.68	27	27	0	12.34	14	-11.85
CHM2-T	46	2.6	1.72	32	34	-5.88	17.58	NR	-
CHM3-T	46.3	2.4	2.13	39	30	30	10.24	NR	-
Hard cheese									
CHH1-I	39	4.3	1.44	38.5	40	-3.75	16.79	14	19.92
CHH2-I	37	4.5	1.42	40	36	11.11	17.08	14	22
CHH3-I	38	4	2	36.55	NR	-	19.5	NR	-
CHH1-S	36	4	1.7	38	NR	-	20.3	NR	-
CHH2-S	35	3.9	3.39	35	39	-10.25	22.77	23.7	-3.92
CHH3-S	29	4.9	1.13	42	45	-6.66	22.97	27	-14.92

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CHH1-T	38	5.2	1.06	39	43	-9.30	16.77	31	-45.90
CHH2-T	40	5.6	1.61	38	NR	-	14.81	NR	-
CHH3-T	39	4.6	2.32	37	36	2.77	17.17	19.3	-11.03
Mean soft cheese	3.71± 64.52	0.23± 1.71	0.86± 2.90	2.85± 20.65	-	-	2.89± 10.18	-	-
Mean semi-hard cheese	2.95 ± 48.75	0.56± 2.96	0.32± 1.73	7.01± 34.22	-	-	5.40±12.29	-	-
Mean hard cheese	3.30± 36.77	0.58± 4.55	0.72± 1.78	2.02± 38.22	-	-	2.86± 18.68	-	-
Mean Iran	12.09± 51.15	1.16± 2.90	0.93± 1.99	9.18± 32.83	-	-	5.13±11.11	-	-
Mean Saudi	12.61± 47.97	1.11± 3.06	0.65± 2.09	9.19± 30.01	-	-	5.53 ±16.80	-	-
Mean Turkey	11.67± 50.92	1.60± 3.26	0.99± 2.32	8.82± 30.25	-	-	3.76± 13.23	-	-
Significance of variables and interactions									
Cheese type	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	-	$p < 0.001$	-	-
Country	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	-	$p < 0.001$	-	-
Cheese type * country	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	-	$p < 0.001$	-	-

C: Calculated; L: Label; Δ%: difference (Value obtained in the analysis/value described on the label×100)–100 ; NR = not reported

CHS: soft cheese; CHM: smi-hard cheese; CHH: hard cheese; I = made in Iran; S = made in Saudi Arabia ; T = made in Turkey

Figure 1 shows the water activity values of cheese samples manufactured in Iran, Saudi Arabia and Turkey. The average water activity values were (0.921 ± (0.036, 0.906 ± 0.056, 0.915 ± 0.052) for each of the cheeses produced in Iran, Saudi Arabia and Turkey, respectively. The average water activity values for soft, semi-hard and hard cheeses were (0.972±0.003,0.910±0.001, 0.859 ± 0.022), respectively. The lowest water activity value was in CHR3-S samples, which was 0.793 ± 0.003, while the highest water activity value was found in CHS2-S and CHS3-S samples,

Water activity

which was 0.977 ± 0.003, 0.977 ± 0.004, respectively.

The results of the statistical analysis showed that there was a significant effect of the variables "cheese type" and "country" or their first-order interaction. Significant differences ($p \leq 0.05$) were observed for the water activity values in the cheese samples produced in Iran and the cheese samples in Saudi Arabia, and no significant differences ($p \geq 0.05$) were observed between the cheese samples produced in Iran and those produced in Turkey, as well as between the cheese samples produced in Saudi Arabia and their

counterparts produced in Turkey. The results also indicate that there were significant differences ($p < 0.01$) between CHS1-I and both CHS2-I and CHS3-I, while no significant differences were observed between all types of soft cheeses in both Saudi Arabia and Turkey (Figure 1a). The results also showed no significant differences ($p \geq 0.05$) between CHM1-S and CHM3-S and between CHM2-S and CHM3-S, while there were no differences between all types of semi-hard cheeses in both Iran and Turkey (Figure1b). Significant differences

