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Cheese Analogues

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Review Article

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ABSTRACT

Cheese analogue or imitation cheese with its other name, mozzarella cheese analogue (MCA) is defined as products made milk, dairy fat and other ingredients namely protein in the presence of emulsifying salts by the use of particularly vegetable-originated different non-milk constituents under the influence of thermal and mechanical energy. Cheese analogue production is also, such as the production of other cheeses, heating, mechanical processing, cutting and emulsifying with salts. They are being preferred due to their cost-effectiveness and the simplicity of their manufacture. Due to textural and functional properties (easily meltable, cuttable, stretching etc.) cheese analogues are preferred especially in pizza products.

INTRODUCTION

It has been known that for a long time, human beings consume milk and dairy products which have a significant place in nutrition. It has been estimated that there are 2000–4000 types of cheese all over the world. Some of them are commercially produced in large amounts and some are locally produced and sold [1,2]. Cheese is categorized in many aspects regarding to the criteria such as coagulation agent, ripening condition, fat rate, water rate and boiling the curd. Coagulation, the main production phase for all cheese types, is the transition of milk from liquid to gel (curd) as a result of the decomposition of protein fractions stabilization. Milk coagulation is achieved through three methods which are rennet addition, acid addition or heat treatment with acid addition. Cheese types produced through adding rennet to the milk are described as rennet-curd cheese and 77% of world cheese production consists of this type of production [3,4]. Cheddar, Gouda, Emmental, White, Kashar and Tulum cheese can be regarded as sample of rennet-curd cheese; Cottage and Quark cheese as of acid-curd cheese and Ricotta and Sapsago as sample of cheese produced through heat treatment with acid addition.

Cheese analogue known as imitation cheese or Mozarella type cheese (MCA) is defined as a cheese-like type of cheese which is produced from components such as milk, milk fat and protein or through using vegetable-based substances other than milk in the presence of emulsifying salts with the effect of thermal and mechanic energy. Cheese analogue is considered as a engineering product and according to Shaw [5] it is classified into three groups which are

(i) Produced through milk (casein, caseinates, milk fat, etc.),
(ii) Produced through using partial milk (casein, caseinates, milk fat and soya oil, etc.)
(iii) Produced through components other than milk (soya protein, soya oil, etc.).

CHEESE ANALOGUES PRODUCTION

Although cheese anologue was defined by Shaw [5], its popularity increased after 2000. When compared to the production of other cheese types, cheese analogue has a diversity of formulation and as it can be understood from its categorization, hundreds of production formulation can be obtained. Milk, milk fat, rennet casein, vegetable oil, salts, acids and flavor agents are used for its production. Besides, its composition is enhanced with vitamins and minerals and other additives. Ingredients used in cheese analogue production are given in **Table 1**.

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Table 1: Ingredients used in the manufacture of cheese analogues.

Ingredients	Stimulant / Function	Sample
Fat	Desired composition, texture and dissolvability, milk product taste	Butter, soya bean / corn / palm kernel oil
Milk proteins	Desired composition, semi-hard texture, sliceable, flowability and elasticity, physico-chemically stable product formation	Casein, caseinates, whey
Vegetable proteins	Desired composition, less price according to casein	Soya bean / peanut / wheat protein
Starch	Replacement instead of casein and price advantage	Natural / modified corn / rice / potato starch
Stabilizers -ES - Hydrocolloids	Physico-chemically stabile product formation, textural and functional properties, product stability development	Na-phosphates, Na-citrates, hydrocolloids; guar gum, xanthan gum
Acidifying agents	Last product pH control	Organic acids, lactic acetic, citric, phosphoric
Flavourings	Taste development especially in cheese	Enzyme-modified cheese, starter extract, smoke extract, spices
Flavour enhancers	Taste development	Salt, yeast extract
Colouring agents	Desired colour	Annatto, paprika, artificial colouring agents
Preservatives	Mold development avoiding, long shelf life	Nisin, K-Sorbat, Ca/Na-Propionate
Minerals and vitamins	Improve nutritive value	Mg-oxide, Zn- oxide, iron, Vitamin A palmitate, riboflavin, thiamin, folic acid

