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The influence of the degree of cheese maturation used as raw materials in the manufacture of processed traditional cheese on emulsifying salts consumption

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Abstract

The aim of this research was to optimize the use of emulsifying salts by using matured cheese as raw materials. The duration of the melting process for experimental variants was in inverse correlation to the percentage of raw mature materials used in experimental recipes. Melting time dynamics were very similar to the experimental variants with addition of emulsifying salts.

Keywords: emulsifying salts, processed cheese, chemical composition

Introduction

Cheese is one of the most widely used ingredients in prepared foods for imparting taste, texture and nutritional qualities [1]. They are very suitable for the food service industry, and they have a relatively long shelf life [2]. Processed cheese is manufactured by heating and blending comminuted cheeses of different types and maturity into a homogeneous mass in the presence of emulsifying salts (ES) [3] and other dairy and non-dairy ingredients followed by heating and continuous mixing to form a homogeneous product with an extended shelf life [4-7]. Traditionally, processed cheese was made by heating and stirring a mixture of natural cheeses, chelating salts, fats and water at a temperature between 70 ^{0}C and 95 ^{0} C for a short period of time (about 5–10 min) [8].

Processed cheese may have different forms – i.e. block, slice, spread – but must contain natural cheese. Products which do not meet this requirement must be labeled as cheese imitations or as analogues [9]. The main characteristics of cheeses are type, flavor, maturity, consistency, texture and pH [10]. For a given cheese variety, variations in cheese composition (e.g., pH, calcium-to-casein ratio, and the level of intact casein) can occur owing to variations in milk composition, cheese making conditions, and degree of maturation [11].

The standards of cheese quality require that these products have optimal fat and moisture content as the, cheese from which they are made [12,13]. The emulsifying salts most commonly used are sodium citrates, sodium hydrogen orthophosphates, sodium polyphosphates, and sodium aluminum phosphates [14]. Trisodium and disodium phosphate were reported to produce the most pronounced melting effects, while Kasal and Kasomet proved to be ineffective. Sodium citrate induced significant melting only at the highest tested concentration (3.0%) [15]. Emulsifying salts are often considered to act as Ca^{2+} chelating agents [6]. They play a major role in the formation of the processed cheese gel network. The two main functions of emulsifying salts are chelation of calcium (that aids in breaking the calcium-phosphate cross-linked protein network present in natural cheese) and pH adjustment

[17]. Applying an appropriate mixture of emulsifying salts causes an increase of the cheese blend pH from 5.0–5.5 up to 5.6–5.9 and, furthermore, contributes to pH stabilization due to its buffering capacity [18-20]. Due to this particular pH increase, the calcium-masking ability of the emulsifying salts is increased by the negative charges on the para-caseinate, thus promoting a concomitant increase in hydration and solubility of para-casein and the formation of a stable product [21]. In their absence, processing would generally lead to the formation of a heterogeneous, gummy, pudding-like mass that undergoes extensive oiling-off and moisture exudation during manufacture and on cooling [22].

The real art of combining various emulsifying salts comprises of bringing individual components into such a combination that positive characteristics of the salts strengthen processing and subsequent keeping quality, whereas negative characteristics are compensated so as to have no effect on the process [23]

The goal of this research is to optimize the use of emulsifying salts by using cheese seasoned raw materials. It also aims to improve the organoleptic, physico-chemical, biological and nutritive features of the processed cheese.

Materials and methods

Chemicals

All reagents used in the research had analytical purity and were purchased from Merck ROMANIA SRL.

Emulsifying (melting) salts addition

Two types of emulsifying salts commonly have been used. These were noted as S9 and S90. From technological point of view the salt S90 gives a consistency of the finished product and a low capacity of ionic exchange and S9 gives a lower consistency of the finished product and a higher capacity of ion exchange.

The traditional Sibiana cheese production

The traditional Romanian Sibiana cheese recipe has been chosen (having 55% water content and 45% fat dry weight. Chemical composition of raw materials from standard recipes were taken into account with the values given in **Table 1**

Table 1. Composition of raw materials used in the standard recipe

Range	Dry weight (%)	Fat dry weight (%)
Sibiana cheese	55	45
Fresh fat cheese	46	45
Butter with 74% fat	75	98
Skimmed milk powder	98	0
Emulsifying salts	100	0

In the present research two kinds of cheese raw materials have been chosen, namely Sibiana fermented cheese matured for 110 days, and fresh cheese after 48 hours of production. Both of them have been combined in different proportions described as experimental variants.

Experimental variants of processed cheese have been chosen on the criterion of changing the report of dry weight content from ripened /unripened cheese (Table 1). The amount of dry weight from ripened and unripened cheese remained constant for each experimental variant and also has been equal with the control blank (41.55 kg). The recipes have been calculated in accordance with the recommended addition of 3% emulsifying salts.

