Acta Sci. Pol. Technol. Aliment. 21(4) 2022, 401–409

www.food.actapol.net pISSN 1644-0730 eISSN 1898-9594 http://dx.doi.org/10.17306/J.AFS.2022.1086

ORIGINAL PAPER

Received: 21.09.2022
Accepted: 29.11.2022

PHYSICOCHEMICAL AND SENSORIAL CHARACTERISATION OF MARINATED WHITE CHEESE MADE FROM GOAT MILK WITH OLIVE OIL AND THYME

Yassine Zine-Eddine, Fouzia Kzaiber, Abdelkhalek Oussama, Khalid Boutoial

Laboratory of the Engineering and Applied Technologies, Higher School of Technology, Sultan Moulay Slimane University
Higher School of Technology, Mghila University Campus, Pb 591 Béni Mellal, **Morocco**

ABSTRACT

Background. White cheese is of great interest for consumption. In Africa, the United States, and Greece, in particular, a significant number of new varieties of this cheese were introduced in 2008. 16.62% of the Moroccan population does not like goat milk because of its intense flavour, which also affects the consumption of products derived from it. Hence, this study aims to develop a white cheese from goat milk by improving the flavour of the cheese to make it more acceptable to the Moroccan population by using different coagulants and olive oil and thyme during ripening.

Materials and methods. Six batches of white cheese made from goat milk were produced in this study and expressed in three groups. Two fresh white cheeses formed the first group: fresh white cheese milk coagulated by a microbial enzyme (MF) and fresh white cheese coagulated by a vegetable enzyme (VF). Marinated white cheese made from goat milk made up the second group; it contained: marinated white cheese with olive oil coagulated by a microbial enzyme (MH) and marinated white cheese with olive oil elaborated by an original plant enzyme (VH). The third group contained: marinated white cheese with olive oil and thyme made by a microbial enzyme (MA) and marinated white cheese in olive oil and thyme coagulated by an original plant enzyme (VA). pH values, moisture, fat content, protein content, and water activity (a_w) were the main physicochemical parameters analysed for all the types of cheese studied. All the studied cheeses were analysed for sensorial properties. The sensory evaluation was carried out by 14 panellists formed and explicitly trained on this subject to identify a set of sensory characteristics. An acceptance test was also carried out for all cheeses.

Results. The aromatic effect of olive oil and thyme increased consumer acceptance of the studied white cheese. Thyme had an antimicrobial effect in addition to its aromatic effect, which reduced the value of a_w. Marinating the white cheese made from goat milk produced in this study with olive oil and thyme reduced the intensity of the bitter aftertaste and the “goaty” flavour, which was almost non-existent in the white cheeses marinated with thyme. It’s worth noting that the vegetable enzyme also masked the “goaty” flavour. Coagulated white cheeses with the vegetable enzyme were the least hard and easiest to chew and had the most acidic smell and taste compared to those coagulated by the microbial enzyme.

Conclusion. This study presented a new cheese variety of white cheese made from goat milk. All of these cheeses have been characterized physiochemically. A sensory and acceptance analysis of these was also carried out. According to the results, the change in the type of coagulant and the mode of ripening affects the physicochemical and sensory characteristics of the studied cheeses. The aromatic effect of olive oil and thyme increased consumer acceptance of the studied white cheeses. In addition to the aromatic effect of thyme, the latter exhibited an antimicrobial effect, decreasing the value of a_w, adding that the use of a plant enzyme as a coagulant masked the “goaty” flavour.

Keywords: vegetable coagulant, aromatic plant, marinated product

✉zineeddine.yassine95@gmail.com, https://orcid.org/0000-0002-5549-8411

INTRODUCTION

One of the most widely consumed types of pickled cheese worldwide is feta cheese (McMahon et al., 2009). Historically, Greece has manufactured it since the Homeric era. Unquestionably, the cheese prepared by the Cyclops Polyphemus and most ancient Greeks was the forerunner of contemporary feta. Numerous sources support the Greek origins of this cheese as well as the ongoing influence of the Greeks on its development (Robinson and Tamime, 1996). Feta cheese is a Protected Denomination of Origin (PDO) prepared from sheep milk or a combination of sheep and goat milk (Rantsiou et al., 2008). The Greek government created a global standard for Feta cheese in 1988 and submitted it to FAO/WHO. It has been and continues to be a vital component of the Greek diet, and its name has numerous associations with Greek history and customs (Robinson and Tamime, 1996). Feta is a soft white cheese that is brine-ripened (Sarantinopoulos et al., 2002). It is well-liked worldwide and has a pleasant organoleptic quality with a salty, somewhat acidic taste. The body and texture of the cheese are firm, creamy, and smooth, making it sliceable (Kandarakis et al., 2001; Sarantinopoulos et al., 2002).

