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Influences of Ingredients and Melting Temperatures on the Physicochemical Properties of Process Cheese

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Abstract

Process cheeses were made in a laboratory with natural cheese, water, butter, and emulsifying salts varying in quantity and temperature. With the emulsifying salts, the hardness of process cheese varied from 286 to 580g, the pH values 5.1-5.9 and the solid content 56.8-63.7%. The water activity measured 0.96-0.98, the crude protein content 27.1-27.7%, the crude fat content 58.3-59.9% and the ratio of protein to fat 45.3-47.5%. The various properties of samples showed no natable difference. Increasing the water addition, the hardness and the ratio of the protein to fat decreased, while both the pH values and the water activity increased. With increasing the melting temperatures from 75 to 80, 85, 90 and 95 °C. The other indices showed no remarkable differences among the samples.

Key words: process cheese, emulsifying salts, water, melting temperature

Introduction

Process cheese has a great potential for the diary industries and consumers on account of its storage stability, nutritional variety and public acceptability. Because of its short history, only a limited number of researched cases concerning physicochemical changes during processing have been reported. Characterizing natural cheeses as raw materials for process cheese is urgently needed.[1]

Factors such as age, type of protein, pH, moisture content of ingredients, protein/fat ratio and types of emulsifying salts affect the property of process cheese.[2] The rheological and physicochemical properties of process cheese can also vary with ingredients and manufacturing conditions. The structural studies of the ripening process of cheeses suggested that the water content related the structure of casein micelles.[3] Some authors have reviewed the general effects of emulsifying agents on the texture and other characteristics of process cheese[4-10]. However, they failed to explain more systematically the effect of ingredients and technical parameters on the property of process cheese.

The purpose of this study is to examine the effect of different emulsifying salts, water content and melting temperature on the physicochemical properties of process cheese.

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Materials and Methods

Three months aged Cheddar cheese with a pH 5.26 containing 62.1% of solid substance, 24.5% of protein and 31.8% of fat was processed in a pilot size glass cooker. Each batch was prepared with different emulsifying salts such as Joha C Special (JCS), Joha S9 (JS9), Sodium tripolyphosphate (Na-TP) (Benkiser-Knapsack, Ladenburg, West Germany), Solva 35S (S 35S) and Solva 90 (S90) (Giulini Chemie, Ludwigshafen, West Germany).

The natural cheese was comminuted with a noodle cutter. Sixty grams of cut natural cheese, 2.5g of emulsifying salts, 15.0g of butter (moisture; 17.4, protein; 0.5, fat; 81.6%) and 10.0, 20.0, 30.0 and 40.0g of water were added in the cooker.

These raw materials were heated at 85 °C with a rotary agitation of 500 rpm for six minutes. Hardness of cheese texture was measured

with a Stevens-LFRA Texture Analyzer (St. Albans, England). pH values were checked as described by Rohse[11]. Water activities were measured with a Novasina Thermoconstanter (TH 2 RTD-33L Zurich, Switzerland) at 20°C. Solid contents were determined as described by Rohse[12]. Crude protein content was determined by Kjeldahl method and crude fat was determined by the Schmid-Bondzynski-Ratzlaff method[13]. All samples were analyzed in duplicate.

Results and Discussion

Effects of emulsifying salts on process cheese

Table 1 shows the physicochemical properties of process cheese made with 2.5g of various emulsifying salts, 60.0g of Cheddar cheese, 15.0g of butter and 22.5g of water. These materials were melted at 85°C. The highest solid content appeared in the sample containing Solva 35S, at 63.7%. In the other case, the contents were within the range of 56-58%. The pH value of Solva 35S was the lowest at 5.08 and that of Solvà 90S was the highest at 5.92. Meyer[6] recommended the pH values for normal process cheese as 5.4-5.9. The pH values varied from 4.0 to 10.2, according to the emulsifying salts used in the processing of cheese. The pH affected the protein configuration and solubility as well as the extent to which emulsifying salts bind calcium[7]. Because of the pH falling effect, the Solva 3S should be mixed with other pH-enhancing emulsifiers. The water activities were measured at about 0.96 except those containing Solva 90S, in which case they were measured at 0.98. The hardness of the cheese was varied with the emulsifying salts. The sample with Na-TP was the softest and that with Solva 35S was the hardest. Lee *et al.*[14] investigated the hardness of processed cheese by adding polyphosphate and concluded that it increased when the salt concentration and the melting temperature were increased. The protein contents in solid substances were within the range of 27.1-27.7% and did not show any significant difference among the samples. The fat contents the soldi substances were about 59% and did not vary significantly eigher. Schott[8] suggested that the fat content in the solid substance for process cheese should be 60%, which could reduce the viscosity and consistency and induce a more creamy texture. The ratios of protein to fat were between 45.2 and 47.5 and were slightly lower than those of commercial products.

