

Comparative Study of Chemical Composition and Texture Profile Analysis between Camembert Cheese and Chinese Sufu

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Abstract:

Chinese sufu and camembert cheese were similar in the processing technology and final appearance. The study was a comparative analysis of common soft ripened cheeses and Chinese traditional fermented soybean products on the market. The result of chemical analyses revealed that cheese's moisture (61.63%), pH (6.41), protein (23.16%), and fat (24.33%) were higher than sufu's moisture (52.76%), pH (6.31), protein (14.87%) and fat (10.34%), while cheese's amino acid nitrogen (1.36 mg/g) and salt (1.21%) were lower than sufu's amino acid nitrogen (6.64 mg/g) and salt (8.21%). Although Chinese sufu's the total amount of free amino acids (147.93 mg/g) were lower than camembert cheese (90.28 mg/g), the types were more complete. Texture profile analysis of the camembert cheese and Chinese sufu showed that all of the indicators of cheese were higher than sufu. The chewiness (81.23 g), adhesiveness (-42.24 g.sec), cohesiveness (0.69), springiness (0.75) and resilience (0.27) were higher than the sufu's chewiness (29.65 g), adhesiveness (-281.52 g.sec), cohesiveness (0.45), springiness (0.65) and resilience (0.084), and the significant difference was very. However, the hardness of cheese (155.89 g) and sufu (95.10 g) was significant difference.

Keywords: Camembert cheese; Chinese Sufu; Texture profile analysis; Chemical analyses

1. INTRODUCTION

Cheese is condensed into dairy products, easy to digest with high biological value. It has been produced in Europe, America and other Western countries for thousands of years, and almost become essential in the European and American people for each meal. Camembert cheese a kind of mold-ripened soft cheese was originated in France Pays d'Auge. It contains high protein, and many necessary nutrients for the growth of the human body which is one of the staple products of the dairy in the world so that known as the "King of the dairy products" [1]. Sufu, Fu-ru written in hieroglyphics, is a traditional Chinese fermented soybean curd and a highly flavored, soft creamy cheese-type product, which can be used in the same way as cheese [2][3]. It also called Mao-tofu, a fermented soybean food covered with white fungus (*Mucor*) mycelia. This fermented product has been widely consumed by Chinese people as an appetizer for many centuries. The processing of Mao-tofu is similar to that of camembert-ripened cheeses but with a shorter ripening time (5-6 days) [4] than that of camembert cheese. Sufu tastes delicious with unique flavor and abundant nutrients. Being an appetizer or a side dish, sufu is very popular in China market and is consumed to add zest to the bland taste of a rice and flour diet. It has been estimated in China that the annual production of sufu is over 300,000 tons and it is becoming increasingly popular in Western countries [5].

Chinese sufu and camembert cheese have the similarities both in principle and in production. In Europe, sufu was called "Chinese cheese" [6] because the texture of sufu is similar to soft cheese. Cheese is an animal protein product, while fermented bean curd is a vegetal protein product. Protein amino acid composition of soybean protein is not only superior to others plant, but also not contains cholesterol, so that it is the best substitute of animal proteins.

Texture profile analysis is a very important feature when grading and evaluating the quality for Chinese sufu and camembert cheese. Texture directly affects the mouth feel and the thorough impress of the products and it changes with the variety processing conditions as well as the maturation time. The composition of component in the final product, including moisture, proteins, fats and salt, are the main reason influence the texture. This article conducted the texture and composition comparison which was based on the similarities and differences between Chinese sufu and camembert cheese, which was supposed to strengthen a deeper understanding and further utilization of both products.

2. MATERIALS AND METHODS

2.1 Materials.

Chinese sufu and camembert cheese samples were obtained from Chinese supermarket. Camembert Cheese (manufactured by Käserei Champignon. Heising/ Bavaria. Germany Fabrique par Käserei Champignon. Heising/Bavière. Allemangne).

Sufu (manufactured by Bei Jing Wangzhihe Food CO., Ltd).

