Determination of the effectiveness Iron addition in the chemical and sensory properties of Ricotta cheese

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Abstract

This study aimed to evaluate the quality characteristics of ricotta cheese produced using whey and milk fortified with iron to improve the nutritional value. In this study, three treatments of ricotta were made, the first treatment made from sweet whey served as a (control 1), the second treatment made from whole milk, (control 2) and the third treatment made from a mixture of fresh milk12% and whey, (control 3). These three treatments were repeated with addition of 25ppm and 45ppm ferrous sulphate (FeSO4) to milk or sweet whey to determine the effect of iron fortification on the properties of ricotta cheese. The results showed that the yield increased from 10 % to 11% in ricotta cheese made from sweet whey only fortified with 45ppm FeSO4, and from 25% to 27% in ricotta cheese made from fresh whole milk only, fortified with 45ppm FeSO4 The yield increased from 11 to 25 in ricotta cheese made from a mixture of fresh milk **12**% and whey fortified with 45 ppm FeSO4.. The samples were analyzed for pH, moisture, protein ,ash and total solids. Cheese samples were also assessed for organoleptic properties. The sensory evaluation showed that ricotta cheese was generally acceptable. Results indicate that it is possible to produce good quality, Fe-fortified ricotta cheese.

Keywords: Ricotta cheese , Iron fortification , Product quality , chemical composition

Abbreviation key: WF1= Ricotta cheese made from sweet whey fortified with 25ppm FeSO4, WF2= Ricotta cheese made from sweet whey only fortified with 45ppm FeSO4, MF1= Ricotta cheese made from fresh Whole milk, fortified with 25ppm FeSO4,

MF2=Ricotta cheese made from fresh Whole milk only, fortified with 45ppm FeSO4, MWF1= Ricotta cheese made from a mixture of fresh milk12% and whey fortified with 25ppm FeSO4, MWF2= Ricotta cheese made from a mixture of fresh milk**12**% and whey fortified with 45 ppm FeSO4.

Introduction

The management of food waste and by-products, due to the global increase of population and food consumption, as it contains a great quantities of organic substances is a challenge for the food industry that faces growing economic costs for the treatment [1]. In fact whey contains 6-7% total solids which represent more than half of the solids in the original milk, including about 20% of the proteins, most of lactose, minerals and water-soluble vitamins Ricotta is a high moisture soft cheese also known as whey cheese [2]. It can be produced using cheese whey or milk, or a mixture of both [3]. It is obtained after direct acidification of milk or whey and heating for denaturation and aggregation of protein. Ricotta can be made from almost any type of sweet uncolored whey provided the initial pH is >6.0 and titratable acidity (TA) of the whey is ≤0.16% (optimum, 0.13%–0.14% [4] . Milk is a relatively poor source of iron (0.2–0.5 mg/L) so milk and milk products are generally selected for iron fortification as they are processed through centralized control systems, regularly consumed by all age and social groups, and also because the stability and bioavailability of the nutrients remain high. Iron (Fe) is an essential mineral in human nutrition. In developed and developing countries, Fe deficiency is most common and widespread. Fortifying dairy products with Fe increases their nutritional value [5]. Iron is an essential trace element in humans since it plays an important role in transport and storage of oxygen and is also a cofactor in various biochemical processes[6].

Cheese fortification must not compromise the sensory and physical-chemical properties in order not to damage the acceptability and palatability of the final product by the consumers.

The objectives of the present study were: produce of ricotta cheese using whey and milk fortified with Fe and evaluate the chemical composition and sensory quality characteristics of the manufactured ricotta cheese .

Materials and Methods:

Preparation of Ricotta Cheese:

Ricotta cheese made from the whey from milk cheese, which was heated to denature and coagulate the whey proteins; the coagulated protein was scooped from the whey. Ricotta made from milk or milk/whey mixture [7]. All treatments were acidified using citric acid. Cheese samples were packed in plastic container and stored at 4°C.