)$p < 0.05$) were also found between CHR1-S and CHR3-S, while the results showed no significant differences between all types of hard cheeses in both Iran and Turkey

)Figure 1c.(

Kaczyński [19] found that the water activity values of cheeses ranged between 0.6379 and 0.9697, which corresponds to the water activity of cheeses ranging from 0.7 to 1. The water activity increases as a result of the transfer of water from the inside of the cheese to its surface, especially when stored in plastic containers, where the accumulation of water droplets leads to its increase. Murtaza et al.[20] also explained that the water activity index is affected by the moisture content and dissolved substances in the cheese. The water activity index increases with the decrease in the sodium salt content due to the increase in the moisture content of the non-fatty materials. In contrast, the water activity decreases due to evaporation and loss of water during storage or when the concentration of salts and soluble substances that bind to water and reduce its availability increases. These findings align with the study conducted by Vrdoljak et al.[21], who analyzed locally produced soft, semi-hard, and hard cheeses in Croatia. Their research revealed that when stored at 4°C for 15, 270, and 450 days, the water activity levels varied within the following ranges: soft cheeses (0.945±0.01 to 0.990±0.02), semi-hard cheeses (0.806±0.02 to 0.910±0.01), and hard cheeses (0.650±0.04 to 0.907±0.05

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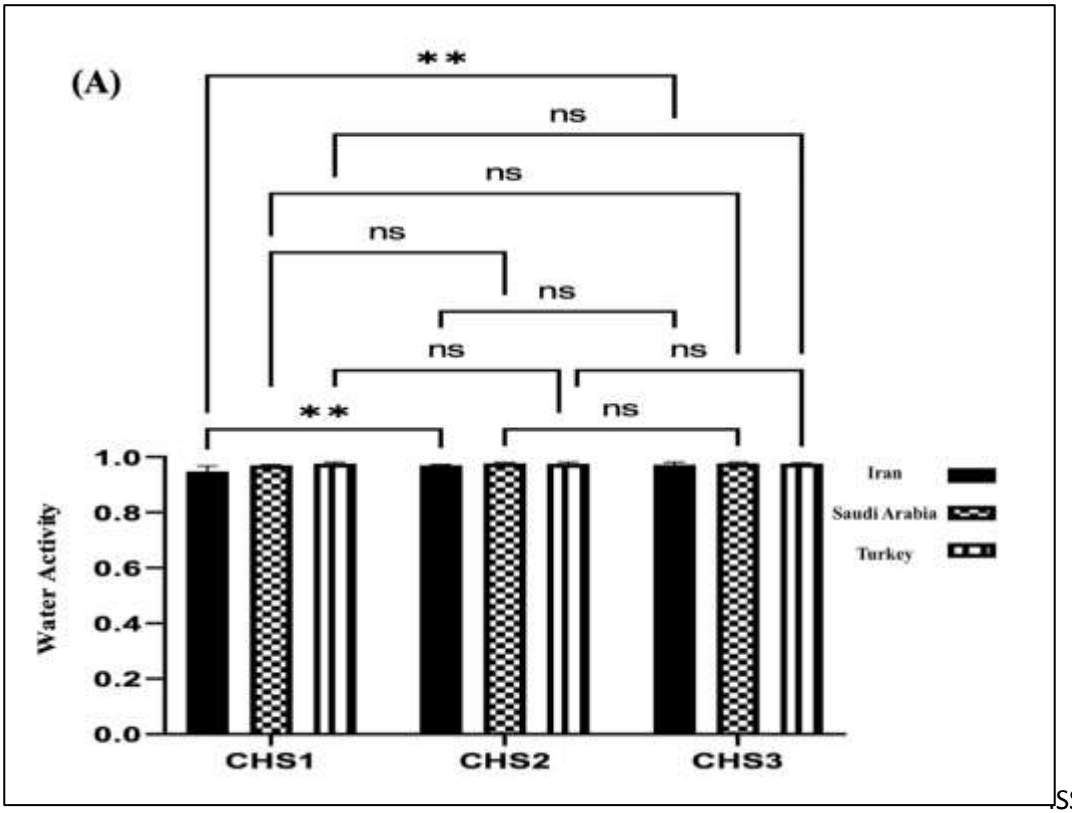