2.2 Sampling.

Preserving the samples at 4°C refrigerator, and then cut into 1.5cm*1.5cm*1.5cm. The cubes were rinsed and soaked in distilled water for 2 min, and then the water was decanted. Koji mash was filtered through a screen to separate the koji granules and infusion. They were subjected to analysis immediately or kept at -20°C until analyses were performed.

2.3 Measurement of the moisture.

Moisture content was determined by conventional oven-drying (80°C, 48h) of 10g samples.

2.4 Measurement of pH and free amino nitrogen.

A sample (2g) was homogenized with 18 mL demineralised water. The pH was measured by a digital pH meter (Type GB1EVEE, US). While stirring continuously and working in a fume hood, 0.10M NaOH was added to the suspension to a constant pH 8.5, followed by addition of 5mL formaldehyde. After 2 min the suspension was titrated by semi-automated burette with 0.10M NaOH to constant pH8.5 again (pH should be constant for 30s). It was fitted using the following relationship for free amino nitrogen:

$$x = 0.1 * V / m \quad (1)$$

Where x is the free amino nitrogen (mM/g), V is the volume of 0.100M NaOH and m is the sample fresh weight^[7].

2.5 Measurement of protein and fat.

Fat content was analyzed by Van-Gulik method^[8] and total nitrogen content by Kjeldahl method^[9]. The conversion of protein content of camembert cheese use a factor of 6.38 and the factor of Chinese sufu is 5.71.

2.6 Measurement of salt concentration.

A sample (2g) was homogenized with 18 mL demineralised water. This 10-fold diluted sufu or cheese was titrated with 0.1M AgNO₃, and 10%w/v K₂CrO₄ solution was used as indicator. The following equation was used:

$$x = V * M * 0584 * 100 / m \quad (2)$$

Where x is the concentration of salt, V and M are the volume and molarities of AgNO₃ used, and m is the mass of a fresh sample^[7].

2.7 Measurement of free amino acids.

Free amino acids were determined according to the method described by Sarker et al.^[10]. A 10 g sample was homogenized

with 10mL of 8% sulphosalicylic acid solution. The slurry was then diluted to 50mL with the same solution and centrifuged at 10,000g for 20 min followed by filtration of the supernatant through a 0.45 μm membrane. Amino acids were extracted based on the procedure of Abiodun et al. ^[11] with slight modification. Eight milliliter of 6 N HCl was added to a 100 mg sample in a sealed tube, which was held for 24h in an oil bath at 110°C. A Hitachi 835-50 Amino Acid Auto analysis (Hitachi Co.Ltd, Japan) was used for separating the amino acids. Total free acid was the sum of the content of the individual amino acids ^[12].

2.8 Measurement of texture profile analysis.

The texture profile analysis (TPA) method is an instrumental texture measurement using double bite compression and was developed to imitate the compressing action of molar teeth during food mastication ^[13]. TPA of camembert cheese and Chinese sufu were measured with a TA-XT2i Texture Analyzer (England Stable Micro System CO. ,Ltd) with Texture Expert for Windows(Texture exponent 32 software), equipped with a cylinder probe (Type p/0.5).Test evaluation was carried out in three different locates of each cheese or sufu sample. The speed of the crosshead before analysis was kept at 2.0 mms^{-1} , after speed was 0.5 mms^{-1} , and the analysis was carried out at a crosshead speed of 0.5 mms^{-1} .The measuring run was 5.0mm and the initial force was 3.0g. The uniaxial compression test was performed in two successive cycles, and textural parameters were calculated as described by Bárcenas et al. ^[14].

2.9 Statistical analysis.

The mean value and standard deviation were calculated from the date obtained from the three separate experiments. One-way analysis of variance (ANOVA) was used to evaluate the significance levels of the data. SPSS 15.0 software for Windows (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The level of confidence required for significance was set at $P < 0.05$.