1-Ricotta cheese made from sweet whey without addition of ferrous sulphate (control1).

2- Ricotta cheese made from sweet whey with addition of 25 and 45 ppm of ferrous sulphate.

3- Ricotta cheese made from whole cow milk without addition of ferrous sulphate (control 2).

4- Ricotta cheese made from whole cow milk with addition of 25 and 45 ppm of ferrous sulphate.

5- Ricotta cheese made from mixture sweet whey and fresh milk (88 :12), without addition of ferrous sulphate (control 3).

6- Ricotta cheese made from mixture sweet whey and fresh milk (88 :12)

with addition of 25 and 45 ppm of ferrous sulphate.

Cheese yield:

$$\text{Yield} = \frac{\text{Weight of cheese} \times 100}{\text{Weight of whey}}$$

The resulting cheese was weighed immediately using weighing balance. The yield of cheese was calculated as[8]

Methods of analysis:

Cheese samples were analyzed for pH , moisture, total solids ,ash and total nitrogen, protein concentration is calculated as total nitrogen × 6.38a as described in [9].

Texture determination:

Ricotta hardness evaluated by compression tests in a texture analyzer (CT3(4500) Brookfield engineering lab).The hardness of samples were, measured and the operation conditions were an artificial plastic cylinder (20 mm in diameter) was inserted into each product to a depth of 15 mm with 5.0g trigger and speed of 1 mm/s[10].

Iron determination:

Fe in all samples was determined by Inductively Coupled Plasma - Optical Emission Spectroscopy ICP-OES (Model Icap 7600 Dual/ ICP-OES [thermo fisher]). Iron was determined depending on the method [11].

Digestion procedure for iron determination:

The samples were digested using microwave digestion method. The samples of approximately1.0 g were digested with 6 ml of HNO_3 and 2 ml of H_2O_2 in microwave digestion system . The resulting solutions were cooled and diluted to 10 ml with distilled water. The determination of metal contents in this clear solution was carried out by Inductively coupled plasma optical emission spectrometry (ICP-OES).

All samples were analyzed in triplicates by instrument icap 7600 Dual/ ICP-OES [Thermo Fisher].

Organoleptic assessment:

Cheese samples were evaluated organolepticlly for their different quality attributes i.e. flavor (especially metallic flavor) 40 points , body (15 point) , texture (15 point), bitterness (20 points) and appearance (10 points) by an expert panel of 5 judges [12].

Statistical analysis

The analysis of variance (ANOVA)was applied to the data. Factorial experiment with three replications was used by XLSAT program ver. 7.5.2 and conducted using Complete Randomized Design (CRD). All possible comparisons among the means were carried out by using (Dunkin) test at the significant level of 0.05 after they show their significant in the general test .

Results and discussion:

Table (1) shows the chemical composition of ricotta cheese made from whey. The yield of ricotta cheese samples, presented in table 1, shows that with an increase of iron , the yield of cheese increases and this is due to the fact that iron have high affinity to

interact with whey proteins which cause their crosslinking and precipitation [13]. The moisture content cheese was 68.476 and 69.362 which were lower than in control1 and this is due to iron role in increasing interactions between whey proteins and reducing the pore size of the protein network, thus reducing the separation of whey from the cheese [14]. Results show that there were no significant differences in pH, protein and Ash.