- **Control sample (M)**: percentage of dry weight was from ripened Sibiana cheese.
- **Sample P1:** percentage of dry weight was from fresh cheese reported to the amount of dry weight from raw material cheeses (100%) and from fermented Sibiana cheese (0%).
- **Sample P2**: percentage of dry weight was from fresh cheese reported to the amount of dry weight from raw material cheeses (75%) and from fermented Sibiana cheese (25%).
- **Sample P3**: percentage of dry weight was from fresh cheese reported to the amount of dry weight from raw material cheeses (50%) and from fermented Sibiana cheese (50%).
- **Sample P4**: percentage of dry weight was from fresh cheese reported to the amount of dry weight from raw material cheeses (25%) and from fermented Sibiana cheese (75%).
- **Sample P5**: percentage of dry weight was from fresh cheese reported to the amount of dry weight from raw material cheeses (0%) and from fermented Sibiana cheese (100%).

Physico-chemical parameters of raw materials and cheese evaluation

Dry weight content

The total dry weight content of processed cheese was determined in accordance with the method described in ISO 5534:2004I [22]

Fat content

The fat content of processed cheese was determined in accordance with the method described by Van Gulik method (ISO 3433:2008) [23]**.** The fat content in skimmed milk powder was determined in accordance with the method described in ISO 1736:2008 [27]. The fat content in butter was determined in accordance with the method described in ISO 17189:2003 [28]

Protein content

The protein content of processed cheese was determined in accordance with the method described in Kjeldahl method [24].

pH value

The pH value was determined in accordance with the method described in ISO 5546:2010 [25] and was measured potentiometrically by using a pH meter (model inoLab® pH 720 and pH electrodes model (SenTix® FET).

Moisture content

The moisture content of processed cheese was determined in accordance with the method described in ISO 17189:2003 [26].

Statistical analysis

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation ($\bar{x}$ ± SD). Statistical analysis was conducted using the IBM SPSS Statistics version 20 packet program for Windows (SPSS, Chicago, IL, USA). Significant differences between the means were studied using the F-test (Fisher) test at all the levels of (P-value <0.05).

Results and discussions

In Table 2 are presented the main physico-chemical parameters for the raw materials used for cheese variant preparing.

By comparing the parameters of the two lots of used cheeses can be observed that the dry weight of ripened Sibiana cheese had a value of 11.1% which was higher than the fresh fat cheese. The content of protein and fat (% dry weight) presented very close values as well.

The pH value of Sibiana ripened cheese was with 0.69 units higher than the fresh cheese, which indicates a high level of cheese ripening.

Table 2. Physico-chemical parameters for the raw materials

Raw material	Dry weight content (%)	Fat		Protein (%)	pH
		(%)	(%, dry weight)		
Fresh cheese (at 48h from fabrication)	48.5±1.2	23.0±0.5	47.3±0.2	25.12±0.5	4.81±0.01
Ripened Sibiana cheese (at 110 days from fabrication)	59.6±2.5	28.4±0.2	47.6±0.1	24.54±0.3	5.5±0.02
Skimmed powder milk	98.0±5.2	0.5±0.1	0.5±0.4	-	-
Butter of 74% fat content	75.0±1.1	74.0±0.5	98±0.8	-	-
Emulsifying salts	100±3.2	-	-	-	-

Values are expressed as the mean ± standard deviation of three determinations, there are no significant differences.

In order to achieve the optimal effect of melting, it was very important to analyze few parameters as pH, dry weight (%) and the fat content (%) of the cheeses mixture before melting (Table 3). These analyses have been done in order to achieve the physical and chemical characteristics of the final product and to choose the correct emulsifying salts and their effective dosage.

Table 3. Physico-chemical parameters for the mixture variants

Parameter	Variants					
	M	P1	P2	P3	P4	P5
pH	5.68±0.02	4.95±0.02	5.11±0.03	5.30±0.01	5.58±0.02	5.71±0.04
Dry weight (%)	43.4±2.2	43.31±1.5	43.40±0.3	43.51±0.4	43.30±0.2	43.40±0.1
Fat (% dry weight)	48.1±1.2	48.22±3.2	48.01±2.1	48.10±2.4	48.30±1.3	48.21±2.0

Values are expressed as the mean ± standard deviation of three determinations, there are no significant differences.

It can be seen that in comparison with M variant which already had an optimal pH for melting, the sample P1 (0 % Sibiana cheese) presented the lowest value of pH. This value was out of optimal range (5.3 to 5.9) and with 0.73 units lower than M variant.