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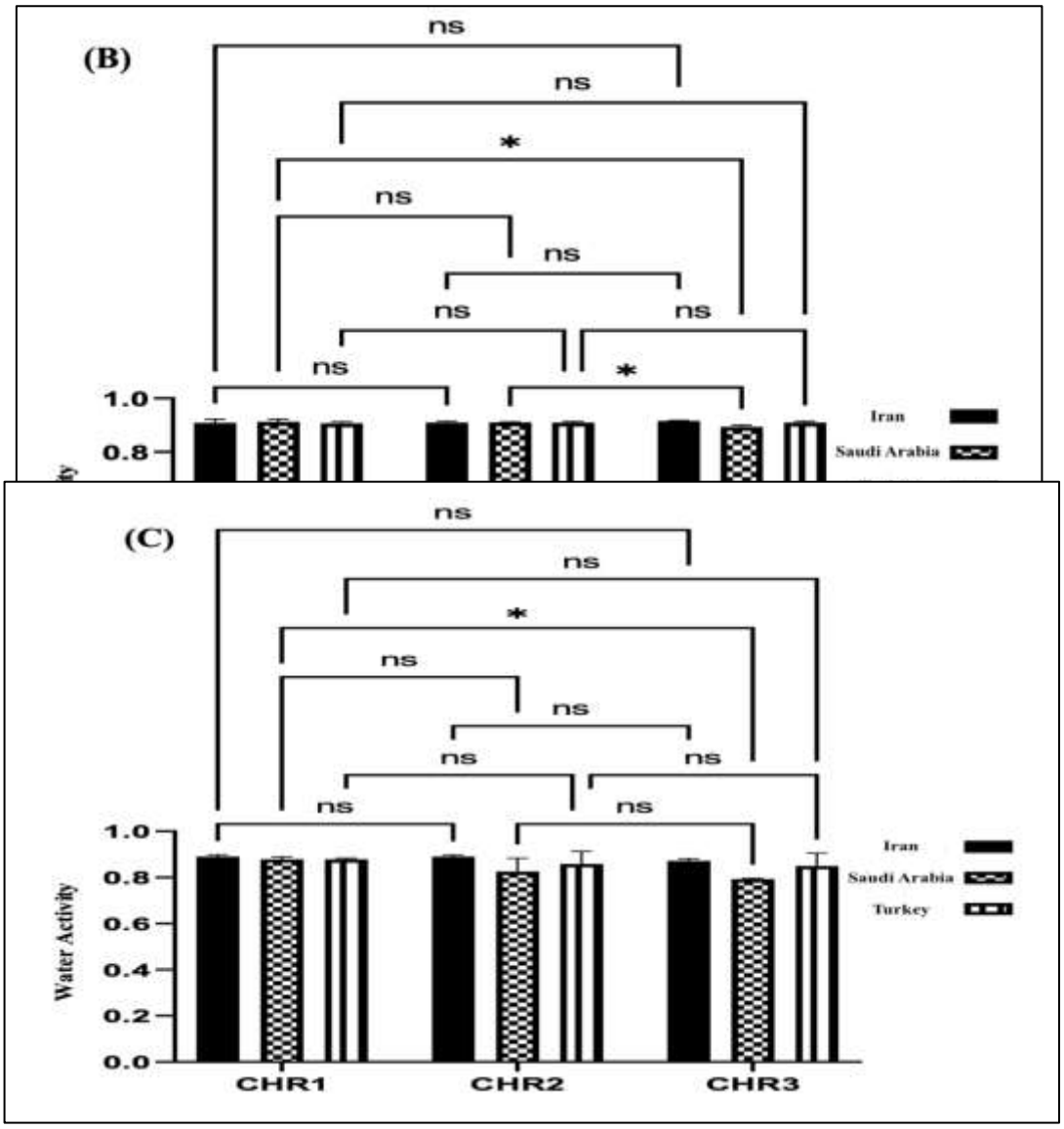


Figure 1. Water activity values of soft cheese samples (a), semi-hard cheeses (b), and hard cheeses (c) in Iran, Saudi Arabia, and Turkey.

