Development of the Technology of Soft Camembert-type Cheese with Flowery rind in Morocco

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Research

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Abstract

Camembert is a French cheese characterized by a soft paste and a flowery rind. Morocco imports camembert cheese paste as a raw material. Today, Moroccan cheese manufacturers are looking to uncover the secrets associated with making Camembert cheese including the ones facilitating the smooth running of the stages of its manufacture. In Morocco, this type of cheese is scarce, not fully enumerated and no studies have been conducted on it as of yet. This is why we tried to manufacture this type of cheese in the laboratory to valorize it in Morocco due to its growing importance in the international market. The objective of this work is the optimization of the production of soft cheese with a flowery rind such as Camembert, while determining the quantity of microorganisms used for the fermentation of milk. Four types of industrial ferments with pre-established doses were used in addition to rennet. Fifteen cheese samples were made. The physico-chemical parameters checked during the manufacturing tests were fat content, pH and titratable acidity. The results show that the production of cheese requires the use of milk of good microbiological quality as well as the selection of specific ferments depending on the type of cheese to make. The best amount of the ferments used to make Camembert-type cheese during this work is: from 0.6% to 0.8% mesophilic if the viability rate is more than 3.73×10^2 , 0.3 % to 0.4% thermophilic if the viability rate is more than 3.95×10^3 , 1% to 5% yeast if the viability rate is more than 2.60×10^3 , and 2% to 10% mesophilic if the viability rate is more than 3.30×10^3 . The most effective dose formula is two doses of Mesophiles for one dose of Thermophile. Or two doses of *Penicillium Candidum* mold for one dose of *Geotrichum Candidum* yeast. The microbiological quality of the milk used in this work and the cheese produced during this work is generally acceptable and conforms to Moroccan standards. During each Camembert production, whey quantity was measured. Cheese yield was determined by measuring cheese portions before and after ripening from a known quantity of milk. The sensory properties of dairy products are defined by their appearance, texture and flavor and are ultimately evaluated by tasting panels from the Agronomic and Veterinary Institute of Rabat.

Introduction

Given its health importance from a nutritional standpoint, cheese has an important place in the dietary balance. It is an important source of calcium, a well-known and essential nutrient to the constitution of skeleton and teeth. It is also rich in proteins, fat, fatty acids, vitamins and lactose (Aguenaou et al, 2016). Soft cheeses with a flowery rind are part of a vast group of diverse products (e.g Brie de Meaux, Camembert, Chaouce, etc.). Their name comes from their rheological properties as well as the development of mold on the cheese surface during ripening. Additionally, the lipolytic activity of surface microflora leads to the development of sensory properties typical of cheese (Prosekov, A. et al 2019; Kim, N. S 2014; Tatiana Voblikova et al 2020). Camembert is a lactic cheese due to the use of two types of ferments such as lactic ferments and ripening ferments. Its moisture content is superior to 50% and it is soft, flexible and smooth, with usually an ivory color. Its balanced flavor emits aromas of butter that is sometimes rancid. Its fat content varies from 25–75%. Its ripening lasts between 2 and 6 weeks. The procedure for making most varieties of cheese roughly involves the steps of acidification, coagulation, whey drainage and salting, sometimes followed by a more or less prolonged ripening period. The acidification of milk due to pH

decrease is favorable for the action of rennet on caseins, thus promoting whey drainage in the process. A period of ripening of the cheese may ensue in order to obtain the desired textural and aromatic properties, during which time the bacteria in the ferment will characteristically influence the development of flavors, aromas, and texture in the cheese. The variation of certain manufacturing parameters (cooking, drainage) determines the characteristics of the desired variety of cheese, and the bacterial flora also plays a crucial role throughout the manufacturing process (Beresford et al, 2001). Ripening starts as soon as the paste is removed from the mold, so after acidification and whey drainage. The characteristics of the milk used in the process, the technical methods of preparation and the types of micro-organisms involved in ripening are all determining factors which modify the texture, consistency, flavor and aroma of cheese. Ripened soft cheeses were traditionally made in France with basic soft cheese making practices (Shaw, 1981). The largest producer of this type of cheese in the world is France, with 263,000 tons of bovine milk/year (Antonio et al 2020). Camembert and related varieties of cheese with flowery rind are known to possess a white/gray rind formed by mold such as *Penicillium candidum*, and yeasts such as *Geotrichum candidum*, *Debaryomyces hansenii* and *Kluyveromyces* spp. growing on the surface of the cheese (Gripon, 1997; Leclercq-Perlat, 2011; Galli et al., 2016; Danton Batty et al 2018).

