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Local honey goat milk yoghurt production. Process and quality control

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Abstract

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Keywords:

1 Introduction

Goat milk is regarded by Desjeux (1993) as a therapeutic food and became widely consumed in the word regarding to its nutritional and microbiological qualities (Feknous et al., 2018). Its specific lipid composition provides it with an interesting nutritional value (Araújo et al., 2021; Ceballos et al., 2009). Raynal-Ljutovac et al. (2008) stated that the size of fat globules and its fatty acids content in short and medium chain enable the absorption of fats and supply energy to malnourished children. A team of pediatricians has also highlighted that it was possible – thanks to this milk – to successfully refeeding children showing intolerance to bovine proteins (Roy, 2003). Desjeux (1904) noticed an increase in weight in sick children after consuming this milk which contains almost as much selenium as in human milk and twice as much glutathione peroxydase than cow milk (Lambert-Lagacé, 1999; Hadjimbei et al., 2019). Selenium is a required metal for the enzymatic activity of glutathione peroxydase involved in reducing the free radicals. An American study has established that selenium concentration of goat milk is close to that of the human milk and that the glutathione peroxydase activity is higher in goat milk (Debski et al., 1987). Moreover, this milk includes nearly twice as much Pro-Vitamin A under the form of retinol than cow milk (Lambert-Lagacé, 1999). This milk contains generally higher calcium, magnesium and copper content (Fangmeier et al., 2019; Lucatto et al., 2020) and more potassium and phosphorus than cow milk. It also has a high alkalinizing ability and buffering capacity, thereby contributing -inter alia- maintaining a good skeletal mass (Lambert-Lagacé, 1999). Several products are derived from the transformation of goat milk like cheese (Soustre, 2007; Boumendjel et al., 2017; Öztürk & Akin, 2018; Shabbir et al., 2019; Tadjine et al., 2020; Frau et al., 2021), cream cheese (Fangmeier et al., 2019) yoghurt such as 'dulce de leche' (Chaves et al., 2018), sour milk, kefir, clarified butter prepared in India and Iran along with infant formulae made in Taiwan, New Zealand and Australia. In Greece, goat milk-based yoghurts are sold in local markets (Kalantzopoulos, 1993). Yoghurt is a diary product that is popular to consumers which makes it an easy choice as a carrier of probiotic strains (Farnworth, 2008; Ranadheera et al., 2019). According to Kalliomäki et al. (2001) ; Mercenier et al. (2003) and Gourbeyre et al. (2011): Probiotics consumption allows: improved lactose digestion, increase nutritional value, regulating intestinal motility, preventing osteoporosis, cancer,

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hypertension and atherosclerosis, reducing cholesterol VLDL levels and immune system modulation in addition to decreasing inflammation or allergic reactions (Mituniewicz–Małek et al., 2019). In an effort to make sick children better accept goat milk due to its particular and stronger taste relative to other milks, we focused in the present study on setting up a manufacturing process of a goat-milk based yoghurt accompanied with a natural flavoring product, honey. To do so, six (06) types of yoghurt were prepared : an unflavored mixed cow and goat milk at 50%, a flavored mixed cow and goat-milk at 50%, an unflavored 100% goat-milk yoghurt, a flavored 100% goat-milk yoghurt, a flavored 100% goat-milk yoghurt, two types of 100% goat-milk yoghurts supplemented with natural honey. Physical chemical, microbiological, sensory and nutritional analyses were carried out on the prepared samples.

2 Material and methods

2.1 Goat-milk sampling

The goat-milk used in this study comes from a goat farm of alpine breed located at the mountainous region of Seraidi (city of Annaba, north east of Algeria). The breeding area of the goat herd is located at the north western side of the village of Seraidi (Figure 1), over the hills of Edough at all but 800 m altitude. The livestock is followed up by a veterinary doctor and is free of all pathologies or mastitis that could affect the bacteriological quality of collected milk.

2.2 Vegetation Inventorying of the rangelands

Inventorying of the existing plants at the region of Seraidi enabled to draw up the grazing itinerary and route of the goats. To do so, plant identification was done based on the herbarium of de Bélair (2019).