There was a substantial number of new white cheese varieties introduced in 2008, particularly in Africa, the US, and Greece. Approximately 10^9 kg of feta-type cheeses are produced yearly, representing 7% of all cheese made worldwide (McMahon et al., 2009); indicating a great interest in white cheese consumption.

The creation of rennet replacements has received a lot of interest recently. Proteolytic enzymes of plant, animal, bacterial, and fungal origin have all been studied (García et al., 2015). Still, only a few appear to have significant potential as calf rennet substitutes, including microbial rennet for partial or complete replacement of calf rennet in cheese production (Alichanidis et al., 1984). Microbial coagulants have been employed as alternatives to animal rennet because they are easy to generate through fermentation, allowing for indefinite availability and a reduced price. Proteases derived from *Rhizomucor miehei*, *Rhizomucor pusillus*, and *Cryphonectria parasitica* are the most often used microbial coagulants; the first of these, *Rhizomucor miehei*, has been utilised as an alternative to animal rennet for almost 40 years (Jacob et al., 2011; López et al., 2012). Numerous plants have been investigated as potential coagulants, but only a few have proven suitable for commercial cheese manufacturing (Lo Piero et al., 2002). Thistle (*Cynara cardunculus*) extract is the most well-known vegetable coagulant and is utilised in the Iberian Peninsula, mainly for manufacturing ewe's milk cheeses (García et al., 2015). Torta del casar is an example of a cheese that used *Cynara cardunculus* as a coagulant from the maceration of these flowers in water (Delgado et al., 2010). Nonetheless, aqueous extract made from *Cynara cardunculus* flowers, which has been used for years in producing artisanal cheese, particularly in the Mediterranean, southern Europe, and western Africa, produces the desired results (López et al., 2012).

Goat milk is characterized by its intense taste and smell (goaty flavour), which is responsible for the non-consumption of this milk. This (goaty flavour) affects the consumption of products derived from this milk. About 16.62% of the Moroccan population does not like this milk because of its intense flavour (Zine-eddine et al., 2021a).

This study aimed to determine the physicochemical characteristics and the organoleptic properties of white cheeses made from Alpine goat milk coagulated separately by microbial and vegetable enzymes. It also aimed to improve the flavour of this cheese to make this product more acceptable to the Moroccan population by marinating it with olive oil and thyme during ripening.

MATERIALS AND METHODS

Milk sample

Fresh goat milk from an alpine breed was studied for cheesemaking. It was collected from a farm in Béni Mellal city, Morocco. The goats were fed with a mixture of fodder and pasture. The milk samples were stored at 4°C until laboratory analysis; these analyses were carried out on the same day as milking occurred. The physicochemical parameters were analysed by Milkoscan in a combi Foss 5000, Foss Electric, Hillerod, Denmark. The acidity of the milk was measured by acid-base titration with sodium hydroxide (NaOH), as described by (Guiraud, 1998), using phenolphthalein as a colour indicator. The results are expressed in Dornic degrees (°D).

Table 1. The mean values and standard deviations of physicochemical compositions of milk samples

Variable	Fat %	Solid-non-fat %	Density	Freezing point °C	Protein %	Lactose %	Salts %	Acidity °D	pH
Mean	3.55 ±0.60	8.42 ±0.29	1.03 ±0.00	0.53 ±0.02	3.07 ±0.10	4.61 ±0.15	0.69 ±0.02	17.25 ±1.33	6.77 ±0.07

The mean values and standard deviations for the physicochemical composition of the milk samples are summarised in Table 1. These results concluded that the goat milk samples used in this study were homogeneous and that the samples could be prepared as a mixture.

Coagulants

In this study, two coagulants were used. The first was HANNILASE XP 200 CHR-HANSEN, DENMARK (Activity: ~200 IMCU/ml, Dosage: 33–66 IMCU/L of milk) from *Rhizomucor miehei*. Pistil from the flowers of *Cynara cardunculus* was used as a coagulant of plant origin. We extracted the vegetable coagulant by suspending 10g of powdered flowers in 90 mL of water for 30 minutes. After being centrifuged for 10 minutes at 4000 rpm, the resultant extract was filtered through a cheesecloth. Using filter paper, the supernatant was purified and stored at 4°C until use (never more than 2 days; López et al., 2012). Using the Berridge method, the coagulants were standardised to have the same milk clotting activity in standard milk as defined by IDF (López et al., 2012).

