PHYSICOCHEMICAL AND SENSORY PROPERTIES OF YOGURT PROCESSED FROM COW MILK AND SOYMILK ALONE AND IN COMBINATION

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Abstract
Consumption of fermented soymilk was reported to be beneficial to human intestinal health. Furthermore, fermented soymilk, unlike fermented milk or yogurt drinks, contains no lactose or cholesterol. In this study, yogurt was processed by inoculation of cow milk and soymilk used alone and in combination (ratio 1/1 v/v) with freeze-dried culture of Lactobacillus bulgaricus and Streptococcus thermophilus. Samples of processed yogurts were evaluated for physico-chemical and sensory properties using a commercially available yogurt as control. pH values obtained were about 4.65±0.03 for cow milk-based yogurt, 4.60±0.05 for soymilk-based yogurt, and 4.64± 0.01 for mixed milks-based yogurt. Soymilk-based yogurt was low in titratable acidity (81.66±1°D). Fat and total solids were highest in cow milk-based yogurt: 31±1 g/l and 106.6±0.2 g/l, respectively. There was significant difference (P < 0.05) in the protein content between cow milk-based yogurt (3.1±0.2 g/l) and soymilk-based yogurt (3.47±0.01 g/l). Yogurt prepared from soymilk or cow milk and their mix were compared favorably well with commercially available yogurt in sensory attributes namely appearance, taste, color, texture, and aroma. Yogurt from soymilk used alone or in combination with cow milk can be adopted as substitute to cow milk yogurt especially by the low income earners due to its cheaper raw materials, and as protein supplement at household level.

Keywords: Cow milk, soymilk, yogurt, mix, physic-chemical properties, sensory properties.

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1. INTRODUCTION

Yogurt is one of dairy product largely consumed throughout the world due to its nutritional properties, and sensory attributes influencing positively consumer acceptability. It has been reported that the most of the commercial yogurts are dairy-based. However, casein and lactose content of such products make them allergenic and intolerable by some individuals (Kazemi et al., 2014).

Hence, the development of non-dairy yogurts could be an alternative for new functional products (Canganella et al., 1999; Chang et al., 2010; Santos et al., 2014). Among these products, soymilk-based yogurt (or sogurt) produced by fermentation of soymilk using lactic acid bacteria is arousing an increasing interest due to its important nutritional properties and absence of casein and lactose (Rinaldoni et al., 2012).

Indeed, fermented soy products were reported to contain many functional ingredients such as soy protein, isoflavones, saponins, phytic acid, phytosterol, and phenolic acid (Yamauchi et al., 1975; Anderson and Wolf, 1995). Furthermore, fermented soymilk, unlike fermented milk or yogurt drinks, contains no lactose or cholesterol and may have the health benefits from both soy itself and the fermentation. The bioavailability of isoflavone is more effective in fermented soy milk than unfermented soy milk (Kano et al., 2006). It has been suggested that fermented soymilk is positive in lowering total cholesterol and triglyceride accumulation in the liver (Lin et al., 2005; Kitawaki et al., 2009), food allergies (Biscola et al., 2017).

Milk is used in dairy industry to produce yogurt, but the possibility of using of soymilk as other protein-rich substrate to make yogurt has not been adequately considered. In this study, we examined yogurt production using a formulation of soymilk and cow milk on the basis of their sensory as well as nutritional properties. We prepared yogurt by lactic acid fermentation from soymilk alone and soymilk mixed with cow milk, and compared their physicochemical and sensory properties.

2. MATERIALS AND METHODS

2.1. Preparation of yogurt

Soymilk samples used in this study were provided by the company SOYATECH Nutrition et santé located at Blida city (Algeria) whereas cow milk was freely provided by dairy manufactory of Tizi ouzou (Algeria). Commercially available sugar (lactose) and aroma (strawberry) were used in yogurt formula.