Peroxide value

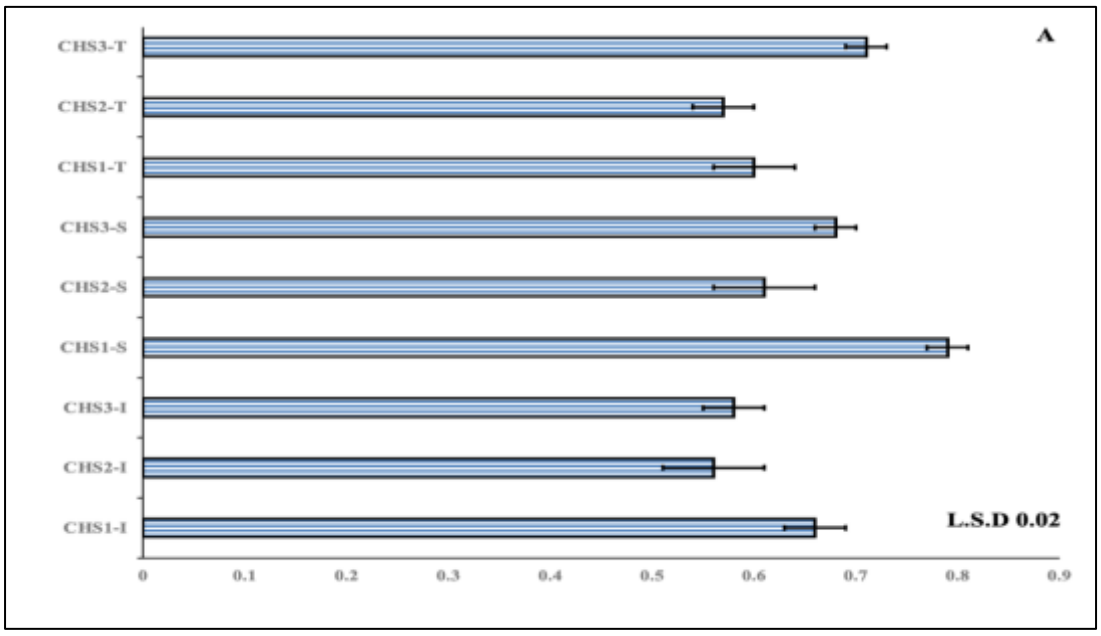
Figure 2 shows the changes in peroxide values of cheese samples used in the study and manufactured in Iran, Saudi Arabia and Turkey. The results indicated that the average peroxide values reached (0.640 ± 0.07, 0.547 ± 0.08, 0.544 ± 0.04) mEq peroxide/kg for soft cheeses, semi-hard cheeses and hard cheeses, respectively. The average peroxide values were (0.570 ± 0.07, 0.614 ± 0.08, 0.548 ± 0.07) mEq/kg for each of the cheeses produced in Iran, Saudi Arabia and Turkey, respectively. The results also showed that the highest peroxide value was in the CHS1-S samples, which reached 0.79 ± 0.03 mEq /kg. These results were consistent with what was indicated by Saad et al.[14], who explained that the high percentage of unsaturated fatty acids (USFA) can encourage the occurrence of

rancidity due to the oxidation of USFA and thus lead to harmful effects on the health of the consumer.

The results also showed that the peroxide value in the CHH1-I sample was 0.61 ± 0.04 mEq/kg, which was higher than the peroxide values of other samples that contain similar percentages of unsaturated fatty acids. This may be attributed to the fact that the CHH1-I sample contained 10.2858% Arachidic acid according to the results of the GC-MS determination of fatty acids obtained in this study. This finding is consistent with the observations of Abd El-Gawad et al.[22], who reported that the addition of vegetable oils, particularly palm oil, led to an increase in peroxide values in cheese. Kesenkaş et al.[23] found that the content of saturated fatty acids is a good indicator of adulteration of dairy products with vegetable oils. Uzunov et al.[24] revealed that the degree of change in saturated fatty acids and unsaturated fatty acids depends on the type and amount of added vegetable oil.