Sample P2 also had an outside value of the optimum pH but was higher because of the 25% matured cheese addition. The pH value of the mixture was higher by 0.15 units compared with mixture P1.

Sample P3 which contained 50% ripened cheese had a value of pH which was in the range of optimum melting pH of 5.3 - 5.9.

Sample P4 which was obtained by 75% addition of ripened cheese had a pH value close to the value of M variant. The difference was lower only by -0.1 units.

Sample P5 (100% addition of ripened cheese) had a pH higher than the control samples by 0.03 units.

In Table 4 are presented the results for characterization of the samples after applying the melting. It can be noticed that the lack of melting salts in their composition has led to a very close content of dry matter of the mixtures used in the study.

The pH value presented a high influence of the melting process because according to its value the type of melting salts can be chosen.

The melting salt S90 because had a low ion exchange capacity and a strong melting activity has been used for samples P1, P2, P3 (lowest pHs). For samples M, P4, P5 which presented a higher pHs the melting salt S9 which has a medium capacity of ion exchange and a strong melting action have been used.

In the case of variant M, melting salt was added directly using a dose of 3%. The melting time was 15.

Also the samples P1, P2, P3 and P5 were subjected to melting in order to have the optimal dose for the addition of melting salts.

After the melting process the pH values of samples was determined. This is very important for the sensorial properties of the final products.

Table 4. Value of pH after melting, % of added melting salts and melting time for all studied variants

Parameter	**M**	**P1**	**P2**	**P3**	**P4**	**P5**
pH after melting	5.78±0.02	5.31±0.02	5.36±0.02	5.50±0.05	5.73±0.08	5.89±0.06
Emulsifying salts (%)	3	4.2	3.7	3.2	2.9	2.6
pH compared to the mixture before emulsifying salts addition	0.11±0.06	0.36±0.06	0.26±0.01	0.2±0.02	0.15±0.02	0.18±0.02
Melting duration (minutes)	15	25	23	20	16	14

Values are expressed as the mean ± standard deviation of three determinations, there are no significant differences.

By analyzing the results from this table can be conclude that the opportunity to use emulsifying salts was indirect proportional to the pH value before melting.

For the samples where was no addition of ripened cheese or the addition has done in low proportion (P1 and P2 samples) the addition of melting salt was even higher in order to achieve an acceptable melting effect.

All pH values of processed cheese at the end of the melting process were within the optimal range of melting (5.3 to 5.9) because of the emulsifying salt's effect.

The noted difference was only the proportion of added emulsifying salts and melting time.

The required time for melting process was indirect proportional to the value of pH before melting and direct proportional to the percentage of added emulsifying salts.

In Table 5 are presented the correlation between the percentage of ripened cheese and the dose of emulsifying salts used for melting.

Table 5. Correlation between the percentage of ripened cheese addition in the mixture and the dose of emulsifying salts used for melting

Sample	**Percentage of ripened cheese addition (%)**	**Emulsifying salts (%)**
M	77.2	3.0
P1	0	4.2
P2	25	3.7
P3	50	3.2
P4	75	2.9
P5	100	2.6

Values are expressed as the mean ± standard deviation of three determinations, there are no significant differences.

The sample M contains 77.42% dry weight from ripened cheese used and the sample P4 contains 75% dry weight. All other parameters presented similar values and for the both samples.

The concentration of emulsifying salts addition was lower with the use of higher proportions of mature cheese as raw material in studied variants.

pH values of the mixtures before melting the samples presented an increasing evolution proportional to the addition of seasoned raw materials in recipes.

The concentration of emulsifying salt's addition was indirect proportional to pH values in the studied variants. Because the pH value of the mixture before melting was lower the percentage of added emulsifying salts was higher for proper melting process.

Conclusions

Cheese type and maturation, used as raw materials to obtained processed cheese influences the specific parameters of the melting process, cheese quality and safety of final products.

The pH value was a relevant factor which provides useful information on the degree of maturation of raw materials, the possibility to choice the type and the dose of emulsifying salts.

The influence of the cheese maturation degree provides very important information which may decide the proportions of emulsifying salts dosage according to their technical specifications provided by suppliers to avoid overdose and achieve specific chemical and sensorial characteristics. The possibility to change the proportion of raw materials in the recipe depends on available varieties to prevent defects of the final products.

By increasing the proportion of ripened cheeses in the processed cheese recipes a decrease of emulsifying salts addition necessary to achieve optimal effect of melting process was observed.

By increasing the proportion of ripened cheeses addition in processed cheese a decrease of the melting time was achieved. This is an advantage to avoid caramelization and other defects due to exceeding the melting temperature and time, which leads to proportional reduction of costs.

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