3 RESULTS AND DISCUSSION

3.1 Chinese sufu and camembert cheese's processing technology.

Camembert cheese was manufactured by the traditional method. It has ripened very quickly because of their high moisture content and the rapid growth of surface mold. It had been reported that the semi-hard cheese manufacture and ripening ^[15]. However, the studies of Chinese sufu's processing technology were more and more. There are many different types of sufu, produced by different local processes in China, while mould-fermented sufu is the most popular type. The appearance of camembert cheese and Chinese sufu were exhibited in Fig. 1 and Fig. 2. The processing technology of the camembert cheese and Chinese sufu were showed in Table 1.

The appearance of camembert cheese and Mao-tofu were similar whose surfaces were covered by a layer of mould and Camembert cheese and sufu's processing technology had a lot of similarities that the coagulant was added to liquid milk and soy-milk leading to solidification, and then the curds were cut into cubes and whey was drained. The making of camembert cheese was drained three times at 15min interval, after raising the temperature to 35°C. The curbs were pressed at 0.3Mp for 2h in a cylindrical mould. It was then removed from mould and cut into cubes. The cheese was smeared with Murcor spp .on the surface of cheese curd after salting in refrigerated brine for 18h, and cultured at $28 \pm 1^\circ\text{C}$ for 24h. Later on, all the cheese samples were transferred to a ripening chamber maintained at a temperature of $4 \pm 1^\circ\text{C}$ and a relative humidity of 85%-90%.



FIG. 1. THE APPEARANCE OF CAMEMBERT CHEESE



FIG.2. THE APPEARANCE OF MAO-TOFU AND CHINESE SUFU

TABLE 1. THE PROCESSING TECHNOLOGY OF THE CAMEMBERT CHEESE AND CHINESE SUFU

No.	Processing Technology	Camembert Cheese	Chinese Sufu
1	Processing of raw materials	Milk	soymilk
2	Sterilization	Pasteurization (75°C, 15s or 60°C, 30min)	Refine and cook pulp (100°C, 5min)
3	Cooling	30~33°C	70~80°C
4	Acidification	pH5.7	Natural
5	Coagulation	By fermentation agent (1.4% Lactobacillus), coagulator (0.016% Calcium chloride) and rennet(0.04% Valley acid transaminase)	By coagulator(4.0%-5.0% brine, Contains of MgCl ₂ , CaSO ₄)
6	Cutting and mixing	Cut into cubes(1~1.5 cm ³)	Cut into cubes (1~1.5 cm ³)
7	Drain whey	15-20min	2-3min
8	Pressing	0.3MPa, 2h	1MPa, 30min
9	Salting	5% salt content, 18h	12% salt content
10	Smearing with mould on the surface	<i>Mucor spp.</i>	<i>Actinomucor elegans</i>
11	Culture	28±1 °C, 24 h.	28±1 °C, 48h(The product is called Mao doufu)
12	Mature	1-2 months	4-6months

However, sufu's manufacturing process was following: (1) the preparation of tofu by salt precipitation from boiled soymilk, (2) the preparation of pehtze by spray-inoculation of diced tofu with a pure culture fermentation starter (*Actinomucor elegans*) and the mould was grown in a mixture of steamed rice at 28±1 °C for 48h, (3) salting and (4) the aging of salted tofu cubes in saline solution^[16]. The cycle of sufu is approximately 4-6 months.

In the late stage, the samples are fermented by microbial so as to produce protease, lipase and other enzymes, which are beneficial for protein degradation. After a period of storage, the final product has formed a special color, texture and taste which has the similarities in both products.

3.2 Chemical analyses of cheese and sufu.

The determination of moisture, pH, amino acid nitrogen, protein, fat, salt of camembert cheese and Chinese sufu were presented in Table 2.