Table (1): Composition of Ricotta cheese made from whey

Sample	Yield (%)	pH	Total solids(%)	Protein (%)	Ash (%)	Moisture (%)
Control 1	10^{a}	5.6^{a}	24.310^{c}	9.910^{a}	0.587^{a}	75.685^{a}
WF1	11^{a}	5.53^{a}	31.474^{a}	9^{a}	0.618^{a}	68.476^{c}
WF2	11^{a}	5.56^{a}	30.630^{b}	9.370^{a}	0.654^{a}	69.362^{b}

N=3, p < (0.05)

Table (2) shows the chemical composition of ricotta cheese made from fresh whole milk , The yield shows that with an increase of iron concentration, the yield of cheese increases in MF2 and this increase may be related to the effect of ion increasing the number and strength of bonds between milk proteins ,among the milk proteins, ~ 90% of iron added to milk binds to the caseins[15] . The results showed that there were no significant differences in pH and protein ratio . The results showed that protein recovery in ricotta cheese made from whole milk was higher than ricotta cheese made from whey only, and this was due to the fact that more milk proteins are available in milk in comparison with whey and these proteins are linked to each other by ion bridge result from Iron addition[16] and crosslinking between κ-casein and β-lactoglobulin during heat treatments[17].

Table (2): Composition of ricotta cheese made from whole milk

Sample	Yield (%)	pH	Total solids (%)	Protein (%)	Ash (%)	Moisture (%)
Control 2	25^{b}	5.9^{a}	37.710^{a}	20.450^{a}	5.520^{b}	62.153^{c}
MF1	25^{b}	5.76^{a}	36.656^{b}	20.560^{a}	1.157^{a}	63.345^{b}
MF2	27^{a}	5.9^{a}	35.664^{c}	20.110^{a}	1.115^{a}	64.005^{a}

N=3, p < (0.05)

Table (3) shows the chemical composition of ricotta cheese made from a mixture of fresh milk12% and whey. The yield increased by the increasing of iron addition. There were no significant differences in pH, protein . protein recovery increased in this type of cheese compared with treatment 1 ricotta cheese that made from whey only because casein presence in fresh milk lead to increase protein ratio in the mixture used to prepare ricotta cheese which allow binding of iron to major milk proteins, i.e. caseins and whey proteins[18].

Table (3): Composition of ricotta cheese made from a mixture of fresh milk12% and whey

Sample	Yield (%)	pH	Total solids (%)	Protein (%)	Ash (%)	Moisture (100%)
Control 3	11^{b}	5.833^{a}	30.8^{a}	19.380^{a}	0.557^{c}	69.2^{c}
MWF1	11^{b}	5.867^{a}	30.514^{b}	19.110^{a}	0.733^{b}	69.480^{a}
MWF2	25^{a}	5.9^{a}	30.636^{ab}	19.02^{a}	0.918^{a}	69.354^{b}

N=3, p < (0.05)

As shown in the table 4 , 5 ,6 hardness increased significantly with increasing iron. Hardness is a vital factor which limited the properties of cheese , this increase is related to the increase in the number and strength of cross-linking of the milk proteins by ions[19]. The results also indicate that cheese hardness increased with the increment of milk proteins concentration and this increase may be related to the effect of increasing of protein on the higher number and strength of bonds between milk proteins and iron [20].

Table (4): hardness (gm) and Fe (ppm) of ricotta cheese made from whey

Sample	Hardness (gm)	Fe concentration (ppm)
Control 1	70^{c}	16.131^{c}
WF1	215.667^{a}	27.524^{b}
WF2	176.33^{b}	41.204^{a}

N=3, p < (0.05)

Table (5): hardness (gm) and Fe (ppm) of ricotta cheese made from whole milk

Sample	Hardness (gm)	Fe concentration (ppm)
Control 2	446.667^{b}	17.254^{c}
MF1	503.433^{b}	20.310^{b}
MF2	602.5^{a}	33.729^{a}

N=3, p < (0.05)

Table (6): hardness (gm) and Fe (ppm) of Ricotta cheese made from a mixture of fresh milk12% and whey

Sample	Hardness (gm)	Fe concentration (ppm)
Control3	200.467^{c}	17.450^{c}
MWF1	290.8^{b}	29.621^{b}
MWF2	389^{a}	32.896^{a}

N=3, p < (0.05)

Table (7) summarizes the mean scores for sensory attributes of the ricotta cheese ,the result indicated slight differences of the various sensory

parameters of cheese samples. There were significant differences $p < (0.05)$ of ricotta cheese flavor , texture and bitterness . Generally, the panelist highly accepted ricotta cheese WF1 and WF2 when compared to control 1. However, there were no significant differences in appearance, body and overall of the various cheese types.