2.3 Yoghurt production process

Preparing yoghurts required in the first place a double pasteurization at two different temperatures: a first pasteurization of raw milk at 45 °C during five minutes, then after adding 12.5 g of sugar, a second pasteurization at 95 °C during 05 minutes. Sowing ferments (*Streptococcus thermophilus* and *Lactobacillus delbureckii subsp bulgaricus* YC-X16 -CHR HANSEN) in an amount of 0.005 g in 125 ml of cooled milk at 45 °C is achieved, followed by adding 0.125 mL of flavorant to produce flavored yoghurts. Honey yoghurts are developed in the same way by adding 15 g of honey in 125 mL of cooled milk at 45 °C. Parboiling of pots so prepared is done at 45 °C during 5 to 6 hours. After fermentation, the yoghurts are stored in the refrigerator (between 4 to 6 °C) prior to analysis.

2.4 Physical-chemical analysis

Physical chemical analyses were performed on the raw material (goat milk) as well as yoghurts. The following parameters were undertaken: pH, acidity, total dry extract, fat content. Acidity is titrated against NaOH (0.01N) on a 10 mL sample while adding 2 to 3 drops of phenolphthalein. Milk density is measured by way of Gerber lactometer. Fat content is calculated by introducing in a butyrometer 10ml of sulfuric acid (91%), 11 mL of sample to be analyzed and 01 mL of Isoamyl alcohol. After shaking the butyrometer, the samples are centrifuged at 500 rpm during 05 min at 65 °C. The results are reported in g/L by direct reading on the butyrometer' scale. The total dry extract is found out by a Radwag type desiccator, the results of which are expressed in percentage (%).

2.5 Microbiological analysis

After completion of a range of dilutions, coliforms are sought by in-depth sowing on desoxycholate agar. Incubation

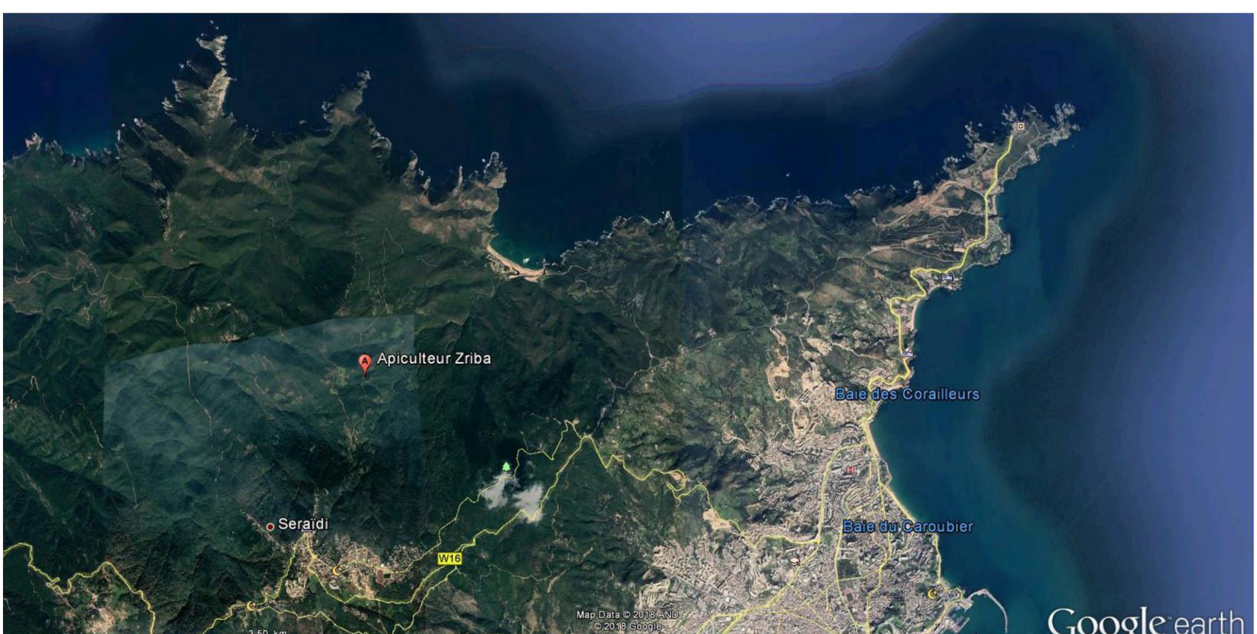

Figure 1. Localization map of apiculture and goat farm in Seraidi region.