Table 2. Chemical composition of sufu and cheese

Type	Cheese	Sufu	Significant
Moisture (%)	61.63±0.082	52.76±0.045	***
pH	6.41±0.05	6.31±0.01	*
Amino acid nitrogen (mg/g)	1.36±0.11	6.46±0.95	**
Protein (%)	23.16±0.31	14.87±0.53	***
Fat (%)	24.33±0.87	10.34±0.69	***
Salt (%)	1.21±0.089	8.21±0.089	***

*P<0.05; **P<0.01; ***P<0.001

Table 2 showed that the differences of chemical composition between the camembert cheese and Chinese sufu was very notable ($P<0.05$). Moisture, pH, protein and fat of camembert cheese were higher than that of Chinese sufu, while its amino acid nitrogen and salt content were relatively lower than the latter. The moisture content of Chinese sufu was 52.76% which varied from camembert cheese of 61.63%. The variation in the moisture content of the both samples is probably due to the differences in gel network within the particles that is influenced by different anions and its ionic strengths towards the water holding capacity of protein gels. The Chinese sufu's amino acid nitrogen (6.46mg/g) was higher than that of camembert cheese (1.36mg/g), which suggest that protein hydrolysis occurred mainly in the stage of post-fermentation and produce good flavour. The variation of the fat and salt were effected people's views on acceptance and using. Results showed that the reasons leading to the difference of the both components may be the different raw materials and the influence of protein degradation degree in the late fermentation.

The FAAs content of the camembert cheese and Chinese sufu were determinated and the results were presented in Table 3.

TABLE 3. CONTESTATION OF FAAS IN SUFU AND CHEESE (MG/G)

FAA	Cheese	Sufu
Asp	7.33	7.12
Glu	40.69	21.34
Ser	3.57	2.91
Gly	0.40	3.01
His	0.00	1.29
Arg	0.34	1.23
Thr	1.69	3.58
Ala	4.43	6.93
Pro	14.36	4.52
Val	10.72	4.97
Met	6.33	1.47
Cys	0.00	0.28
Ile	3.21	5.36
Leu	19.33	8.97
Trp	0.00	1.06
Phe	8.32	6.24
Lys	15.09	5.56
Tyr	12.12	4.44
Total	147.93	90.28

The free amino acids were important flavour enhancing compounds and the different flavour compounds in sufu and cheese were the results of volatile compounds formed from decarboxylation, deamination, transamination and other transformations of FAAs, which made substantial contributions to the flavour. Table 3 shows that camembert cheese's total amount of free amino acids (147.93mg/g) was higher than the total free amino acid of sufu (90.28mg/g). The salt addition increased the composition, which may possibly cause lower FAAs. Most of the FAAs in camembert cheese and Chinese sufu were formed during the ripening stage of post-fermentation since the FAAs content increased greatly.

Table 3 also showed that there were certain differences between cheese and sufu's leading amino acids. Glutamic acid in camembert cheese was the most abundant acid, followed by Leucine acid, together representing around 41% of total FAAs. Glu, Leu, Lys, Pro, Tyr, Val, were leading amino acids (concentration ≥ 112.31 mg/g) of camembert cheese and occupied 75.92% of total FAAs. However, sufu's Glu, Leu, Asp, Ala, Phe, Lys (concentration ≥ 56.16 mg/g) occupied a 62.21% of total FAAs, and those were the leading amino acid of Chinese sufu.

Although the total FAAs of camembert cheese obtained in the present work was higher than that of Chinese sufu, His, Cys and Trp were not detected in camembert. 18 FAAs were present in the Chinese sufu and its comparison types were more complete than camembert. The large difference in FAAs composition and content of the both products resulted from the different raw material, fermented processing and maturation time.

We knew that FAAs plays an important role in food taste. Therefore, the difference of the contents may be caused the

different taste and sensory evaluation between of the two products.

3.3 TPA of camembert cheese and Chinese sufu.

TPA test also known as Two Bite Test, primarily through the simulation of human oral chewing movements, the samples are compressed twice. The texture has been reported to be an equally important attribute as nutritional quality that affects the product acceptability. The textural characteristics are the important determinants for consumption. Hardness value is defined as the maximum force necessary to attain a given product deformation while brittleness is the force required to attain a significant break or fracture.