Cheesemaking

Six batches of white cheese made from Alpine goat milk were produced in this study and expressed in three groups. Two fresh white cheeses formed the first group: fresh white cheese coagulated by a microbial enzyme (MF) and fresh white cheese coagulated by a vegetable enzyme (VF). Marinated white cheese from goat milk made up the second group; it contained: marinated white cheese with olive oil coagulated by a microbial enzyme (MH) and marinated white cheese with olive oil elaborated by an original plant enzyme (VH). The third group contained: marinated white cheese with olive oil and thyme made by a microbial enzyme (MA) and marinated white cheese with olive oil and thyme coagulated by an original plant enzyme (VA).

The two fresh white cheese types (MF and VF) were produced with the two coagulants mentioned earlier. Alpine goat milk was pasteurised at 73°C for 15 s and immediately cooled to a temperature of 32°C. Calcium chloride is always required to produce white cheese from pasteurised milk to ensure superior curd quality and coagulation (Robinson and Tamime, 1996). For this, calcium chloride dihydrate (SIGMA--ALDRICH GERMANY) was used to prepare a calcium chloride solution at a concentration of 510 g/l. From this solution, calcium chloride was added in the order of 0.3 ml per litre of milk (García et al., 2015). The mesophilic culture was used as a starting culture, which was preincubated in milk at 32°C for a time of 20 min (Tejada et al., 2006). The two types of white cheese were prepared in the same way up to this stage. The two types of coagulants were added separately for each preparation, with doses previously adjusted as mentioned above to obtain a coagulation time of 40−45 min. After coagulation, the curd was cut into cubes with an edge of 2 to 3 cm with very thin vertical and horizontal knives and left to stand for 10 min. Stirring was applied slightly until grains the size of chickpeas were obtained, accompanied by the elimination of partial whey (more than two–thirds). The curd obtained was left to drain in moulds at around 22°C. The moulds were turned 4 times at 20-minute intervals and incubated at 22°C for approximately 22 to 24 hours. The cheese blocks were removed from the moulds and cut into 100 ±1 g pieces in preparation for brining. The cheeses were immersed in a 20% brine solution at a temperature of 16°C for 6 hours. They were sent to a cold room at 4 to 6°C for 72 hours, where they continued to mature. This cheese was presented as the fresh white cheese type for both types of coagulants.

Regarding the marinated white cheeses with olive oil (MH and VH), the fresh white cheese made from each preparation was taken and placed separately in dark jars containing olive oil for 2 weeks at room temperature of 20−22°C.

For the marinated white cheeses with olive oil and thyme (MA and VA), it was the same process as the marinated white cheeses with olive oil, adding 3% of thyme and ripened for 2 weeks.

Physicochemical analyses

The pH values, moisture, and fat content were the three most critical compositional factors that affected cheese properties (Karami et al., 2009). The pH was determined by suspending grated cheese (5 g ±0.1 mg) in 30 mL of distilled water and stirring the mixture (water and cheese) for 10 minutes (Boutoial et al., 2013). The total fat content was measured using Gerber Van Gulik butyrometers (Boutoial et al., 2013). The moisture content of the cheese samples was determined by heating them to a constant weight at 102 ±2°C (Georgala et al., 2005). The proteins were determined using "Kjeldahl" standard methods (Adamopoulos et al., 2001). The water activity (a_w) was measured using Novasina® equipment (TH 200, Lachen, Switzerland). Saturated salt solution patterns with known relative humidity values were used for calibration. The crushed sample was placed in the device's cell, and the reading was allowed to stabilise (1 hour) before recording. All analyses were done in triplicate.

Sensory evaluation

The cheese samples were subjected to sensory evaluation. The sensorial assessment was conducted by 14 panellists formed and explicitly trained on this subject to identify a set of characteristics (whiteness intensity, hardness, grainy texture, porosity, elasticity, stickiness, chewiness, dryness, acid smell, cream smell, goat smell, acid taste, salty taste, goat taste, bitter aftertaste, olive oil smell, olive oil taste, peculiar aroma smell, and peculiar aroma taste) on a scale of 0–10 where the intensity increases with increasing number. The results were expressed as an average score for each characteristic. The six types of white cheese were evaluated. In order to remove any aftertaste, mineral water was supplied in between samples (Zine-eddine et al., 2021b).