takes place during 24hours for total coliforms and at 44-45 °C during 48 hours for fecal coliforms. Tracking *Staphylococus aureus* required at first an enrichment in a Broth of Giolitti and Cantoni. The latter is incubated at 37 °C during 24h. Isolation of Chapman medium is performed with incubation at 37 °C during 24 h and identification by sowing the collected suspect colonies from the Chapman medium in a BHB broth. After incubation at 37 °C over 24h, searching coagulase is achieved by sowing 0.5 mL of BHB and 0.5 mL of rabbit plasma. An observation of the plasma every two hours is conducted to monitor coagulation of the latter. As for *salmonella*, an enrichment of yoghurt samples is realized in a Selenite Cystine Broth (SCB) then incubated at 37 °C for 24 h. Isolation on a SS medium (*Salmonella Schigella*) is performed to ascertain the presence of pathogenic bacteria.

2.6 Nutritional analysis

The nutritional value along with the amount of macronutrients were reached for the sake of the following parameters: Energy value, proteins, carbohydrates, lipids and mineral salts (phosphorus, potassium, calcium and sodium), and this for 100% natural and honey goat milk-based yoghurts.

2.7 Sensory analysis

A hedonic analysis is carried out by an 'expert' panel of ten persons. This experienced panel is used to take part in all types of sensory tests of yoghurts at laboratory level. Sensory analyses covered six variants of prepared yoghurts: UGMY 50%, FGMY 50%, 100% UGMY 100%, FGMY 100% and HGMY2 100%. The taste panel is conducted in standard conditions and by filling out comment cards for the previously prepared goat milk yoghurts. The sensory analysis has therefore focused on the following visual, gustatory and olfactory parameters: General appearance, consistency, color, odor, general taste, acidity, sweetness and a final and overall assessment on the yoghurt. A Lickert scale is used to calculate the objectified average of collected feedbacks. The consistency and creaminess stand for key inputs for the consumer on the yoghurt quality (Schmidt et al., 1994).

2.8 Benchmarking of yoghurts

The results of the various physical-chemical and sensory analyses help ranking the yoghurts from 1 to 4 (1 being the best parameter score). An average grade of all scores is calculated for each of the examined yoghurts. A radar chart is drawn up in order to best view the comparison study altogether.

2.9 Statistical analysis

All of the obtained results are reported by the average of the repeated tests ± standard deviation.

3 Results and discussion

3.2 Physical-chemical analysis of the raw material (goat milk)

The results are reported in the following table (Table 1):

The pH

The pH of goat milk was at 6.70 ± 0.007 average value. As per Remeuf et al. (1989), the pH of goat milk reveals a slight acidity compared to cow milk, with an average of 6.7.

Acidity

As per Vignola (2002), goat milk acidity ranges between 14 and 18°D. The acidity of our sample is within the standards with a value of 17.377 ± 0.506 while the max value is 18°D.

Density

According to Food and Agriculture Organization of the United Nations (1990), the density of goat milk varies between 1027 and 1035. The average density of our sample stands at 1028.555 ± 2.364 with a max value of 1029.4.

Total dry extract

The total dry extract average of the goat milk sample used in our tests was at 13.73% while the max value is 14.45%. The lactation stage has a big impact on the total solids content of goat milk (Mestawet et al., 2012). The peaks of these contents take place at the beginning (Mestawet et al., 2012) and towards the end of lactation (Haenlein, 2004). Our findings tally with those of Guo et al. (2001)who have found that the total dry extract of the goat milk mixture collected in the USA had the following values : 12.7%, 11.3% and 13.4%.

Fat content

The butyric rate set forth by Pradal (2012) is between 33 g/kg and 38 g/kg against 36.15 g/kg of the cow milk Grappin et al. (1981), our milk sample had a higher rate than the norm estimated at 40 ± 7 g/kg where the max value is 45 g/kg.