Due to their nutritive and functional properties such as fat emulsification, casein derivatives are commonly used in cheese analogue production. Cheese analogue demonstrates better properties than known cheese types during storage in terms of fat leaking, texture thickness and sliceable. Its resistance is more than the other types, thus it is started to be produced in a wide spreading amount nowadays. Cheese analogues used especially for pizza are produced by using rennet casein, acid casein, vegetable oil mixtures and other functional additive substances (ES: Emulsifying salts etc.) [6-10]. A typical MCA formulation is determined by Guinee et al. [11] as casein and caseinates 18-24%, vegetable oil 22-28%, starch 0-3%, ES 0.5-2, sweeteners and flavorants 0.5-3%, stabilizer 0-0.5%, acidifiers 0.2-0.36%, colourants 0.04%, preservatives 0.10% and water content 45-55%.

As in the other cheese production, cheese analogue production includes processes like heat treatment, mechanical processing-fragmentation and emulsifying with salts. Cheese analogue produced commercially especially in developed countries with various methods and properties and the production techniques are patented. Advantages of cheese analogue production can be accepted as use of maltodextrin, casein and etc. which are cheaper than usual milk dry matter, simple production method, less labor and equipment for production [8].

It is known that consumers tend to prefer foods containing low saturated fat and less salt. If the cheese analogue is produced with low fat and less salt, the physical properties, such as appearance, texture, flavour, melting features and other relevant properties of it improve [12]. In the pasteurized cheese production, the effects of some parameters on the textural properties of cheese are examined. When the rate of ES concentration is between 0-0.5%, textural properties (the values of firmness, elasticity, spreadability, heating and viscosity) of the cheese increase while textural properties are negatively affected if the rate of ES is between 0.5-3.0%. Although the value of textural properties decrease when the proteolysis degree rises, it is positively affected with an increase in casein level. When the moisture content and pH level in the composition of cheese production increase, firmness and elasticity values decrease but spreadability value rises. On the other hand, during the cheese production process with an increase in the temperature, firmness and elasticity values increase but spreadability and heating viscosity values decrease [11].

pH adjustment is a significant stage in cheese analogue production process and generally citric, lactic, adipic or malic acid is used to adjust this level. It is stated that the pH adjustment with lactic acid reveals positive consequences. Besides, using a little amount of cheese enzyme or starter culture to achieve a desirable flavour is acceptable. Water used during the cheese production process aids casein, maltodextrin, salt, flavour agents and emulsifying salts dissolve and it also determines the last moisture content of the product [13]. With the use of casein melted in water for cheese analogue production, the moisture content of cheese increases and thus, the desirable moisture content (47-50%) and efficiency is achieved as in the natural mozarella cheese. Without using stabilizer, the desired sliceable properties and the properties of less stickiness cannot be reached [7]. For cheese analogue production, maltodextrin using contributes to decrease the firmness resulting from the use of casein, to improve the chewiness of cheese and to fix the melting feature of cheese. If merely casein is used in cheese analogue production, undesirable extensive firmness and gum like cheese product occurs. By using maltodextrin, moisture content of the composition rises and sliceable properties improve [8].

The type of emulsifying salt, fat and protein used for cheese analogue production affects the functional properties of cheese significantly [14]. Emulsifying salts assist rennet casein dissolve. Emulsifying salts adjust the melting feature of the cheese by reacting to protein and fat [8]. It is determined that melting properties are directly proportional to high pH level, soft texture, high rate of dissolved casein and low emulsifying fat [15]. Rennet casein consists of calcium paracasein which has an insoluble structure. It becomes soluble, that is phosphate paracaseinate, by the support of heating treatment and emulsifying and calcium separating salts such as disodium phosphate (DSP) or trisodium citrate (TSC) [16]. Emulsifying salts used in cheese analogue production not affect directly as surfactant like emulsifiers. They perform calcium binding/enclosing and pH adjustment and provide protein dis-