Material And Methods

Raw material

Fifteen samples of Camembert-type cheese were made from pasteurized cow milk enriched with calcium and acidified by two ways: the acid way using four types of ferments, mesophiles (*Flora danica*), thermophiles, *Penicillium candidum* and *Geotrichum candidum*, and the enzymatic way using rennet. The ferments used are trademarked. Calcium content in traditional Camembert cheese is 388 mg/100 g (USDA, 2018). The variability of our products indicates the presence and absence of calcium chloride added during cheese processing (Table 1). In accordance with the works of (Antonio et al 2020) and (LUCEY et al., 2003) 0.02 g/L of calcium chloride were added to the milk which helps to achieve constant firmness in the gel and facilitates coagulation time. Most types of natural cheese are made using rennet to coagulate micelles in milk (Hyslop, 2003; JA Lucey et al 2003). Rennet-modified micelles cluster together in clusters and chains forming a network system surrounding fat globules. Serum is also trapped in the spaces (pores) between and within these aggregates. (Dejmek, 1987; Zoon et al., 1988a, 1988b; (JA Lucey et al 2003) The enzymatic coagulation of milk is reflected by a rapid increase in the stiffness of the gel, which begins to flatten after some time, depending on the concentration of the enzyme used. Gel formation is strongly influenced by pH, Calcium concentration, protein content and temperature (Lucey, 2002; JA Lucey et al 2003 Gel stiffness increases with a decrease in pH to a maximum of 6.0 to 6.2 (JA Lucey et al 2003).

Physicochemical and microbiological analyses of raw material and finished product

Before the cheese was made, the milk was subjected to physicochemical analyses (measurement of pH, titratable acidity, densimeter, and fat) and microbiological analyses (Total Aerobic Mesophilic Flora, fecal coliforms, total coliforms and staphylococcus) in order to determine its hygienic quality. The ferments underwent a bacteriological analysis to determine the viability rate, and the final product (cheese) also underwent the same analyses as milk.

Determination of the quantity of milk acidifying agents.

The amount of calcium added, rennet, and lactic acid bacteria (Mesophiles, Thermophiles) was chosen in accordance with the Agro-Food Technology Breeding Center in France (CETAA, 1999). Similar to (Danton Batty et al.), calcium chloride was added during fermentation at a concentration of 6.6 ml / 100 kg. The quantity of yeast and mold (*Geotrichum candidum* and *Penicilium candidum*) was determined by the probability method as follows: the information marked on the packaging of the ferment amounts to 10U. After weighing, it was found that the sachet contains 10g of ferment, thus 10U is considered 10g. after the preset amount has different doses. These estimates were made in order to determine the best result.

Manufacturing procedure

The production of this type of cheese in order to obtain its specific organoleptic properties requires the success of many technological steps, mainly: inoculation, maturation, coagulation, whey drainage and ripening.

Reception of milk: Pasteurized milk, with different fat content (skimmed and semi-skimmed) purchased from a cheese factory in Rabat. The milk was subjected to physicochemical (measurement of pH, titratable acidity, densimeter, and fat) and microbiological (the viability rate of ferments, FMAT, CF, CT and Staph) analyses to determine its quality.

Inoculation: The milk was inoculated with ferments (mesophilic lactic ferment, thermophilic lactic ferment, *Geotrichum Candidum* yeast and *Penicillium Candidum* mold) and was subjected to stirring for 15 minutes after being kept at a temperature of 35°C for 40 minutes. Ferments are specified in Table 1.

Renneting: When pH decrease was considered sufficient around 6.1 and 6.5 for 40 min, the milk was renneted at a rate of 0.25 ml to 0.4 ml of rennet per liter of milk. The solution was homogenized well and then maintained at a temperature of around 35°C until a gel was obtained. (Approximately from 1h15min to 7h30min). In lactic acid technology, the coagulum is formed by the joint action of the acidity produced by the metabolism of lactic acid bacteria and rennet (enzymatic action). It's a mixed technology with lactic dominance because the acidification plays an essential role in the final characteristics of the gel. If the milk is pre-acidified or matured with a starter culture, then rennet pH is lower than the natural pH of milk. (LUCEY ET AL. 2003) Gel formation happens more quickly due to a pH decrease caused by the decrease in repulsion of charges between micelles and rennet acceleration. LUCEY ET AL. 2003. In rennet-induced gels, most of the whey is lost after cutting the coagulum. (Rennet induced gels are used when low moisture cheeses are desired since acid coagulation cheeses have a very high moisture content (LUCEY ET AL. 2003).

Cutting: The gel was cut into cubes by a grid in equal portions allowing a more or less rapid and significant separation of whey, the cutting conditions the manner of drainage and is therefore an important factor. When the gel reached sufficient firmness, which is traditionally determined subjectively by the manufacturer, it was cut with a knife. In practice, if the curd is cut when it is very soft, the moisture content of the resulting cheese is lower (John-fils et al., 2001; LUCEY ET AL 2003). If the gel isn't cut immediately, the moisture

content of the cheese becomes higher. Presumably, this change in moisture content is a reflection of the extent of the links between and within CN particles, which increase over time (LUCHEY ET AL 2003).

Stirring: Stirring was done for 5 minutes in our case to standardize the size of curd grains and promote the expulsion of serum. According to ECK 1987 the stirring aims to activate the drainage by renewing the exudation surfaces of the serum, because due to the proportion of the curd grains which tend to polymerize, the grains agglomerate in clusters, which slows down whey elimination. Stirring was carried out from 20 to 25 minutes after coagulation in order for the product to be placed correctly into the mold and for the destruction of fatty matter sticking to the surfaces of curd grains.

Molding: The molding was done after obtaining a firm gel by the ladle, the curd was taken in layers because the surface layer contains more fat than the other layers. The obtained gel was placed gently in the molds, thus making it possible to standardize the quantity of curd per mold.

The molds were left for drainage at a temperature of 25°C for 2 days during which two procedures were performed: Turning and salting and/or brining.