For the acceptance test, civil servants, teacher-researchers, and students from the Béni Mellal Higher School of Technology (Sultan Moulay Slimane University, Morocco) took part in the consumer test (56 participants). These participants evaluated the cheeses and gave them a mark on a scale of 0–10. A set of 336 samples was tested.

Statistical analysis

The statistical analysis was carried out using IBM SPSS Statistics version 25. A one-way multivariate ANOVA and a Tukey test with a 0.05 significance level were carried out for the data analysis.

RESULTS AND DISCUSSION

Physicochemical analyses

Table 2 gathers the physicochemical parameters of the six types of white cheese. It expresses changes in mean values for water activity, protein, %, fat, %, moisture,

Table 2. One way ANOVA analysis of the physicochemical parameters versus the types of cheese using the Tukey method for the grouping information and 95% confidence

Cheese	a_w	Protein, %	Fat, %	Moisture, %	pH
MF	0.947^{a}±0.001	16.74^{d}±0.0115	20.00^{c} ±0.000	56.60^{b} ±0.0361	5.00^{a} ±0.00
VF	0.937^{b}±0.001	16.55^{e}±0.0100	20.67^{bc}±0.577	57.32^{a} ±0.0200	4.98^{a} ±0.01
MH	0.937^{b}±0.001	19.10^{b} ±0.0100	21.00^{abc} ±0.000	54.68^{f} ±0.0300	4.68^{c} ±0.01
VH	0.936^{b} ±0.001	17.55^{c} ±0.0100	22.00^{a} ±0.000	55.57^{d} ±0.0100	4.94^{b} ±0.01
MA	0.932^{c} ±0.001	19.73^{a} ±0.0300	21.67^{ab} ±0.577	54.90^{e} ±0.0100	4.66^{c} ±0.01
VA	0.928^{d}±0.001	19.09^{b} ±0.0100	21.67^{ab} ±0.577	55.89^{c} ±0.0100	4.92^{b} ±0.02

Means that do not share a letter are significantly different.

%, and pH. The pH of the cheese was less than or equal to 5 (range of 4.62 to 5.00), as is generally reported for Feta cheese (Litopoulou-Tzanetaki et al., 1993). These pH values are required for mature Feta cheese to keep its high quality while being stored (Karami et al., 2009). White cheeses MF and VF shared the same group and exhibited high pH values ($P < 0.05$). A decrease in pH was observed for the marinated white cheese, where the white cheese VH and VA with the values 4.94 and 4.92 successively exhibited the highest pH values of the marinated white cheese. No significant difference was observed between these two types. This was followed by white cheese MH and MA, which did not differ significantly and represented the lowest pH values. Tejada et al. (2006) mentioned that vegetable coagulants had intense proteolysis for cheeses made from these coagulants, which explained the slight change in pH between ripened and fresh cheese. This result may be due to the release of alkaline amino acids that raised the pH (Karami et al., 2009; Werner et al., 1999).

The moisture content values differed significantly ($P < 0.05$), ranging from 54.68% to 57.32%. Fresh white cheese VF and MF presented the highest humidity values, 57.32% and 56.60% respectively. A decrease in moisture is marked in marinated white cheese types (the moisture of Feta cheese decreases during ripening (Robinson and Tamime, 1996). This fact stood out more in white cheese varieties marinated in olive oil alone than those with thyme. This decrease is due to dehydration of the cheese during ripening (Alichanidis et al., 1984). According to Alimentarius (2003), "first" quality Feta cheese has a maximum moisture content of 56.00%. This was the case for our study's MH, VH, MA, and VA cheeses. The average protein content values of the six batches of cheese ranged between 16.55 and 19.73%, and all the averages were significantly different ($P < 0.05$). An increase in protein levels was marked for marinated (ripened) white cheeses, which is normal where decreasing moisture is indicated. This was the case for the fat where the latter's level increased during ripening for the marinated white cheese samples (Table 2). This result is also explained by the decrease in moisture (Robinson and Tamime, 1996). The measurement of a_w is a method for determining water's chemical potential, which is associated with a food's microbiological and enzymatic stability (Grummer and Schoenfuss, 2011; Rahman and Sablani, 2009). In cheese, water activity is crucial since it affects the product's quality, stability, and safety (Marcos, 1993). All cheeses showed low a_w values (0.928−0.947). A decrease in a_w was marked from fresh to pickled white cheese types ($P < 0.05$), so olive oil had a lower effect on these cheeses' water activity. Notably, this decrease was most noticeable in the marinated white cheese with olive oil and thyme. Consequently, more than the sensory effect of thyme and olive oil, they positively influenced the microbial stability of these white cheese types.