The TPA test characteristic curves of camembert cheese and Chinese sufu were shown in Fig. 3 (Examples of seed samples to select a characteristic curve). The texture parameters of camembert cheese and Chinese sufu evaluated are depicted in Table 4.

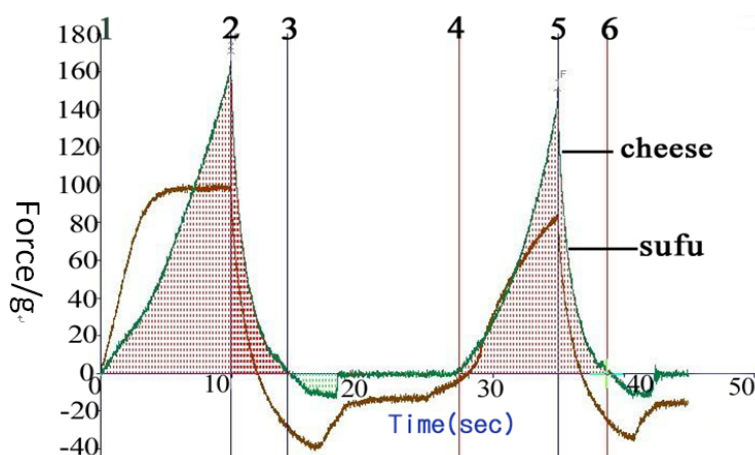


FIG.3 THE TPA TEST CHARA CTERISTIC CURVES

Table 4 showed a significant difference in the textural characteristics of the samples and hardness exists significantly differences ($p < 0.05$), which camembert cheese of average hardness (155.89 g) was greater than that of sufu (95.10g)so that required a larger force to resist deformation. In addition, other parameters were highly significant difference in texture of Chinese sufu and camembert cheese.

Camembert cheese has higher adhesiveness and springiness than sufu, so that there are an extrusion deformation ability with thoroughly restored. This relationship between hardness and brittleness was observed in the present study as camembert that had the higher hardness force is the least brittle and chewable. The hardness probably was due to denseness and compact structure of the samples, an implication that coagulator has the ability to create a more dense structure by making protein molecules closer due to loss of water during coagulation step.

TABLE 4. TPA PARAMETERS OF CAMEMBERT CHEESE AND SUFU

Parameters	Cheese	Sufu	Significant
Hardness	155.89±23.40	95.10±5.62	*
Chewiness	81.23±18.94	29.65±1.64	**
Adhesiveness	-42.24±21.69	-281.52±29.23	***
Cohesiveness	0.69±0.031	0.45±0.018	***
Springiness	0.75±0.048	0.650±0.072	**
Resilience	0.27±0.050	0.084±0.014	**

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Low holding water capacity has been associated with higher hardness in samples. The difference in textural characteristics as a result of the raw materials and the processing technology could be attributed to the higher moisture content of these products and probably an occurrence of incomplete precipitation of protein which causes a loose network encompassing many air gaps within it instead of having a compact protein network. Camembert cheese with high chewiness was more

difficult to eat. However sufu's texture parameters were relatively low, so that it can be used as butter.

Two kinds of products' quality characteristics are different, because of the product components, such as moisture, protein, fat, salt are the main reason of texture. Therefore, we can learn the texture of different impact on consumers' product sensory evaluation and acceptance from the texture parameters analyzer determination results.

4 CONCLUSIONS

There was a certain amount of similarities in the processing technology of camembert cheese and Chinese sufu. Camembert cheese was a higher quality animal protein, while sufu was a higher quality vegetal protein product, and both of them had their own advantages. Camembert cheese's protein content (23.16%) was better than sufu (14.87%). The FAAs content of cheese (147.93mg/g) was slightly larger than the fermented bean curd (90.28mg/g), but types of FAAs in sufu were more complete. For a combination of texture analysis, there was some certain gap in hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness. That is why European countries and China have different love and acceptance for the camembert cheese and Chinese sufu. Based on this, the study did a detailed of a comparison of the two products so that people can have a deeper understanding on the camembert cheese and Chinese sufu.

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