4 Physical chemical analysis of the finished product (the yoghurt)

The results of the physical chemical analysis of the yoghurts are outlined below:

4.1 The pH

The yoghurts prepared with 50% of goat milk experienced an average pH of 4.36 ± 0.011 for the UGMY and 4.36 ± 0.005 for the FGMY. The 100% goat milk yoghurts meanwhile averaged the following pH: 4.74 ± 0.011 for the UGMY, 4.75 ± 0.011 for the FGMY, 4.95 ± 0.011 for the HGMY1 and 4.91 ± 0.011 for the HGMY2 (Table 2). The results achieved indicate that the

Table 1. Physical-chemical analysis of goat milk (n = 9).

Parameters	pH	Acidity	Density	Dry extract	Fat extract
Results	6.70 ± 0.007	17.37 ± 0.506	1028.55 ± 2.364	13.73 ± 0.623	40.00 ±7.00

Table 2. Physical chemical analysis of the six yoghurts (n = 3).

	UGMY 50%	FGMY 50%	UGMY 100%	FGMY 100%	HGMY1 100%	HGMY2 100%
pH	4.36 ± 0.111	4.36 ± 0.005	4.74 ± 0.011	4.75 ± 0.011	4.95 ± 0.011	4.91 ± 0.011
Acidity	76.66 ± 0.577	77 ± 0.00	72 ± 3.464	71.88 ± 3.271	71 ± 0.00	70.33 ± 0.577
Dry extract	23.34 ± 0.270	23.24 ± 0.308	25.36 ± 0.251	25.34 ± 0.219	25.11 ± 0.011	25.1 ± 4.351
Fat content	39.33 ± 6.350	39.33 ± 6.350	29.36 ± 2.281	29.33 ± 2.309	32 ± 0.00	32 ± 0.00

ferments used for preparing the yoghurts were viable and active and dropped the initial pH of goat milk that was at 6.70 ± 0.007. The two bacteria utilized in preparing the yoghurts *Lactobacillus delbureckii subsp bulgaricus* and *Streptococcus thermophilus* have the major role of reducing the milk's pH to the isoelectric point of casein (pH 4,6) so as to form a gel (Sodini & Beal, 2012). With respect to goat milk, the isoelectric-pH is 4.2 (Moualek, 2011). Our pH findings are slightly higher than those concluded by Ghalem & Zouaoui (2013), as well as to the pH of the fruits-enriched yoghurts of *Caryocar brasiliense* (Silva et al., 2014).

4.2 Dornic acidity

Acidity measurement of yoghurts UGMY50%, FGMY50%, UGMY100%, FGMY100% , HGMY1100% and

HGMY2 100% respectively provided the following averages : 76.66 6 ± 0.577 °D, 77 °D, 72 ± 3.464 °D, 71.888 ± 3.271 °D, 71 °D et 70.333 ± 0.577 °D (Table 3). These numbers are well above the acidity of the initial milk prior to fermentation (17.377 ± 0.506 °D). According to Abdalla & Ahmed (2010), this increased acidity relates to the growth of lactic bacteria which gradually convert lactose into lactic acid. Our results are lower than the acidity values found by Ghalem & Zouaoui (2013) in parboiled natural and honey yoghurts enriched with officinal rosemary essential oils (*Rosmarinus officinalis*).

4.3 Dry extract

The dry extract of 50% goat milk yoghurts varies between 23.24 ± 0.270% and 23.246 ± 0.308% (Table 3). The Dry extract of natural and flavored 100% goat milk yoghurts ranges between 25.36 ± 0.251% and 25.34 ± 0.219%. The dry extract of 100% goat milk supplemented with natural honey ranges from 25.113 ± 0.011% to 25.11 ± 4.351%. The latter had high dry extracts because of the integration of honey to the yoghurts.