The results for soft cheeses indicate that there were no significant differences between CHS1-T and CHS2-S, as well as between CHS2-I and CHS2-T, and between CHS2-S and CHS1-T. In addition, no significant differences were observed between CHS2-T and CHS2-I, and also between CHS3-I and CHS2-T. In contrast, significant differences were observed between the other cheese types. There was no significant difference between CHM1-I and each of CHM1-S, CHM2-S, CHM3-S, CHM3-T, as well as between CHM1-S and each of CHM1-I, CHM2-S, CHM3-S. No significant differences were recorded between CHM1-T and CHM3-T. Similarly, there was no significant difference between CHM2-I and each of CHM1-I, CHM2-S, CHM3-S, as well as between CHM2-S and each of CHM1-I, CHM1-S, CHM2-I, CHM3-S. Finally, the results showed no significant differences between CHM3-S and each of CHM1-I, CHM1-S, CHM2-I, CHM2-S, and there was no significant difference between CHM3-T and CHM1-T. In contrast, statistically significant differences were observed among the other semi-hard cheeses.

The results of the LSD test showed that there were no significant differences between some types of hard cheeses. Also, no significant



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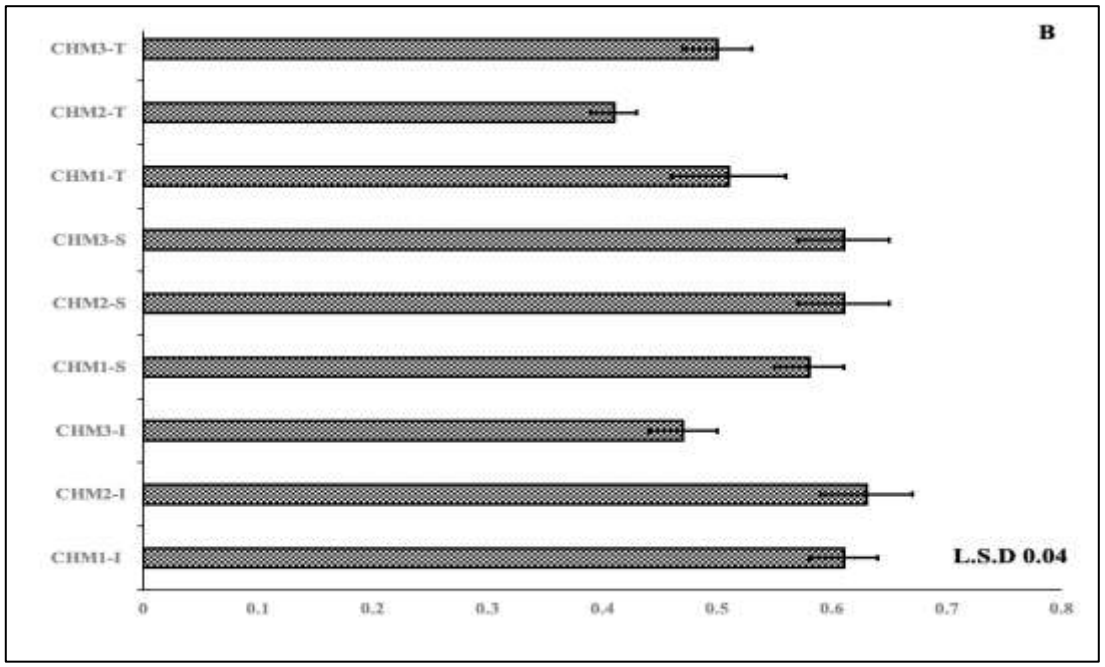
differences were recorded between CHH1-S and each of CHH2-I, CHH2-S, CHH2-T, CHH3-T, while the differences were clear with the rest of the types. There were also no significant differences between CHH2-S and each of CHH1-S, CHH1-T, CHH2-I, CHH2-T, CHH3-T, while significant differences appeared with CHH3-I. On the other hand, CHH2-T did not show significant differences with CHH1-S, CHH1-T, CHH2-I, CHH2-S, CHH3-S, CHH3-T, while there were significant differences with CHH3-I. As for CHH3-I, it showed Significant differences with all other types, indicating its clear difference. While there was no significant difference between CHH3-S and each of CHH1-T, CHH2-S, CHH2-T, CHH3-T. Finally, no significant differences were recorded between CHH3-T and each of CHH1-S, CHH1-T, CHH2-I, CHH2-S, CHH2-T, CHH3-S. The results of the statistical analysis also showed that there were significant differences between the average peroxide values of cheese samples produced in Iran, Saudi Arabia and Turkey.