Table (7): Organoleptic properties of ricotta cheese made from whey

Sample	Flavor (40)	Texture (15)	Appearance (10)	Body (15)	Bitterness (20)
Control1	36.5^{a}	13.8^{a}	7.2^{a}	13.9^{a}	18.1^{a}
WF1	35.9^{ab}	13.2^{ab}	6.8^{a}	13.6^{a}	16.9^{ab}
WF2	34.7^{b}	12.4^{b}	6.9^{a}	13.1^{a}	16.2^{b}

N=3, $p < (0.05)$

In table (8) there were no significant differences in appearance, body of the various cheese types. However There were significant differences $p < (0.05)$ of ricotta cheese flavor , texture . Generally, the panelist highly accepted ricotta cheese when compared to control however the cheese was fortified with iron 25ppm and 45ppm. Sensory profile is the most important characteristic that contributes to the overall quality of cheese. It is the property by which consumer first identifies and judges the specific variety.

Table (8): Organoleptic properties of ricotta cheese made from whole milk

Sample	Flavor (40)	Texture (15)	Appearance (10)	Body (15)	Bitterness (20)
Control2	36.8^{a}	12.7^{a}	6.6^{a}	13^{a}	16.7^{a}
MF1	35.9^{ab}	12.2^{ab}	5.8^{a}	12.6^{a}	14.8^{a}
MF2	34.8^{b}	11.5^{b}	5.8^{a}	12.3^{a}	14.8^{a}

N=3, $p < (0.05)$

Table(9) shows result of the sensory evaluation of ricotta cheese made from a mixture of fresh milk12% and whey, MWF1 and MWF2 there were no significant differences in flavor , body and bitterness of the cheese , this indicate that the addition of iron did not affect the sensory evaluation. Similar results were published by [21].

Table (9) : Organoleptic properties of ricotta cheese made from a mixture of fresh milk12% and whey

Sample	Flavor (40)	Texture (15)	Appearance (10)	Body (15)	Bitterness (20)
Control3	32.2^{a}	13.1^{a}	6.5^{a}	13.3^{a}	17.4^{a}
MWF1	32.4^{a}	12.4^{a}	6.6^{a}	12.5^{a}	16.7^{a}

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MWF2	31.4[a]	11.2[b]	5.4[b]	12.1[a]	16.8[a]

Conclusion

It can be concluded that iron fortification using ferrous sulphate had a significant effect on chemical composition and sensory attributes of ricotta cheese; at an optimal dosage of 25 and 45ppm. From the results of this study it is recommended to encourage the local dairy industry in Kurdistan Region in Iraq and to introduce ricotta cheese so as to meet the local need and to use whey in the other dairy products.

References:

[1] Pires, A.F.; Marnotes, N.G.; Rubio, O.D.; Garcia, A.C.; Pereira, C.D. 2021. Dairy by-products: A review on the valorization of whey and second cheese whey. *Foods, 10, 1067.*

[2] Modler, H.W. and Emmons, D. B. 2001. The Use of Continuous Ricotta Cheese Processing to reduce ingredient cost in further processed cheese products. *International Dairy Journal 11:517-523.*

[3] Pizzillo, m, Claps; Cifunj, G.F.; Fedel, V. and Rubion, R. 2005. Effect of Goat Breed on the Sensory, Chemical and Nutritional Characteristics of Ricotta Cheese *Live Stock Production Science 94:33-40.*

[4] Maubois, P.L. H., Ottogalli, G, and Fax, P. F, 2004. Diversity of Cheese Varieties: an overview, in Cheese; Chemistry, Physics and Microbiology Vloume 2 Major Cheese Group, 3rd edn, P. F. Fox, P. L. H. McSweeney, T. M. Cogan and T. P.Guinee (eds), *Elsevier Academic Press, Amsterdam, pp. 1-22.*