The first turning was done five hours later, after the drainage was assessed. The molds are made of microperforated plastic. The second turning was carried out 10 minutes after the first one, and third turning was carried out 10 minutes after the second one.

Salting and Brining: Salting was carried out twice during drainage, at each turning, with fine dry salt. This dry technique avoids wetting the surface, which allows it to dry out and form a rind. This is a delicate operation since each portion of cheese must be salted equally and evenly. In our case the salting took about 10 hours. It was followed by a brining step which consisted of immersing the pieces of cheese in brine for a few seconds. The cheese pieces were left still for about 30 minutes. The amount of salt used was about 1.2% to 1.5% of the cheese mass. (Danton batty et al) reported that 2% of salt (w / w) was used. The salt content was from 1.5 to 2.0% (w / w) for camembert (Antoine et al 2020 LECLERCQPERLAT, 2011). Most other cheeses are salted by immersing the block of cheese in saturated brine for a long period which is dictated by the type of cheese and the shape and size of the block. There is a diffusion of salt into the cheese within cheeses salted in brine (Lucey.J.A et al, 2003). The composition (and proteolysis) of the cheese varies from the inside to the outside of the block, and this is reflected in the differences in texture and functional properties in the block of cheese (Lucey.J.A et al, 2003). The drainage time for the tests from 1 to 4 was 39 hours, and it was 22 hours for the tests from 5 to 15.

Ripening: the ripening of lactic cheese makes it possible to differentiate and diversify the group. It allows to obtain the desired cheese according to the target market (notably *via* the microflora: texture, surface covering, taste). The cheese portions were transferred to a thermohygro-

static oven where the temperature was set at 12°C and the hygrometry at 90%. The cheeses were deposited on grids allowing a good oxygenation of the surface of each cheese. They were turned once every 2 days in order to regularize the shape of the cheeses and homogenize the development of the desired microflora and inhibit the development of undesirable microflora. Their residence time varied between 12 and 15 days. Ripening is the period during which the cheese undergoes, under the action of natural and microbial enzymes, physicochemical transformations giving it its organoleptic characteristics (texture, taste, aspect).

Yield: During the cheese making process, the amount of serum was determined along with the monitoring of cheese portions for each test before and after ripening. The amount of water lost from the cheese portions during ripening was also determined.

Results

Determination Of The Quantity Of Milk Acidifying Agents

Table 1							
Quantity of ferments, calcium and rennet used in the transformation of milk to cheese							
Number of tests	Ferments doses (D)				Addition of Ca ²⁺⁺ g /l	Rennet ml/l	Coagulation time
	Mesophile %	Thermophile %	Geotrichum candidum %	Penicilum Candidum %			
15	2 Doses (from 0.6–0.8%) of mesophile for 1 Dose (from 0.3–0.4%) of thermophile	5 Tests			0.03	0.25	75 min to 3h
		1D		1D			
		3 Tests					
		2,5D		1 D	0.03	0.25	7h30min
		5 D		1 D	0.03	0.25	6h
		6 Tests					
		1 D		2 D	-	0.25	75min

Assessment of the physico-chemical analyses of milk, during processing, and of the finished product (Cheese). Figure 1 : Physicochemical parameters of the milk intended for manufacturing cheese

Microbiological Quality Of Milk And Cheese (camembert)

Table 2				
Results of the microbiological analyses of milk				
Number of tests	TAMF	STAPH	FC	TC
15	Absent			

Microbiological Quality Of Final Products

Table 3
Microbiological analysis of cheese

Undesirable microorganisms						
Tests	AVG.	MIN	MAX	STAPH	FC	TC
	TAMF					
15	Inferior to 1					

Microbiological Quality Of Ferments

Table 4
:Microbiological analyses expressing the cellular concentration of ferments CFU/g.

Ferments	Ferments concentrations CFU/g		
	Min	Max	Avg.
Mesophile	2.83×10^2	8.50×10^3	5.79×10^3
Thermophile	1.85×10^2	6.00×10^3	4,65
Yeast	2.00×10^2	1.00×10^4	4,94
Mold	2.40×10^2	9.50×10^3	6,39

Table 5
Gel type according to the quality of the ferments, Fat, and coagulation time

Tests	Avg. Fat content (g/L)	Coagulation time	Gel type	Quality of used ferments
From 1 to 3	33	1h15min	Firm	High
4	3	1h15min	Crumbly	Low
5	29	3h	A little crumbly	Low
6	30	7h30min	Firm	Low
7	28	6h	Soft	Very low
From 8 to 14	30	1h15min	Firm	Very high
15	46	1h15min	Very firm	Very high

Table 6
Ferments and rennet quantities used for manufacturing Camembert-type cheese.