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persion and hydration, in other words they cause a homogenous distribution of proteins in the structure and assist proteins bind free water in environment. Emulsifying salts which improve the emulsifying property of proteins cause protein hydration with this mechanism and provide combination of ion exchange process with pH controlling property. As a result of these effects, cheese analogue waited in cold-storage in the end of production process gains a homogenous structure. Depend on the concentration in formulation and the type of emulsifying salts, the ability of protein hydration and fat emulsion are shaped with the binding by emulsifying salts. Commonly used emulsifying salts are phosphates and citrates. With the use of phosphates and citrates together, a type of cheese with a favorable firmness and a desirable melting property. Moreover, thanks to the antimicrobial properties of phosphates, the product can be preserved better from microorganisms. The same amount of phosphate-ES has a better ability of calcium binding than the ability of citrate-ES. Chelating ability of phosphates increases depending upon the amount of them in the P_2O_5 composition and are ranged as poly->pyro->ortho-phosphates [6,11,17]. The properties and composition of emulsifying salts used in cheese production are demonstrated in **Tables 2** and **3**.

Table 2: Properties of emulsifying salts used in pasteurized cheese production.

Group	Common used forms	Physico-chemical change during process			
		Calcium chelating	Buffering	Para-casein hydration	Oil emulsification
Citrates	Trisodium citrate	Low	High	Low	Low
Ortho-phosphates	Disodium phosphate	Low	High	Low	Low
	Trisodium phosphate				
Condensed phosphates					
Pyrophosphates	Disodium pyrophosphates	Medium	Medium	Very High	Very High
	Trisodium pyrophosphates				
	Tetra sodium pyrophosphates				
Polyphosphates	Pent sodium tripolyphosphates	High	Low	High	Very High
	Sodium tetrapolyphosphates	Very High	Very Low	Low	Low
	Long-chain polyphosphates				

Table 3: Properties and composition of emulsifying salts used in cheese production.

Group	Emulsifying Salts	P_2O_5 content (%)	Solubility (%, 20°C'de)	pH (%1 solution)
Citrates	Monosodium citrate monohydrate	-	16.8	3.75
	Trisodium citrate dehydrate	-	75	8.55
	Trisodium citrate undekahydrate	-	79.4	7.95
Orthophosphates	Sodium dehydrogenate phosphate (SDP)	59	85.2	4.5
	SDP monohydrate	51	-	4.5
	SDP dehydrate	45	39.9	4.5
	Disodium hydrogen phosphate (DSP)	50	9.3	9.1
	DSP dehydrate	40	80	9.1
	DSP heptahydrate	26	-	9.1
	DSP dodekahydrate	20	2.0	9.1
	Trisodium phosphate (TSP)	44	11	11.9
	TSP hemi hydrate	41	-	11.9
	TSP dodekahydrate	19	-	11.9
Pyrophosphates	Disodium pyrophosphate	64	13	4.1
	Trisodium pyrophosphate	35	32	6.7-7.5
	Tetrasodium pyrophosphate	32	10	10.2
Poliphosphates	Pentasodium Tripoli phosphate	58	14.6	9.7
	PSTPP hekzahydrate	45	-	9.7
	Sodium tetrapoliphosphate	60	170.0	8.5
	Sodium hekzametaphosphate	70	157.0	8.6
Al-phosphates	Sodium aluminum phosphate	-	-	8.0

Studies on cheese analogues

Ripening of cheese analogues produced with casein and caseinates derivatives are originated from proteolysis during the storage period. These type of cheese do not contain any coagulators or starter bacteria, they take their final form as a result of some rheological changes from which a proteolytic enzyme named plazmin is responsible [18,19]. Plasmin (brinolysin E.C.3.4.21.7) is a kind of enzyme similar to trypsin and is activated in 37,3°C and 7,0 pH. Plazmin can be found in cow milk in zymogen and