Sensory evaluation

Sensory evaluation is a useful criterion for assessing cheese quality and acceptance (Robinson and Tamime, 1996). Table 3 shows the one-way ANOVA analysis of the sensory characteristics' response versus the six types of white cheese from goat milk (MF, VF, MH, VH, MA, VA) using the Tukey method for the grouping information and 95% confidence. The intensity of the whiteness for the six types was significantly different ($P < 0.05$), MF and MH were the whitest in intensity, and the latter decreased for the two types, VF and MA. However, VH and VA presented the least white cheeses in terms of intensity of this colour. Note that the types made by the coagulant of vegetable origin were less white than those made by the coagulant of microbial origin in terms of intensity. López et al. (2012) revealed the same results for fresh cheeses made from goat milk. The decrease in whiteness intensity for marinated white cheeses is due to the chlorophyll present in the olive oil. In addition, the thyme decreased this value. Regarding hardness, all the cheeses were significantly different ($P < 0.05$): MH and MA cheeses were the hardest, MF and VH were less hard, while VA and VF were the least hard of all the types. A significant increase in hardness for fresh white cheese was made by the coagulant of microbial origin when marinated with olive oil and thyme (almost double the value), while this increase was very low for those produced by the plant enzyme. The white cheeses made with the plant-based enzyme were significantly less hard. This was not the case for (López et al., 2012), who found that the plant-based coagulant presented the hardest fresh goat milk cheeses compared with those produced by the enzyme of microbial

Table 3. One way ANOVA analysis of the sensorial characteristics' response versus the type of cheese using the Tukey method for the grouping information and 95% confidence

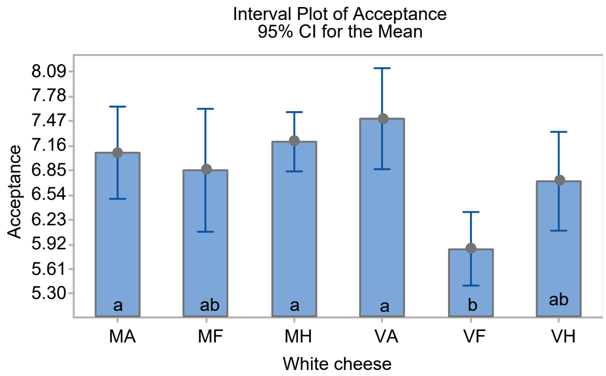
Cheese type	Whiteness intensity	Hardness	Grainy texture	Porosity	Elasticity	Stickiness	Chewiness	Dryness	Acid smell	Cream smell	Goat smell	Acid taste	Salty taste	Goat taste	Bitter after-taste	Olive oil smell	Olive oil taste	Peculiar aroma smell	Peculiar aroma taste
MF	8.571^{A}	3.786^{B}	0.571^{B}	4.929^{B}	1.643^{A}	1.357^{B}	2.643^{A}	2.571^{C}	4.041^{B}	4.214^{A}	2.143^{A}	4.286^{B}	5.000^{A}	2.214^{A}	2.929^{A}	***	***	***	***
VF	7.500^{BC}	3.071^{C}	0.357^{B}	4.071^{C}	1.929^{A}	2.786^{A}	1.143^{C}	1.071^{E}	4.857^{A}	4.429^{A}	0.786^{B}	5.143^{A}	5.214^{A}	1.286^{B}	2.714^{AB}	***	***	***	***
MH	8.143^{AB}	6.429^{A}	4.429^{A}	6.286^{A}	0.500^{B}	0.571^{C}	2.786^{A}	4.643^{A}	0.571^{E}	1.357^{B}	0.357^{BC}	3.500^{D}	3.929^{B}	0.143^{C}	1.714^{C}	3.214^{A}	3.286^{A}	***	***
VH	7.286^{C}	3.429^{BC}	4.143^{A}	4.143^{C}	1.714^{A}	2.929^{A}	1.714^{B}	1.714^{D}	3.714^{B}	0.571^{C}	0.214^{C}	4.071^{BC}	4.000^{B}	0.143^{C}	2.286^{B}	2.571^{BC}	3.000^{AB}	***	***
MA	7.714^{BC}	6.286^{A}	4.143^{A}	5.857^{A}	0.643^{B}	0.857^{C}	2.786^{A}	3.786^{B}	1.786^{D}	0.143^{C}	0.143^{C}	3.000^{E}	3.429^{C}	0.071^{C}	0.643^{D}	2.714^{B}	2.786^{BC}	7.214^{A}	7.286^{A}
VA	7.143^{C}	3.143^{C}	3.857^{A}	3.286^{D}	1.929^{A}	3.143^{A}	1.214^{C}	1.286^{DE}	2.857^{C}	0.357^{C}	0.143^{C}	3.857^{CD}	3.714^{BC}	0.071^{C}	1.500^{C}	2.214^{C}	2.571^{C}	3.929^{B}	7.071^{A}