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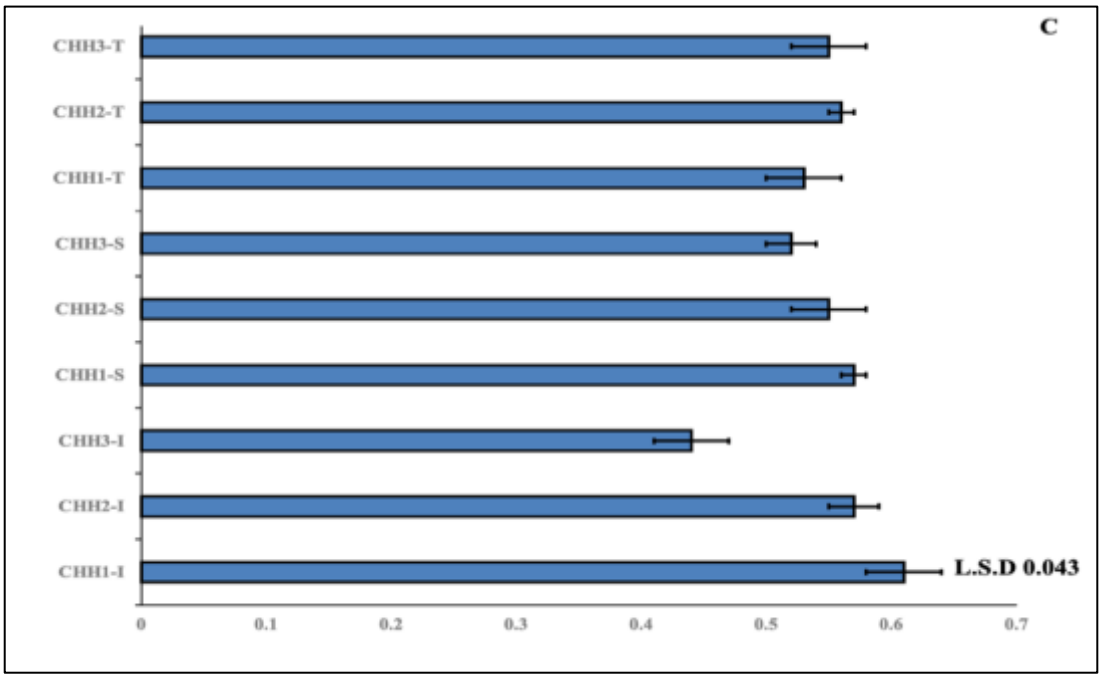

Figure 2. Average peroxide values in samples of soft cheeses (A), semi-hard cheeses (B), and hard cheeses (C) manufactured in Iran, Saudi Arabia, and Turkey

Conclusion

This study has aimed to examine the chemical composition of different types of cheese collected from local markets in Babylon Governorate, Iraq and manufactured in Iran, Saudi Arabia and Turkey. cheeses were classified into three categories: soft, semi-hard and hard cheese. The results showed a difference in the amount of protein and fat fixed on the biscuit wrappers and the amount of protein and fat calculated practically, which leads to the provision of undocumented and inaccurate data. It was found that the declared fat content was less than the actual content specified in 4 cases out of 27. The lowest water activity value was in CHR3-S samples, while the highest water activity value was found in CHS2-S and CHS3-S samples. The highest peroxide value was in the CHS1-S samples.

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