4.4 Nutritional analyses

The nutritional analyses showed that honey-prepared yoghurts HGM1 and HGM2 were richer in carbohydrates (10.5 g) and in energy (89.1 kilocalories) compared to natural and flavored yoghurts (NGMY and FGMY) which recorded a carbohydrate content of 5.3 g and 68.3 kilocalories. The refined sugar and artificial flavors are food additives that do not provide any nutritional value to food unlike honey which is a natural sweetener with a strong sweetening power and a distinctive taste. Honey is a high energy content food (Belhaj et al., 2015), natural, its specific composition might change according to its floral origin. Honey is a nutrient-rich food. Its structure is complex and contains at least 181 various substances (Alvarez-Suarez et al., 2010), the major compounds are the monosaccharides : glucose (around 30 to 40% of the dry matter) and some minor components like enzymes , amino acids, lipids, vitamins, phenolic acids, flavonoids and minerals (Manzanares et al., 2011), Honey has several nutritional and therapeutic properties (Peter, 2006). , Furthermore, it serves as a natural source of antioxidants, the latte play a major role in reducing the risks of heart disease, cancer, immune system and different inflammatory processes (Bertoncelj et al., 2007). The protein content of all yoghurts prepared with 100% goat milk: HGM1, HGM2, UGMY and FGMY were the same and measured at 3.9 g. Ditto for the recorded lipid contents which were at 3.5 g. The amounts of mineral salts like calcium, phosphorus, potassium, and sodium were respectively: 168 mg, 114 mg, 203 mg and 58 mg.

5 Bacteriological analyses of the prepared yoghurts

The results of the bacteriological tests are summed up in Table 3.

There is a total absence of total coliforms, fecal coliforms and pathogenic bacteria, like salmonella and the *Staphylococcus aureus*. This sterility is found in all of the studied parboiled natural and flavored yoghurts, making them products that are complying with the regulatory guidelines. (Algeria, 2017). Ghalem & Zouaoui (2013) found the same conclusions in their works. The absence of bacteria stems from the fact that milk pasteurization was achieved at 95 °C, which helped destroy the pathogenic toxicogenic bacteria and other microorganisms whose growth might compete with that of the lactic ferments (Oteng-Gyang, 1984). On top of this, the protoccoperation generated from the combination of *Streptococcus thermophilus* with the *Lactobacillus bulgaricus* has made it possible to ensure the microbiological stability of the finished products. Yoghurt is fitted with an antibacterial effect on negative and positive Gram pathogenic bacteria like: *Escherichia coli*, *Listeria monocytogenes* and *Salmonella sp.* (Jasjit et al., 1979; Rubin & Vaughan, 1979; Schaack & Marth, 1988; Kotz et al., 1990). Lactic ferments of yoghurt are homofermentative, releasing lactic acid as a main product throughout carbohydrates fermentation (Oteng-Gyang, 1984). The latter operates as an inhibitor towards undesirable microorganisms (Leory et al., 2002), because this organic acid plays the role of bactericidal. It provides an anti-microbial effect to the yoghurt (Wang et al., 2015), and that against *Pseudomonas aeruginosa* (at a concentration of 0.3%), against *Salmonella typhi* (at 0.6%), against *Escherichia coli* (at 2.25%) and against *Staphylococcus aureus* at 7.5% (Oteng-Gyang, 1984).

6 Sensory analysis

The results of the objectified sensory analyses are outlined in the following table. Each of the sensory parameters features a numerical rank going from 1 to 6, starting from the best rank to the less good.

6.1 Visual appearance

Overall, it is clear from the sensory analysis that most yoghurts have a smooth aspect, or even average. According to Vignola (2002), parboiled or firm yoghurts are flavored or natural yoghurts, having a firm texture with a smooth surface. The two best obtained formulae are HGM1 and HGM2.

6.2 Color

Based on the achieved results, none of the yoghurts received a negative rating as to a very unpleasant color. Only 20% of the

Table 3. Bacteriological analyses of the prepared yoghurts.

Bacteria	NGM (50%)	FGM (50%)	NGM (100%)	FGM (100%)	HFGM1 (100%)	HFGM2 (100%)	Standard*
Total coliforms	Abs	Abs	Abs	Abs	Abs	Abs	**10^2**
Fecal coliforms	Abs	Abs	Abs	Abs	Abs	Abs	**10^2**
Salmonella	Abs	Abs	Abs	Abs	Abs	Abs	**Absence**
Staphylococcus aureus	Abs	Abs	Abs	Abs	Abs	Abs	**10^2**

*Journal Officiel de la République Algérienne Démocratique et Populaire, n°39 (Algeria, 2017).

tasters deemed that the 100% natural yoghurt was unpleasant against 30% who felt that the 100% natural yoghurt was pleasant and 50% fairly pleasant. This offers overall an approval result by the taste panel on yoghurts. The color of UGMY 50% was average for 60% and nice for 40% of the panel. FGM, HGM1 & HGM2 yoghurts received a better rating by being ranked number one.