Means that do not share a letter are significantly different.
Standard deviation of all means equals 1.

origin and calf rennet. The results of our study coincided with those obtained from sheep milk cheese (Tejada et al., 2006), where the vegetable coagulant makes the cheese less hard. The casein network is disrupted by the extensive proteolysis occurring in cheeses manufactured with vegetable coagulants, resulting in a more homogenous structure and increased creaminess and softness of the cheese (Tejada et al., 2006). Calvo et al. (2007) found that hardness increased significantly due to low moisture content, which may be related to our hardness results (Table 2) for the microbial coagulant, but this was not the case for white cheese coagulated by a vegetable enzyme. Regarding graininess, the two groups were significantly different ($P < 0.05$). There was almost no graininess in the fresh white cheese, although the graininess increased for the marinated types. Tejada et al. (2006) found that Murcia al vino cheese made using a vegetable coagulant was less grainy when compared to animal rennet. The porosity was more striking in the MF than the VF, and this criterion was raised in the marinated types ($P < 0.05$). This was not the case for the vegetable types, where the porosity remained almost the same for the marinated types and decreased for VA. All of the white cheeses presented a low elasticity with a marked decrease for the marinated white cheese of microbial origin ($P < 0.05$). The different types of white cheese produced by the vegetable enzyme presented the most significantly different stickiness to those made from the microbial origin, where this character was marked more in the vegetable white cheese. However, it was low for the microbial white cheese ($P < 0.05$). All the cheeses showed low values of chewiness, where the white cheese of plant origin was the easiest to chew ($P < 0.05$). Contrary to the results obtained by López et al. (2012), the fresh cheeses made from the vegetable coagulant presented high chewing values. The chewiness and stickiness criteria results can be explained by the intense proteolysis that occurs in cheeses made with vegetable coagulants breaking the casein network, giving rise to a more homogeneous structure, thus resulting in greater creaminess and softening of the cheese (Tejada et al., 2006). Regarding dryness, the white cheese types of microbial origin were the driest, and the intensity increased for the marinated types ($P < 0.05$), unlike the white cheese of plant origin, which were the least dry ($P < 0.05$). For the two fresh white cheeses, the VF was more acidic in smell than the MF ($P < 0.05$). Although this criterion was reduced for the marinated types, this reduction was more striking for the microbial white cheese than the vegetable ones. Similarly, for the acid taste, the vegetable white cheese presented this character more than for the microbial white cheese ($P < 0.05$), while the olive oil and thyme reduced the intensity of the acid taste but not the same intensity in the smell of the latter. It should also be noted that acid taste and smell were always more intense in the vegetable white cheese than in microbial ones. These results highlight the effects of cardoon extracts on the flavour of cheeses. This is probably due to the greater proteolysis of the vegetable coagulant. López et al. (2012) and Tejada et al. (2006) have also confirmed the high degree of hydrolysis of the vegetable coagulant responsible for this result by the production of free amino acids (FAA) present in the cheese (Boutoial et al., 2013; García et al., 2015). The goat taste and smell were marked in the MF more than the VF ($P < 0.05$), hence the masking nature of the "goaty flavour" for the vegetable coagulant. In addition, VH, MH, VA, and MA were significantly different for this criterion compared to fresh white cheese ($P < 0.05$), where olive oil still masked this criterion. In addition, the thyme effect still makes the "goaty flavour" almost nil. This masking character was also the origin of the masking of the cream odour, which was revealed more in fresh white cheese ($P < 0.05$). Although it presented weakly, a significant difference ($P < 0.05$) was detected between the bitter aftertaste of fresh white cheese MF and VF, where VF had less of this criterion (Table 3). These results agreed with those obtained with sheep milk cheeses made using a vegetable coagulant, which did not develop a very bitter taste (Tejada et al., 2006), unlike those of cow's milk cheeses (Tejada et al., 2006). Note that the intensity of the bitter aftertaste is reduced for pickled types (Table 3). This may be explained by the aromatic effect of thyme and olive oil, which masked the bitter aftertaste. The salty taste was significantly reduced ($P < 0.05$) in the marinated white cheese types compared to the fresh white cheese MF and VF, the group which presented the high values, hence the decreasing effect of this criterion by the olive oil and ripening time. In addition, this decreased even more for the types marinated with thyme (Table 3). The taste and odour of olive oil were weakly present in the marinated white cheese types. However, its intensity was marked in the microbial white cheese types, while it decreased significantly ($P < 0.05$) for the marinated white cheese with thyme (Table 3). For the taste of thyme, it was well presented in both MA and VA types, and we did not detect a significant difference ($P < 0.05$) between them. While it existed in the case of smell where the latter was revealed more clearly in the MA than in the VA, this was due to the intense odour originating from the VA previously explained.