[5] Ugo P , Alessandro M , Angelo G and Francesca Garganese (2021): Cheese Fortification: Review and Possible Improvements. Article in Food Reviews

[6] Petranovie D, Batinae T, Ruzie A, Ruzie T (2008) Iron deficiency anaemia influences cognitive function. Med Hypotheses 70:70–72

[7] Lucey, J.A. in Encyclopedia of Dairy Sciences, 2002 CHEESE | Acid and Acid/Heat Coagulated Cheese.

[8] Moneim E. Sulieman, Aisha S. Eljack, Zakaria A. Salih(2012) Quality Evaluation of "Ricotta" Cheese Produced at Laboratory Level; *International Journal of Food Science and Nutrition Engineering 2(6): 108-112.*

[9] AOAC. (2000). Association Of Official Analytical Chemists, Official Methods of Analysis (17th Ed.). Arlington, VA. USA

[10] Bonczar G, Wszołek M, Siuta A. 2002. "The effects of certain factors on the properties of yoghurt made from ewe's milk." Food Chemistry 79 (1): 85-91.

[11] Khan, N., Jeong, I. S., Hwang, I. M., Kim, J. S., Choi, S. H., Nho, E. Y.,& Kim, K. S. 2014. "Analysis of minor and trace elements in milk and yogurts by inductivelycoupled plasma-mass spectrometry (ICP-MS)." Food Chemistry 220-224.

[12] Elham A. El-Den The Chemical and Microbiological Properties of Ricotta Cheese Supplemented with Curcumin and Bifdobacteria, Egyptian Journal of Food Science.

[13] Redwan E.M., Uversky V.N., El-Fakharany E.M., Al-Mehdar H. Potential lactoferrin activity against pathogenic viruses. *Comptes Rendus Biol.* 2014;337:581–595.

[14] Agnieszka Rodzik, Paweł Pomastowski , Gulyaim N. Sagandykova , and Bogusław Buszewski ,(2020) Interactions of Whey Proteins with Metal Ions. *International journal of molecular science.*

[15] Raouche, S., Dobenesque, M., Bot, A., Lagaude, A., and Marchesseau, S. (2009). Casein micelles as a vehicle for iron fortification of foods. *European Food Research and Technology, 229(6), 929-935.*

[16] Kinsella, J. E., Whitehead, D. M., Brady, J . and Bringe, N. A. (1989).Milk proteins. possible relationships of structure and function. In Developments in Dairy Chemistry-4 Functional Milk Proteins, pp. 55–93. Fox P. F ed. London,.UK: Applied Science Publishers.

[17]Corredig, M. and Dalgleish, D. G. (1999). The mechanisms of the heat-induced interaction of whey proteins with casein micelles in milk. Int. *Dairy J. 9, 233-236.*

[18] Kibangou IB., Bouhallab S., Henry G., Bureau F., Allouche S., Blais A., Guérin P., Arhan P. and Bouglé DL. (2005). Milk Proteins and Iron Absorption: Contrasting Effects of Different Caseinophosphopeptides. *International Pediatric Research Foundation, Inc. Vol. 58, No. 4, pp 731-734.*

[19]Lee, Y. H. and Marshall, R. T. (1984). Strength of rennet curd made from milk and.chemically modified soy proteins, *Journal of Dairy Science, 67,263-269.*

[20] Mittal, V.A., A. Ellis, A. Ye., S. Das and H.Singh. (2015). Influence of calcium depletion on iron-binding properties of milk. *Journal of Dairy Science, Vol. 98, Issue 4, pp 2103-2113.*

[21] Zhang, D.; Mahoney, A. W. Iron fortifcation of process cheddar cheese. *J. Dairy Sci.* 1991, *74*(2), 353–358.