FERMENTS	QUANTITY	BACTERIAL VIABILITY RATE (CFU/ml)	TIME AND TEMPERATURE	GEL TYPE	CHEESE QUALITY
Mesophile	From 0.6–0.8%	From 3.73×10^2 to 8.5×10^3	40min 35°C	FIRM	GOOD
Thermophile	From 0.3–0.4%	From 3.95×10^3 to 6×10^3	40min 35°C		
Yeast	From 1% to 5%	From 2.6×10^3 to 10^4	40min 35°C		
Mold	From 2–10%.	From 3.3×10^3 to 9.5×10^3	40min 35°C		
Rennet	0.25ml/l and 0.4ml		30min (35°C)		

Yield

Table 7: Properties of the manufactured cheese

Tests	Appearance	Paste	Odor	Taste	Texture
3 tests	White	Creamy	Good	Good	Slightly hard
4	Too dry and plastery	Dry	Good	Average	Very hard
5	White	Creamy	Good	Good	Slightly hard
6	White with orange dots	Creamy	Good	Good	Slightly flexible
9 Tests	White	Creamy	Good	Good	Slightly flexible

Discussion

Physicochemical quality of milk

Figure 1 expresses the density of pasteurized milk, pH, fat content, and dornic acidity of pasteurized milk used for making cheese. The results show that the density of milk varies between 1.028 and 1.031 with an average of 1.030 and a standard deviation of 0.0015. These values are within the range mentioned in the AFNOR standards., 1985. but the density of the skimmed milk used for test 4 is approximately 1.035, i.e. slightly higher than the value of the density of whole milk. According to Bonnefoye et al. (2002), for values between 1.028 to 1.032, the density of milk is classified as normal. As for the density of skimmed milk, it is greater than 1.035 (Vierling, 2008) since milk skimming leads to an increase in its density (Luquet, 1985). In

our tests, the pH value of the milk varied between 6.5 to 6.8 with an average of 6.60 and a standard deviation of 0.11, so it is within the normal values for cow milk. According to (Hebboul et al., 2005; Dillon, 2008), pH is slightly acidic between (6.5 and 6.8). Bovine milk pH is between 6.6 and 6.8 (Antonio.c et al 2020). Fat values are between 28 g / l and 46 g / l with an average of 29.2 and a standard deviation of 9.12 for whole milk. The observation of the experimental values shows that the titratable acidity of milk is between 15.5 ° D and 18 ° D with an average of 16.83 and a standard deviation of 0.70, a value comparable to the NM 08.4.005 standard. These values are situated within the ranges of the AFNOR standard, 1985. The curve obtained (Figure 1) is characterized by an almost stable acidity value based on the studied samples, and the small variation in acidity is within the [15 -17 ° D] interval defined by AFNOR., 1985. So the obtained values of dornic acidity ensure the milk's conformity for this parameter. The experimental data from the physicochemical characterization show a certain regularity in the milk's quality. This is quite normal as all the supplies have been provided by a single supplier in order to allow consistency of the raw material in the cheese making tests.

Physicochemical quality during cheese manufacturing

pH: (Figure 2) shows that the pH values after the maturation step characterized by the presence of ferments vary between 6.2 to 6.6. The pH value after the coagulation step characterized by the addition of rennet is between 6.0 to 6.4. The ability of milk to coagulate depends on its initial pH (C. HURTAUD et al 2008). pH values drop from one step to another during processing, this drop is caused by the role and activity of starter cultures indicating lactic acid production. The production of this acid by lactic bacteria leads to a decrease in the pH of the medium (Guiraud et al, 2003). Lactic fermentation decreases around pH values of 4.6 and 4.8 (Antonio.c et al 2020). *P. candidum* consumes lactic acid for growth, deacidifying the surface of cheese and promoting lactate migration from the inside to the outside of the cheese (Antonio.c et al 2020) ABRAHAM et al., 2007).

Dornic acidity: The titratable acidity, expressed in Dornic degrees (° D) is from 15 to 18 ° D (figure 3). We distinguish natural acidity, which characterizes fresh milk, from a developed acidity resulting from the transformation of lactose into lactic acid by various microorganisms (CIPC lait, 2011). The value of titratable acidity after maturation is between 14.5 ° D and 20 ° D, and between 10 ° D and 71 ° D after the coagulation step. The value of titratable acidity is variable during milk processing as is observed in figure 3. It was found that the value of the titratable acidity for tests can increase then decrease until the renneting step as can be seen in the case of test 1, it can decrease consecutively like the case of tests 2 and 3, and can also increase consecutively as is the case for test 4, but for test 15 the value decreased to 10 ° D because of the diluted rennet added to milk.

Physicochemical quality of cheese

pH: During the production of Camembert cheese, its pH was measured after drainage and the values obtained are between 4.5 and 5. The changes in pH are shown in figure 4. On the cheese surface, pH increases rapidly to reach values between 5.9 to 6.3. In the cheese core, pH slightly changes to values between 4.2 and 5.9 but it was observed that pH values of cheese are similar to mean pH values between the rind of the cheese and its core (roughly from 5.8 to 5.99), similar to the ones reported by (Kikuchi, 1966)

as well as the one reported by (Lenoir et al., 1985; Leclercq-Perlat et al., 2004a) indicating that for Camembert-type cheeses, pH rises quickly and reaches a value close to 7 on the cheese surface well before the end of the ripening, while the increase in pH inside the cheese is much slower.