6.3 Odor

Goat milk is characterized by a particular flavor and a stronger taste than cow milk (Jooyandeh & Abroumand, 2010). The fermentation of goat's milk with probiotic bacteria, can improving the sensory characteristics through decreasing the caprine smell (Vargas et al., 2008; Muelas et al., 2018). We were expecting that this odor would be pointed out by the taste panel, however, the majority of opinions weighed in favor of a good evaluation of the odor. Most opinions were divided (20 to 30%) between the absence of odor and low odor for the four variants of honey-free yoghurt. Only 20% considered that the 100% flavored yoghurt had a very strong odor. Yet, this appraisal did not only relate to the goat origin of the milk but mainly the flavor added to the yoghurt because none of the tasters had knowledge of the animal origin of the used milk in the making of the yoghurts. Probiotics strains produce pleasant flavor compounds during fermentation (Balthazar et al., 2018). Only the honey yoghurts had a negative assessment as for lack of knowledge of the composition, the panel pointed out a strong odor on both HGM1 then HGM2 samples.

6.4. Texture at tasting

None of the textures of the four yoghurts is grainy. The majority of the panel stated that graininess in yoghurts was average to smooth. The consensus of the panel pertains to the smooth appearance of HGM1 with 100% positive responses going from smooth to very smooth. The texture of a food determines the approval or rejection of a food by the consumer (Budin, 2000). Some bacterial strains produce – from glucose- polysaccharides that by filament formation restrict gel alteration through mechanical processing and help in the viscosity of yoghurt (Schmidt et al., 1994). On top of its acidifying effect, *Streptococcus thermophilus* is responsible of the texture in sour milks. This bacteria enhances milk viscosity by producing polysaccharides, galactose compounds, glucose together with tiny amounts of rhamnose, arabinose and mannose (Bergamaier, 2002). An inconsistency might be caused by poor activity of the utilized ferments arising either from the degeneration of cultures or contamination of ferments through bacteriophages (Strahm et al., 2014). Hence, HGM1 then HGM2 yoghurts would have the highest likelihood of acceptance by the consumer.

6.5 Acidity

None of the tasters deemed the yoghurts were of very high acidity, which helps to products acceptance. Table 5 indicates that 50% goat & cow milk mixtures lead to a more acid taste evaluation of the yoghurts vis-à-vis 100% goat milk yoghurts which seem of low acidity. The best formula being that of HGM2.

6.6 Sweetness

Goat milk has a slightly sweet taste compared to cow milk. That would be expected to affect the assessment of 100% goat milk yoghurts in comparison with 50% mixed yoghurts. However, the panel did not come up with a noticeable difference between 100% and 50% goat milk variants. This leads us to say that the amount of sugar added to the four variants have masked off the basic differences between 100% goat milk and the 50% mixture of cow and goat milk. Such an assessment is in favor of the use of goat milk whatever the percentage is as long as it was not actually detected during tasting. What is more, adding bitter honey helped it get ranked at the 05th position, proving that this variant masks off very well the sweet taste of the yoghurt, as opposed to HGM2 which was ranked 02nd in the same way as UGM 100% and UGM50%.

6.7 Taste

Goat milk is characterized by a particular flavor and a stronger taste than cow milk (Jooyandeh & Abroumand, 2010). We noted in the results we had that of all the yoghurts, none had a negative evaluation regarding an extremely unpleasant taste and very unpleasant taste. Most found that the taste of the six variants was nice and very nice. The best assessment pertained to HGM2 yoghurt. *Lactobacillus bulgaricus* plays a primary role in the development of the yoghurt's organoleptic properties (Marty-Teysset et al., 2000). As a matter of fact, according to Tamime & Robinson (1999) and Sudheer et al. (2006), the lactic acid produced during yoghurt making helps to disrupt casein

Table 5. Yoghourt ranking following sensory analysis.