Acceptance test

Figure 1 shows the Interval plot of participants' acceptance for the white cheese from goat milk (95% CI of the mean). According to this analysis, a significant difference was detected between the responses of the participants ($P < 0.05$). The VA, MH, and MA were the types that were most accepted by the participants, followed by MF and VH. VF was the least accepted type. Therefore, using vegetable coagulants leads to cheeses that consumers accept less. The same results were showed by López et al. (2012). The aromatic effect of olive oil and thyme made VA the most accepted, although, before pickling (VF), it was the least accepted. However, pickling the latter with olive oil alone increased acceptance but not to the same extent as with thyme. Whereas for MF, marinating the latter either with olive oil alone or with thyme made it more accepted by participants (MH and MA). No significant difference was detected between these two types ($P < 0.05$).



a,b Grouping information using the Tukey method and 95% confidence for the one-way ANOVA analysis of participants' acceptance
Means that do not share a letter are significantly different

Fig. 1. Interval plot of participants' acceptance for the white cheeses (95% CI of the mean)

CONCLUSIONS

The stickiness was more marked in the white cheeses produced by the vegetable enzyme. This enzyme made the white cheese less hard, easier to chew, and less white. In addition, the white cheese coagulated by the plant enzyme was more acidic in taste and smell than those coagulated by the microbial enzyme. Marinating the white cheeses with olive oil and thyme reduced the intensity of the bitter aftertaste as well as the "goaty" flavour, while the latter almost did not exist for the marinated white cheese with thyme. Marinating also made the texture of the white cheese more grainy and less white. The aromatic effect of olive oil and thyme made the studied white cheeses more acceptable to consumers. In addition to the aromatic effect of thyme, the latter exhibited an antimicrobial effect which decreased the value of a_w.

REFERENCES

Adamopoulos, K. G., Goula, A. M., Petropakis, H. J. (2001). Quality control during processing of feta cheese NIR application. J. Food Comp. Anal., 14, 431–440. https://doi.org/10.1006/jfca.2000.0976

Alichanidis, E., Anifantakisf, E. M., Polychroniadou, A., Nanouf, M. (1984). Suitability of some microbial coagulants for Feta cheese manufacture. J. Dairy Res., 51, 141–147.

Alimentarius, C. (2003). Food chemical codex. Official J. Hellenic Rep., B, art. 83. Athens, Greece: National Printing Office.

Boutoial, K., Alcántara, Y., Rovira, S., García, V., Ferrandini, E., López, M. B. (2013). Influence of ripening on proteolysis and lipolysis of Murcia al Vino cheese. Int. J. Dairy Technol., 66(3), 366–372. https://doi.org/10.1111/1471-0307.12024

Calvo, M. V., Castillo, I., Díaz-Barcos, V., Requena, T., Fontecha, J. (2007). Effect of a hygienized rennet paste and a defined strain starter on proteolysis, texture and sensory properties of semi-hard goat cheese. Food Chem., 102(3), 917–924.

Carrera, E., Gaya Sicilia, M. P., Medina, M. (1999). Effect of milk coagulant on the formation of hydrophobic and hydrophilic peptides during the manufacture of cows' milk Hispanico cheese. Milchwissenschaft, 54(3), 146–148.

Delgado, F. J., González-Crespo, J., Cava, R., García-Parra, J., Ramírez, R. (2010). Characterisation by SPME-GC--MS of the volatile profile of a Spanish soft cheese PDO Torta del Casar during ripening. Food Chem., 118(1), 182–189.

García, V., Rovira, S., Boutoial, K., Álvarez, D., López, M. (2015). A comparison of the use of thistle (*Cynara cardunculus* L.) and artichoke (*Cynara scolymus* L.) aqueous extracts for milk coagulation. Dairy Sci. Technol., 95(2), 197–208.