Danton Batty et al 2018 reported that cheese pH during salting was 4.31, rind pH increased rapidly to reach a pH value of 6.98 and a maximum pH value of 7.92 at 35 days. Increases in core pH were slow, as expected, reaching 6.15 in 21 days. On day 50, rind pH and core pH were harmonized from 7.65 to 7.70. (Denise Felix da Silva et al 2020, Leclercq-Perlat et al., 2015; Spinnler & Gripon, 2004) reported that pH varied between 4.85 ± 0.1 and 7.2 ± 0.1 in camembert cheeses, which is related to the development of microbial flora and, therefore, to the degree of maturation. Thus, the following authors (Antonio.c et al 2020 and SPINNLER, 2017) reported that external (rind) pH is around 7.0 and internal pH is around 6.0 at the end of the ripening period (5-6 weeks). The faster pH increase at the surface of the cheese in comparison to the core is due to the higher concentration of ripening bacteria at the surface. Surface microflora have two main functions in ripening: they produce enzymes; lipases and proteinases which hydrolyze fat and proteins. Peptidases hydrolyze small peptides and amino acids and they deacidize cheese surface. It is mainly yeasts and molds that have this function. By oxidizing lactate, CO_2 is emitted, which contributes to the increase in pH from 4.8 to 5.8 (TORMO, 2010).

Dornic acidity: The Dornic acidity of the cheese increases during ripening to values between 43 ° D and 80 ° D for all test cheeses obtained during the research period (Figure 5). There is a strong increase in the titratable acidity of Camembert cheese compared to that of pasteurized milk, which indicates a significant lactic fermentation in this product. The acidity of milk increases over time as the lactose turns into lactic acid. This acidity constitutes an indicator of the degree of preservation for which Dornic degree (° D) is used (Hebboul et al., 2005; Dillon, 2008).

Microbiological quality

Microbiological quality of milk: Table 2 shows a total absence of pathogenic bacteria which means that the milk's microbiological quality is satisfactory, the pasteurization was done well.

Microbiological quality of cheese (Camembert): Table 3 shows the results of the microbiological analyses of cheese, the germs counted are considered as indicators of the quality of cheese as well as hygiene practices during production. A total of four tests have either less than 9 bacterial colonies or no colonies at all in the case of staphylococcus. Enumeration is performed if the number of colonies is between 30 and 300 colonies, but in our case we found that the number of colonies is less than 30 so our cheese complies with Moroccan standards from a hygienic standpoint.

Viability rate of ferments

The objective of the microbiological analysis of ferments is to characterize lactic flora, which makes it possible to learn if this flora is alive as is required by standards. The results of the microbiological analyses of the ferments expressed in CFU/g are presented in Table 4. For the ferments used during this work the composition was not mentioned on the ferment packaging so we used the commercial names of ferments, e.g. mesophile (Flora Danica). The results of the microbiological analyses of the 4 samples of ferments were determined on the same day the work was carried out. Each ferment conveys the concentration of

living cells used for each test, it was observed that the viability rate decreases successively over time, for example, in the case of mesophilic ferment, cell concentration used in the first test is approximately 3.9×10^3 , it decreases to 2.4×10^2 CFU/g in test 7. The same was observed for other ferments such as thermophile, yeast and mold. This means that the viability rate is increasingly affected depending on storage temperature and duration, these two parameters influence the quality of the ferments. For tests from 8 to 15, we tried to use new ferments similar to the ferments used in the first tests, with the only difference being the survival rate of the bacterial cells contained in the ferments. The change in ferments led to a higher result of surviving strains than the previous ferments, this causes a change in the transformation criteria observed during the first tests for coagulation, gel type, and cheese yield. The viability rate differs from one ferment to another and from one test to another, for example, the concentration of new ferments is about 8.5×10^3 for mesophile, 6×10^3 for thermophile, 10^4 for yeast, and 9.5×10^3 for mold. But these values decrease more and more over time. So if the survival rate of the strains is low, then the cohesion between curd grains is minimal which means that the small curd grains are passed into the serum thus a low yield of cheese is obtained. According to Leclercq-Perlat MN et al, yeasts are added to milk at a concentration varying between 10^4 and 10^6 cells (or spores) / ml of milk. Ferments inoculated simultaneously should be found alive in cheese at a higher rate than that of surviving lyophilized ferments. This is because the ferments during coagulation, drainage and ripening were multiplying, leading to a rapid increase of colonies. The concentration of the ferments used in tests 4 to 7 ranges from low to very low, which is why coagulation time was increased. For tests from 8 to 15 the ferments were used at a higher concentration which coagulates the milk in an hour and 15 minutes and produces high quality cheeses. In France, the 1963 decree specifies that these lactic acid bacteria must remain alive until the cheese is delivered to the consumer at a rate of at least 10 million bacteria per gram. In fact, in France, on Camembert cheeses produced on a pilot-scale, the active growth phase of *G. candidum* is observed in the first 12 days of ripening and its population can reach 10^7 CFU / g [Leclercq Perlat MN et al (2004)].