Parameters	NGM100	FGM100	NGM50	FGM50	HFGM1	HFGM2
Visual appearance	6	3	5	3	1	1
Color	6	1	5	4	1	1
Odor	3	4	1	1	6	5
Tasting	2	4	6	2	5	1
Texture at tasting	3	3	6	5	1	2
Acidity	3	2	6	5	4	1
Sweetness	2	1	2	5	2	5
Overall assessment	2	1	6	2	2	2
Mean	3.375	2.375	4.625	3.375	2.75	2.25

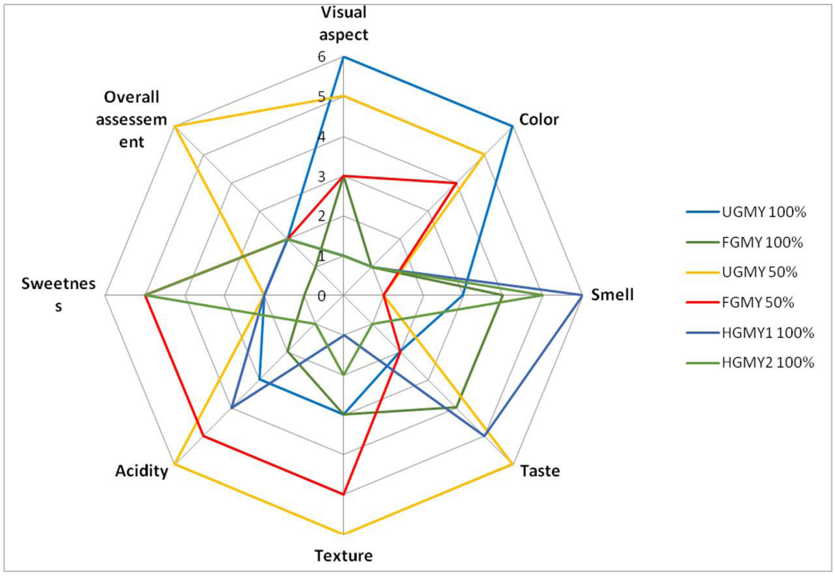

Figure 2. Quality and sensory radar chart of the six yoghurts.

micelles, leading to the formation of a gel giving the yoghurt a characteristic and distinct taste in contributing in the savor and flavoring (aromatization) of the yoghurt. This release of yoghurt's flavors masked off the initial imprints of the goat milk-based yoghurt leaving no indication of a great difference between the 100% variant and the 50% mixed variants.

6.8 Overall assessment

We reported from the sensory analysis that most yoghurts had a good overall review (appearance + color + odor + taste+ texture + acidity + sweetness). Our yoghurts were given generally good to excellent rating with very little difference between the various variants.

6.9 Comparative study and ranking of yoghurts

Below is the radar chart (Figure 2) relating to the sensory parameters of the six tested yoghurts. The yoghurt having the lowest index (1) stands for the best organoleptic evaluation taken by the panel, and that for each of the eight tested parameters.

As per the chart below, HGM2 yoghurt ranks first with its overall score of 2.35, followed by FGM100 with a score of 2.375, followed by HGM1 with a score of 2.750, then followed by the two variants UGM100 and FGM50 with 3.375 and ultimately comes at the last position UGM50 with a final score of 4.625. We realize that 100% milks are always better appreciated in their category (flavored or not) in relation to 50% mixed milks. This very promising result leads to agree upon the fact of a good utilization of goat milks in yoghurt manufacturing. Besides, flavored yoghurts are better, chiefly honey's.

7 Conclusion

Results of physical-chemical analyses revealed that all of the yoghurts were within the standards. Microbiological analyses showed a total absence of pathogenic bacteria and hygiene quality indicator bacteria. The sensory analyses have also demonstrated that the flavored or unflavored 100% yoghurts were more appreciated than yoghurts made of 50% mixed milks. Nutritional analyses of whole-goat milk yoghurts (100%) denoted that honey yoghurts (HGM1 & HGM2) were richer in carbohydrates and in energy vis-à-vis 100% natural and flavored yoghurts (UGMY & FGMY). The sensory analysis allowed ranking the natural goat milk and flavored yoghurt number one out of the six variants. The findings of the present study disclose that goat milk can serve in the preparation of yoghurts as very highly enjoyed by consumers. Adding up another natural product like mountain honey improves its ranking relative to the other variants.

Conflict of interest

The authors declare that they have no conflict of interest.

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