plasminogen form and in 85-90% rate and it is changed into plasmin form by urokinase and some other activators. It is determined that plasmin activity is not effected by pH and salinization method or amount but it is increased parallel to the cooking temperature. Plasmin, plasminogen and plasminogen activators are found together with rennet micelles and rennet casein in milk, but as plasmin and plasminogen inhibitors are present in the serum, they are throwed away whey production. Plasmin and plasminogen amount in the milk increases toward the end of lactation and through the transition to the milk from the mammary gland with mastitis infection [20]. Mulvihill et al. [18,21] stated that in cheese analogue produced with rennet casein, the milk in the end of lactation contains more plasmin than the milk in the middle lactation of the products; in the cheese production with rennet casein, plasmin is the proteolytic agent and is the main cause starting casein hydrolysis. Mulvihill and McCarthy [19] revealed that proteolysis increases by storage while firmness, viscosity and chewiness properties of the cheese decrease. They also stated that compared to plasmin, non-starter lactic acid bacteria (NSLAB) are not effective to start casein hydrolysis, but play a major role after the formation of casein-peptide derivatives. *Lactobacillus* have peptidase, dipeptidase, tripepditase, carboxypeptidase, aminopeptidase and endopeptidase and proteinase enzymes and utilize these enzymes to get the required amino acids for their development. These enzymes are formed by isolating peptids and free amino acids from the hydrolyzed casein. Plasmin and these microbial enzymes struggle in a combined way during the storage period and rise the number of free amino acid to maximum level. In the study of O'Malley et al. [21] although cheese analogue was produced at high temperature levels, an increase was observed especially in the number of lactic acid bacteria at 8°C. With this increase, plasmin had a significant role in the rise of proteolytic derivates of cheese analogue produced with rennet casein and then NSLAB effect was observed. In the cheese analogue stored at 8°C for 30 days, when NSLAB used as dominant flora, the total aerobic mesophilic bacteria number (TAMB) rised from 10^4 cfu/g to 10^7-10^8 cfu/g. Badem [22] applied cheese analogue production method to Kashar cheese production and Kashar cheese production was carried out by adding rennet casein in various amounts without using starter culture. With rennet casein adding, pH and titration acidity levels changed in a statistically significant amount in Kashar cheese production ($p<0.05$). Besides, during the 90-days ripening period, the number of NSLAB reached from 10^5 cfu/g to 10^7 cfu/g and the number of TAMB reached from 10^4 cfu/g to 10^6 cfu/g.

Water holding capacity has been defined as the prevention of water from three dimension structure of food matrix [23]. By increasing the protein content in cheese water binding ability of the curd also increased [24]. This situation derives from the interaction between water and protein due to the factors like load of protein matrix, hydrophobic interactions, hydrogen bonds, S-S bonds, van der Walls bonds, protein ionic bonds, ion types, pH and heat. By proteins' water holding capacity, microbial growth take places more slowly. Ennis and Mulvihill [16] has produced 44 different rennet casein originated MCA and determined that 0.4% DSP rate is a good indicator to measure the water intake performance of casein (maximum viscosity index and maximum viscosity index reached). Ennis and Mulvihill [25] has determined that high amount of furosin in casein has increased the maximum viscosity index reached correlatively. Ennis et al. [26] used dipotassium orthophosphate and diammonium orthophosphate salts in cheese analogue production. In cheese analogoue samples, different hydration abilities and calcium chelating has occurred. It is stated that by using potassium and ammonium salts instead of sodium hasn't made any positive effect.

Jana et al. [7] produced cheese analogoue by using hydrocolloid at different amounts. Cheese analogoue added Xanthan (XG)-Locust bean gum (LBG) has been chosen as the best cheese analogoue and has been determined appropriate for pizza cheese production depending on its firmness and sensorial properties. Jana et al. [27] has determined that cheese produced with carrageenan are more firm than XG and LBG.

CONCLUSION

Cheese analogues, firstly because they are new products, are still studied on their formulation, that's why they have a wide range of production technique and formulation differences. Besides as they are not natural products consumers remain distant. And also because it is a new product there aren't any laws and regulations yet. Cheese analogues which is widely used in pizza production is preferred because of its simple production process and because it is produced at very reasonable prices according to other cheese.

REFERENCES

1. Kamber U and Sireli UT. Some chemical and microbiologıcal quality of surke. Food. 2007;32:123-127.
2. Gulmez M and Güven A. Some microbiological and chemical properties of cecil (civil) cheeses sold in Kars Turkey. Kafkas Univ Vet Fak Derg. 2001;7:63-70.
3. Fox PF. Proteolysis during cheese manufacture and ripening. Journal of Dairy Science. 1989;72:1379-1400.
4. Fox PF and McSweeney PLH. Proteolysis in cheese during ripening. Food Reviews International. 1996;12:457-509.
5. Shaw M. Cheese substitutes: threat or opportunity?. Journal of the Society of Dairy Technology. 1984;37:27-31.
6. El-Bakry M, et al. Effects of emulsifying salts reduction on imitation cheese. Journal of Food Engineering. 2010;100:596-603.