Gel type and ferments quality

In this work, fifteen samples of cheese were produced in the laboratory. Each test is characterized by a fat content and a specific microbiological quality of the ferments. Table 5 shows that the quality of the ferments used for tests 1-2-3 is high and that the fat content varies between 28 and 36 g / l, which produces a firm gel for 1h15min. The milk used is skimmed and contains only 3g / l in fat content, and the quality of the ferments used is low, which produces during 1h 15min a crumbly gel, in this test it was observed during the molding that most of the small curd grains are passed into the serum which produces a small amount of curd. For test 5, it was observed that during 1h15min of coagulation a very crumbly gel is obtained and due to this the coagulation time was increased to obtain a firm gel, but during 3h a slightly crumbly gel is obtained due to the poor quality of ferment even if the fat content is important 29g / l. So in this case it can be deduced that the quality of the ferments plays a more important role on gel type. For test 6, gel type was monitored alongside coagulation time, and after 1h15 min a very crumbly gel was obtained and after 3h the gel obtained is crumbly, fortunately, after 7h 30min a firm gel is obtained, so coagulation time must be increased if the quality of the ferments is low in order to give lactic acid bacteria the chance to multiply. For test 7, even if the coagulation time is increased to 6 hours, the quality of the ferment impacts gel type

negatively, resulting in a soft gel. For tests from 8 to 14, a firm gel is obtained for 1 hour 15 minutes thanks to the high quality of the ferments used. For test 15, it was observed that the fat content of 46% and the quality of the ferments influence gel quality by contributing to the production of a very firm gel. It was observed that the growth rate of the strains and the fat content play a very important role on curd cohesion, which determines gel type and coagulation time. So it can be deduced that if the growth activity of the strains is high, coagulation time is short, and the gels range from very firm to firm, and if the growth activity of the strains used is low, the coagulation time is long, and the gels obtained are either soft or crumbly. It was also observed that the gel is in the form of small grains which pass with the serum. pH influences setting time, drainage and coagulum firmness (C HURTAUD et al 2001; Mietton et al, 1994; Martin er Coulon, 1995), thus cheese stabilization is mainly achieved by controlling the rate and level of lactic acid development during drainage for a final pH value greater than or equal to 5.2 after drainage (Gripon, 1997; Danton Batty et al 2018).

Ferments quantity

It was observed in this work that the cheeses from tests 11 to 15 are of higher quality than the cheeses from other tests. It was also observed that the tests made with a higher quantity of yeast than mold produce slightly harder cheeses than the ones made using two doses of mold for one dose of yeast. It was found that the quantity of the ferments used to make Camembert-type cheese during this work is acceptable and is between the values mentioned in Table 6, if the quantity of rennet is between 0.25ml / l and 0.4ml / l, and if the viability rate of the bacterial strains is between the values mentioned in Table 6, the latter values make it possible to reduce milk pH to 6.2 for 40 min to allow rennet to perform its activity when its activity drops rapidly above pH 6.3. So rennet must be added if milk pH is less than 6.3. The values of these parameters (viability rate, amount of ferment and amount of rennet) give the gel a good (firm) quality for 1h15 min at a temperature of 35°C. It was also observed that if the bacterial viability rate is low, the quantity of ferments must increase. The best dose formula of ferment used in this work is two doses of mesophiles for one dose of thermophile and two doses of *Penicillium C* mold for two doses of *Geotrichum C* yeast.

Yield

Yield assessment during the cheese making process

During the manufacturing of Camembert, the quantity of serum is measured, weighings and samplings were carried out for analyses, in order to monitor the evolution of the weight of cheese before and after ripening, Dornic acidity, pH of the top layer and underlayers as well as the appearance of cheeses. At the beginning of ripening, it was found that the cheese produced by the ferment has a low concentration disturbing a large amount of water (figure 6), even if the ripening conditions conform to standards, a temperature of 12°C and a humidity of 90%. Cheese yield is the mathematical expression of the quantity of cheese obtained from a given quantity of milk (often 100 L or 100 kg) (VANDEWEGH, 1997). Cheese yield is expressed according to the following formula (HANNO et al. 1991; LIBOUGA et al. 2006).

$$\text{Yield} = (\text{FQ} / \text{IQ}) \times 100$$

Yield: Yield of final product in%. / FQ: final quantity in g. / IQ: initial quantity of milk ml.

At the beginning of ripening, a cheese weighed on average 219.315g and approximately 160.85g after 15 days, i.e. an average loss of 58.465g; 26.6% and an average daily loss of 3.9g. The percentage of cheese produced in general during of this study is 6% to 13% (figure 8) . During this work, attempts to prepare Camembert using skimmed milk produced cheeses in smaller quantities than cheeses made using milk with high fat content, which shows that the higher the fat content, the greater the quantity of cheese. Cheese yields correspond to the amount of cheese that can be obtained with a fixed amount of milk. They mainly vary according to the quantity of water retained in the cheese, defined by the technological parameters and the protein and fat content of milk, with the latter being helpful with predicting cheese yields (C. HURTAUD et al.).

Description of obtained cheeses

The evaluation of the sensory quality of Camembert cheeses is carried out by a jury of trained tasters who give for each sample to be compared with samples of Camembert purchased at large retail outlets, a score for sensory descriptors.

Visual appearance: All the cheeses obtained have thin top layers thanks to *penicillium candidum*. However, a defect was observed in the cheese obtained on test 7, such defect can appear when the milk used is skimmed or the ripening is insufficient or when the quantity of *Geotrichum candidum* is higher than *penicilum condidum*. This defect is classified among the texture defects of cheese due to which the resulting cheeses are too dry or plastery. The rind obtained from the cheese is very thin and flowery with a fluffy white coating. *P. Candidaum* is covered with a thin layer of mycelium on the Camembert surface. The cheese obtains its white and fluffy rind that characterizes it (Bockelmann, 2010). The acceptability of the sensory characteristics of cheese largely depends on the taste and shape during maturation. Two classes of important compounds contribute to flavor : volatile sulfur compounds and fatty acids. Free fatty acids contribute to the development of taste and aroma to a large extent. Lipolysis is one of the main biochemical processes that contribute to the development of taste during cheese ripening (Tatiana Voblikova et al 2020).