Table 1. Properties of process cheese made with different emulsifying salts

Physicochemical indices	Emulsifying salts				
	JCS	JS9	S 35S	S 90S	Na-TP
Hardness (load: g)	500	384	580	340	286
pH	5.31	5.67	5.08	5.92	5.67
Water activity	0.959	0.955	0.976	0.958	0.958
Solid content (%)	58.09	57.22	63.73	56.83	57.15
Crude protein content(%/ss a)	27.39	27.28	27.69	27.29	27.09
Crude fat content(%/ss a)	58.63	59.04	58.31	59.51	59.86
Protein/fat ratio(%)	46.72	46.21	47.49	45.86	45.26

a) ss : solid substance

Effects of water content on the property of process cheese

Samples were prepared with 2.5g of Na-triphosphate, 42.5-77.5g of Cheddar cheese, 15.0g of butter and various amounts of water and melted at 85°C. It is evident from table 2 that the solid contents were reduced from 67.0 to 45.8% reciprocally with water content. According to the water

Table 2. Properties of process cheese according to added water content

Physicochemical indices	Added water (g)				
	5	10	20	30	40
Hardness (load: g)	1036	1038	576	116	10
pH	5.34	5.33	5.47	5.61	5.84
Water activity	0.945	0.948	0.956	0.967	0.978
Solid content (%)	67.03	66.09	58.67	53.40	45.82
Crude protein content(%/ss a)	28.20	28.92	27.46	26.07	22.44
Crude fat content(%/ss a)	58.17	59.54	59.98	60.54	61.89
Protein/fat ratio(%)	48.48	48.57	45.78	43.06	39.49

a) ss : solid substance

content, the pH values increased from 5.3 to 5.8, the water activity increased from 94.5 to 97.8, and the hardness of the samplies decreased from 1036 to 10g. This tendency explained why the network structure of casein particles in process cheese is weakened by hydration compared with natural cheese[15]. As water added, the protein content in solid substances showed decreasing tendencies. The fat content of solid substances, on the other hand, increased from 58.1% to 61.9%. This way the ratio of fat content showed decreasing tendencies with the addition of water.

Table 3. Properties of process cheese made with varying temperature

Physicochemical indices	Melting temperature (°C)				
	75	80	85	90	95
Hardness (load: g)	438	360	289	476	601
pH	5.56	5.56	5.67	5.53	5.51
Water activity	0.965	0.980	0.958	0.970	0.971
Solid content (%)	56.41	56.46	57.15	57.35	58.38
Crude protein content(%/ss a)	27.23	27.17	27.09	27.69	27.22
Crude fat content(%/ss a)	60.29	60.41	59.86	60.94	60.77
Protein/fat ratio(%)	45.17	44.98	45.26	45.36	44.79

a) ss: solid substance

Effects of melting temperatures on the property of process cheese

Samples were made with 60.0g of Chedder cheese, 2.5g of Na-triphosphate 15.0g of butter and 22.5g of water. The melting temperatures varied from 75 °C to 95 °C at a 5 °C degrees. The results of the experiments were listed in Table 3. It could be induced that the solid content of process cheese increased with the temperature. The pH values were about 5.5-5.7, which were lower than the results of Gupta *et al.*[16] The water activity showed no remarkable difference with the melting temperature. It is consistent with the result of El-Neshway *et al.*[17], who reported that the moisture content of process cheese showed no significant differences among the treatments. Ruegg and Blanc[18] concluded that the a_w of cheese seems to be affected to a great extent by water and pH. On the contray, Marcos *et al.*[15] reported that there is no significant correlation between a_w and pH.

The crude protein and crude fat content were not affected by the different heat treatments. The hardness of the sample decreased at a temperature of 75 °C to 85 °C and thereafter increased at the temperature of 95 °C. This phenomenon is consistent with the result of Lee *et al.*[14] Kiermeier and Weiss[19] reported that increasing processing temperature improves swelling of the protein and the water binding capacity. When it exceeded the optimum temperature, the swelling and water binding capacity decreased. The ratios of protein to fat did not vary with the temperature though they were lower than the ratios of commercial products.

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첨가물질 및 용융온도가 가공치즈의 이화학적 특성에 미치는 영향

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자연치즈에 수분, 버터 그리고 유화염의 양을 달리하고 용융온도를 변화시켜 실험실 규모로 가공치즈를 제조하였다. 유화염의 종류를 달리하여 첨가시킨 경우 가공치즈의 경도는 286-580g, pH 값은 5.1-5.9 그리고 고형성분 함량은 56.8-63.7%로 시료간에 다소 차이를 나타냈다. 한편, 수분활성도는 0.96-0.98%, 조단백질 함량은 27.1-27.7%, 조지방질 함량은 58.3-59.9% 그리고 지방질에 대한 단백질의 비율은 45.3-47.5%로 큰 차이가 없었다. 수분첨가량을 5, 10, 20, 30, 40g으로 증가시켰을 때 조직의 경도와 지방질에 대한 단백질의 비율은 감소했고 pH와 수분활성도는 증가하였다. 용융온도를 75, 80, 85, 90, 95℃로 변화시켰을 경우 조직의 강도는 85℃에서 감소하였으나 그 이후 95℃까지 증가하였으며 기타 지표들에서는 주목할만한 변화는 보이지 않았다.