7. Jana AH, et al. Quality of casein based mozzarella cheese analogue as affected by stabilizer blends. International Journal of Food Science and Techology. 2010;47:240-242.

8. Shah R, et al. Process standardization for rennet casein based mozzarella cheese analogue. International Journal of Food Science and Techology. 2010;47:574-578.

9. Mounsey JS and O'Riordan ED. Alteration of imitation cheese structure and melting behavior with wheat starch. European Food Research and Technology. 2008;226:1013-1019.

10. Mounsey JS and O'Riordan ED. Modification of imitation cheese structure and rheology using pre-gelatinised starches. European Food Research and Technology. 2008;226:1039-1046.

11. Guinee TP, et al. Pasteurized processed cheese and substitute/imitation cheese products. In: Cheese: chemistry, physics and microbiology, Major cheese groups. Elsevier Ltd. 2004;2.

12. Eymery and Pangborn RM. Influence of fat, citric acid and sodium chloride on texture and taste of a cheese analog. Sciences des Aliments. 1988;8:15–32.

13. Jana AH and Upadhyay KG. Mozzarella cheese analogue - a review. International Journal of Food Science and Techology. 2003;40:1-10.

14. Noronha N, et al. Influence of processing parameters on the texture and microstructure of imitation cheese. European Food Research and Technology. 2008;226:385-393.

15. Cavalier-Salou C and Cheftel JC. Emulsifying salts influence on characteristics of cheese analogs from calcium caseinate. Journal of Food Science. 1991;56:1542-1551.

16. Ennis MP and Mulvihill DM. Compositional characteristics of rennet caseins and hydration characteristics of the caseins in a model system as indicators of performance in mozzarella cheese analogue manufacture. Food Hydrocolloids. 1999;13:325-337.

17. El-Bakry M, et al. Effect of chelating salt type on casein hydration and fat emulsification during manufacture and post-manufacture functionality of imitation cheese. Journal of Food Engineering. 2011;102:145-153.

18. Mulvihill DM and McCarthy A. Relationship between plasmin levels in rennet caseins and proteolytic and rheological changes on storage of cheese analogues made from these caseins. Journal of Dairy Research. 1993;60:431-438.

19. Mulvihill DM and McCarthy A. Proteolytic and rheological changes during aging of cheese analogues made from rennet caseins. International Dairy Journal. 1994;4:15-23.

20. Farkye NY and Fox PF. Observation of plasmin activity in cheese. Journal of Dairy Research. 1990;57:413-418.

21. O'Malley AM, et al. Proteolysis in rennet casein-based cheese analogues. International Dairy Journal. 2000;10:743-753.

22. Badem A. The Effects of Rennet Casein on the Chemical, Microbiological and Sensory Properties of Kashar Cheese. Selcuk University, Health Sciences Institute. 2015;1-126.

23. Chantrapornchai W and McClements DJ. Influence of NaCl on optical properties, large-strain rheology and water holding capacity of heat-induced whey protein isolate gels. Food Hydrocolloids. 2002;16:467–476.

24. Rodriquez J. Recent advences in the development of low-fat cheeses. Trends in Food Science & Technology. 1998;9:249-254.

25. Ennis MP and Mulvihill DM. Maillard reactions contribute to variability in hydration characteristics of rennet caseins in solutions of a calcium sequestering salt. International Journal of Dairy Technology. 1999;52:156-160.

26. Ennis MP, et al. The effect of varying the calcium-sequestering salt cation on the hydration behaviour of rennet caseins in a simple model system. International Journal of Dairy Technology. 2000;53:41-44.

27. Jana AH, et al. Quality of casein based mozzarella cheese analogue as influenced by stabilizers. International Journal of Dairy Technology. 2008;45:454-456.