Georgala, A., Moschopoulou, E., Aktypis, A., Massouras, T., Zoidou, E., Kandarakis, I., Anifantakis, E. (2005). Evolution of lipolysis during the ripening of traditional Feta cheese. Food Chem., 93(1), 73–80. https://doi.org/10.1016/j.foodchem.2004.09.007

Grummer, J., Schoenfuss, T. C. (2011). Determining salt concentrations for equivalent water activity in reduced-sodium cheese by use of a model system. J. Dairy Sci., 94(9), 4360–4365. https://doi.org/10.3168/jds.2011-4359

Guiraud, J.-P. (1998). La microbiologie alimentaire. DUNOD.

Jacob, M., Jaros, D., Rohm, H. (2011). Recent advances in milk clotting enzymes. Int. J. Dairy Technol., 64(1), 14–33.

Kandarakis, I., Moatsou, G., Georgala, A. I. K., Kaminarides, S., Anifantakis, E. (2001). Effect of draining temperature on the biochemical characteristics of Feta cheese. Food Chem., 72(3), 369–378. https://doi.org/10.1016/S0308-8146(00)00245-4

Karami, M., Ehsani, M. R., Mousavi, S. M., Rezaei, K., Safari, M. (2009). Changes in the rheological properties of Iranian UF-Feta cheese during ripening. Food Chem., 112(3), 539–544. https://doi.org/10.1016/j.foodchem.2008.06.003

Litopoulou-Tzanetaki, E., Tzanetakis, N., Vafopoulou-Mastrojiannaki, A. (1993). Effect of the type of lactic starter on microbiological chemical and sensory characteristics of Feta cheese. Food Microbiol., 10, 31–41.

Lo Piero, A. R., Puglisi, I., Petrone, G. (2002). Characterization of "Lettucine", a serine-like protease from *Lactuca sativa* leaves, as a novel enzyme for milk clotting. J. Agric. Food Chem., 50(8), 2439–2443.

López, M., García, V., Rovira, S., Teruel, R., Boutoial, K., Rodríguez, J., …, López, M. B. (2012). Effect of vegetable coagulant, microbial coagulant and calf rennet on physicochemical, proteolysis, sensory and texture profiles of fresh goats cheese. Dairy Sci. Technol., 2012(6), 691–707. https://doi.org/10.1007/s13594-012-0086-1

Marcos, A. (1993). Water activity in cheese in relation to composition, stability and safety. In P. F. Fox (Ed.), Cheese: chemistry, physics and microbiology (pp. 439–469). Boston, MA: Springer.

McMahon, D. J., Motawee, M. M., McManus, W. R. (2009). Influence of brine concentration and temperature on composition, microstructure, and yield of feta cheese. J. Dairy Sci., 92(9), 4169–4179. https://doi.org/10.3168/jds.2009-2183

Rahman, M. S., Sablani, S. S. (2009). Water activity measurement methods of foods. Food Prop. Handb., 9–32.

Rantsiou, K., Urso, R., Dolci, P., Comi, G., Cocolin, L. (2008). Microflora of Feta cheese from four Greek manufacturers. Int. J. Food Microbiol., 126(1–2), 36–42. https://doi.org/10.1016/j.ijfoodmicro.2008.04.031

Robinson, R. K., Tamime, A. Y. (1996). Feta and related cheeses. CRC Press.

Sarantinopoulos, P., Kalantzopoulos, G., Tsakalidou, E. (2002). Effect of *Enterococcus faecium* on microbiological, physicochemical and sensory characteristics of Greek feta cheese. Int. J. Food Microbiol., 76(1–2), 93–105.

Tejada, L., Abellán, A., Cayuela, J. M., Martínez-Cacha, A. (2006). Sensorial characteristics during ripening of the murcia al vino goat's milk cheese: the effect of the type of coagulant used and the size of the cheese. J. Sens. Stud., 21, 3, 333–347. https://doi.org/10.1111/j.1745-459X.2006.00069.x

Werner, H., Nielsen, E. W., Ardö, Y., Rage, A., Antila, V. (1999). North European varieties of cheese. In Cheese: Chemistry, physics and microbiology (pp. 245–262). Springer.

Zine-eddine, Y., Zinelabidine, L. H., Kzaiber, F., Oussama, A., Boutoial, K. (2021a). Analysis of acceptance and factors affecting the consumption of goat's milk in Morocco. Small Rum. Res., 197, 106338.

Zine-eddine, Y., Zinelabidine, L. H., Kzaiber, F., Oussama, A., Boutoial, K. (2021b). The use of paired comparison test on the goat's milk adulteration detection (whole and semiskimmed). J. Sens. Stud., 36(5), e12690.