Texture: The cheese made during this work has a similar texture to the desired cheese, and was well appreciated by the tasting panel. It is characterized by a smooth and homogeneous paste, this can be explained according to NUNEZ et al. (1991), only test 7 cheese is dry and plastery. In this work, it was observed that the cheese produced using a higher quantity of *Geotrichum C* than *Penicillium C* has a hard rind, and due to that, we tried to make the cheese by the application of the following dose : two doses of PC for a dose of GC, which produced a flexible white to light yellow product with a better texture that isn't runny, and without softness. The cheese is firm from the edges to the center. Fat decrease proved to be a challenge, as fat is important for the texture and taste of dairy products, especially for cheese. Fat decrease in cheese leads to an unwanted texture, a lack of taste or presence of extraneous flavors. The profile of fatty acids in the process of cheese maturation has changed significantly (Tatiana Voblikova et al 2020).

Taste: The tasting panel assessed the taste of the manufactured cheese, they judged it to be very acceptable: a slightly acidic and moderately salty taste with a mild mushroom taste, and a pronounced fruity flavor.

Color and odor: All the manufactured cheeses are characterized by a white rind which is formed by *Penicillium C.*, a ripening ferment. Ripened cheeses have a hazelnut odor. The color, texture, odor and taste of all the samples meet the requirements for Camembert-type cheeses. In addition, the organoleptic qualities of the cheeses were assessed and compared to one another by the tasting panel.

Conclusion

In this work, Camembert-type cheese was made in the food technology laboratory of the Agronomy and Veterinary Institute of Rabat, with a particular interest in the effects of industrial ferments on the quality of our product as well as the doses of each ferment (*Flora Danica*, *Thermophile*, *Geotrichum Candidum*, *Penicilum Candidum*). The samples of pasteurized whole cow milk intended for the manufacture of Camembert-type cheese as well as the finished "Camembert" product were analyzed to assess their physicochemical characteristics. The results of the analyses of the physicochemical characteristics (pH, acidity, density, fat) of milk indicate mean values of 6.3 ° D, 1.0315 g / l, 30.7 g / l respectively, which comply with AFNOR, 1980 standards. The results of the analysis of the physicochemical characteristics (pH, acidity, density, fat) of the finished "Camembert" product indicate mean values of 20.28g / l, 50.57%, 49.35% and 29.10% respectively, showing that our finished product is of a satisfactory quality according to the standards specified by the country.

Declarations

Ethics approval and consent to participate

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Consent for publication

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

All data generated or analyzed during this study are included in this article.

Competing interests

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Authors' contributions

H.N ;M.M and M.Mu : Conceived of the presented idea, the analysis of the results ,wrote a part of the manuscript and polished the manuscript , aided in interpreting the results and worked on the manuscript;

H.N and M;Z: verified the analytical methods

H.N ; M.M, M.Z ;M.M conceived and planned the experiments, involved in planning and supervised the work.

N.H ; M.M ; M.Z ; and A.O: Supervise language, correction contributed to the design and implementation of the research.

All authors discussed the results and contributed to the final manuscript, processed the experimental data, performed the analysis, contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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References

-**A. Afif**, M. Faid and M. Najimi, "Microbiological quality of raw milk produced in the Tadla region in Morocco". Reviews in Biology and Biotechnology. Vol. 7, N ° 1, pp. 2-7, 2008.

-**Aguenou.H**, Achaari.A, Barkat.A , Barakat.I,Benamrane.L ...Moroccan Nutrition Guide.2016

-**Antonio Carlos Prestes Pereira**; Priscila Judacewski; Gabriel Coelho; Renata Dinnies Santos Salem; Marina Tolentino Marinho; Aline Alberti; Acácio Antonio Ferreira Zielinski ;Ivo Mottin Demiate; Alessandro Nogueira << Assessment of physicochemical, textural and microbiological properties of brazilian white mold surface-ripened cheeses: a technological approach>> FOOD TECHNOLOGY, v.50:1, 2020 pp

-**C. HURTAUD ,S . BUCHIN ,B . MARTIN ,I, VERDIER-METZ ,J .L. PEYRAUD , Y NOEL** << The quality of milk and its consequences on the quality of processing products: some measurement techniques in zootechnical trials>> Renc. Rech. Ruminants, 2001, 8 pp 37.

-**Danton Batty**, Joy G. Waite-Cusic,* and Lisbeth Meunier-Goddik Influence of cheese making recipes on the composition and characteristics of Camembert-type cheese J. Dairy Sci. 102:164–176
<https://doi.org/10.3168/jds.2018-14964>.

-**Dejmek, P.** 1987. Dynamic rheology of rennet curd. J. Dairy Sci. 70:1325–1330.

-**Denise Felix da Silva**, Danai Tziourib, Richard Ipsena, Anni Bygvrå Hougaard << Towards the manufacture of camembert cheese powder: Characteristics of cheese feeds without emulsifying salts>> LWT - Food Science and Technology 127 (2020) 109412.

- F. Amhour**i, B. Said, A. Hamama, et M. Zahar, <<Microbiological quality of raw milk: Case of the Errachidia region ". Acts Inst. Agron. Vet. 18 (1), Maroc, pp.31-35,1998.
- Ferrão, L. L.**, Silva, E. B., Silva, H. L. A., Silva, R., Mollakhalili, N., Granato, D., et al. (2016). Strategies to develop healthier processed cheeses: Reduction of sodium and fat contents and use of prebiotics. Food Research International, 86, 93–102. <https://doi.org/10.1016/j.foodres.2016.04.034>.
- Hyslop, D. 2003**. Rennet coagulation of milk. Pages 839–878 in Advanced Dairy Chemistry, Volume 1. Proteins. 3rd ed. P. F. Fox and P. L. H. McSweeney, ed. Aspen, Gaithersburg,MD.
- J.A ,LUCEY**. et al. Perspectives on the basis of the rheology and texture properties of cheese. Journal of Dairy Science, v.86, p.2725-2743, 2003.
- J.P. Dumont**, G. Delespaul, B. Miguot et J. Adda, «"Influence of psychrotrophic bacteria on the organoleptic qualities of soft cheeses>>.Original briefs. Milk. pp.569-570,1977.
- Johnson, M. E.**, C. M. Chen, and J. J. Jaeggi. 2001. Effect of rennet coagulation time on composition, yield, and quality of reducedfat Cheddar cheese. J. Dairy Sci. 84:1027–1033.
- J. Y. DUPONT**, E. GERVAIS and N. BARBIER Study of Camembert and Saint-Paulin cheese yields 1970.
- K. Ounine**, A. Rhoutaisse and N.E. El Halou, "Bacteriological characterization of raw milk produced in stables in the Gharb region". Al awamia, 109-110, pp. 187-204, 2004.
- Kim, N. S.**, Lee, J. H., Han, K. M., et al. (2014). Discrimination of commercial cheeses from fatty acid profiles and phytosterol contents obtained by GC and PCA. *FoodChemistry*. vol. 143. pp. 40–47.
- Leclercq-Perlat**, M.-N., Sicard, M., Perrot, N., Trelea, I. C., Picque, D., & Corrieu, G. (2015). Temperature and relative humidity influence the ripening descriptors of Camembert-type cheeses throughout ripening. Journal of Dairy Science, 98(2), 1325–1335. <https://doi.org/10.3168/jds.2014-8916>.
- LECLERCQ-PERLAT, M. N.** Cheese: camembert, brie, and related varieties. In: FUQUAY, J.W.; MCSWEENEY, P.L.H.; FOX, P.F. (Eds). Encyclopedia of Dairy Sciences, 2nd ed., pp. 773– 782. Mississippi: Elsevier, 2011, 4170p.
- Lucey, J. A. 2002**. Formation and physical properties of milk protein gels. J. Dairy Sci. 85:281–294.
- NM 08.4.005**. Milks and derived products: Determination of titratable acidity of milk. Moroccan Industrial Standardization Service. SNIMA 1995.
- N. Ouazzani Taybi**, A. Arfaoui and M. Fadli, "Evaluation of the microbiological quality of raw milk in the Gharb region, Morocco". International journal of innovation and scientific research. Vol. 9 n ° 2, pp. 487-493, 2014.
- Prosekov, A. Yu.**, Dyshlyuk, L. S., Belova, D. D. (2019). Biodegradable antimicrobial packaging in cheese making. Cheesemaking and buttermaking. vol. 3. pp. 40–42.

- Spinnler, H.-E.**, & Gripon, J.-C. (2004). Surface mould-ripened cheeses. Cheese: Chemistry, physics and microbiology: Vol. 2[https://doi.org/10.1016/S1874-558X\(04\)80043-5](https://doi.org/10.1016/S1874-558X(04)80043-5).
- Tatiana Voblikova**, Anatoly Permyakov, Antonina Rostova, Galina Masyutina, and Anastasia Eliseeva Influence of the maturation process on the sheep's milk of Camembert cheese fatty acid profile change BRDEM-2019 International applied research conference «Biological Resources Development and Environmental Management» Volume 2020
- USDA**, National Nutrient Database for Standard Reference, 2018
- Z. Mennane**, M. Ouhssine, K. Khedid et M. Elyachioui, « Hygienic quality of raw cow's milk feeding from waste in two regions in Morocco ». International journal of agriculture and biology. Vol.9, n°1, pp.46-48, 2007
- Zoon, P., T. van Vliet**, and P. Walstra. 1988b. Rheological properties of rennet-induced skim milk gels. 2. The effect of temperature. Neth. Milk Dairy J. 42:271–294.
- Zoon, P., T. van Vliet**, and P. Walstra. 1988a. Rheological properties of rennet-induced skim milk gels. 1. Introduction. Neth. MilkDairy J. 42:249–269.

Figures

Figure 1

Physicochemical parameters of the milk intended for manufacturing cheese

Figure 2

pH values during the transformation of milk to cheese

Figure 3

Dornic acidity values during the transformation of milk to cheese

Figure 4

Assessment of pH values for the three Camembert layers

Acidity °D

Figure 5

Dornic acidity value of Camembert

Figure 6

Quantity of lost water during ripening

Figure 7

Cheese portions yield (g /l) before and after ripening .

Figure 8

Cheese yield in percentage (%)

Supplementary Files

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