To produce three kinds of yogurts, cow milk and soymilk were used alone and in combination using following formula:

- Cow milk-based yogurt : 95% cow milk, 0.1% aroma, 5% sugar
- Soymilk-based yogurt : 95% soymilk, 0.1% aroma, 5% sugar
- Mixed milk-based yogurt : 47,5% cow milk, 47,5% soymilk, 0.1% aroma, 5% sugar

The physicochemical parameters of milks used in yogurt preparation are shown in Table 1.

Table 1: Physicochemical parameters of milks used in yogurt preparation

Parameters	Cow milk	Soymilk
pH	6,56 ± 0.05	6,70± 0.03
Acidity (°D)	16,83 ±0.2	8,83±0.28
Fat (g/l)	31 ± 0.1	19.1± 0.76
Total solids (g/l)	104.6 ± 0.07	70.5±0.06
Density (Kg/m^3)	1026.7±0.0002	1014± 0.0005
Lactose (g/l)	47.1 ± 0.76	0
Proteins (g/l)	3.1± 0.2	3.47± 0.01

Milks samples added with sugar were pasteurized at 80-85°C for few seconds and cooled at incubation temperature used for growth of starter culture (43-44°C). Pasteurization allowed microbes and enzymes destruction. Milk samples were divided into three portions of 100g, and then inoculated with a 4% liquid culture of *Streptococcus salivarius* subsp. Thermophilus and *Lactobacillus delbrueckii* subsp. Bulgaricus (Chr. Hansen Laboratories, Copenhagen, Denmark) (ratio 2:1).

The inoculation was followed by incubation (44°C) allowing fermentation by acidification of milks. At pH about 4.7 to 4.3 fermentation (10h) was stopped by cooling at 4°C yogurts obtained. After incubation, processed yogurts were kept at 4°C until further use.

2.2. Physicochemical parameters assessment

pH of samples were measured at 17 to 20°C using a pH meter after calibration with standard buffers (pH 4.0 and 7.0).

Titratable acidity indicating percentage of lactic acid was measured by titrating 10g of sample mixed with 10ml of boiling distilled water against 0.9 N NaOH using a 1% phenolphthalein indicator.

Fat, lactose, proteins, total solids, density and viscosity of milks and yoghurt samples were analyzed using AFNOR methods (AFNOR, 1986).

2.3. Sensory attributes evaluation

Sensory test was performed according to method described by Yang and Li (2010) with slight modifications. Sensory panel tested three yogurts versus a commercially available yogurt SOUMMAM selected based on market share as well as fat content.

Different kinds of yogurt samples were served randomly at 10 to 12°C in identical plastic cups (100 grams) and coded with random three-digit numbers.

Each sample was served individually with water. Panelists evaluated sensory attributes of yogurts served using a standard 9-point scale in which 1 was equal to the worst and 9 was equal to the best. Sensory attributes of yogurts determined by panelists were overall appearance, color, aroma, taste and texture.

2.4. Statistical analysis

Data are presented as means and standard deviations (SD) from three independent samples. Significant differences among samples were determined by analysis of variance performed by ANOVA and Fisher's least significant difference (LSD) test at $P<0.05$.

3. RESULTS AND DISCUSSION

Table 2: Physicochemical parameters of yogurts prepared from cow milk, soymilk and mixed milks (1/1 v/v)

	Cow milk-based yogurt	Soymilk-based yogurt	Mixed milk-based yogurt
pH	4.65±0.03	4.60±0.05	4.64± 0.01
Acidity (°D)	82.66±3.05	81.66±1	82.2±0.57
Fat (g/l)	31±1	19.3±0.1	-
Total solids (g/l)	106.6±0.2	70.8±0.01	-
Proteins (g/l)	3.1±0.2	3.47±0.01	-
Viscosity (Cps)	171666.66 ±2516.61	182333,3 ±2516.61	239000 ±2000

Yogurt physicochemical proprieties

Physicochemical parameters of yogurts prepared from cow milk, soymilk and their mixtures are shown in Table 2.

Results presented in Table 2 show some differences in physicochemical characteristics of yogurts prepared. Due to the fermentation process the pH of cow milk and soymilk decreased significantly from 6,56±0.05 to 4.65±0.03 and 6,70±0.03 to 4.60±0.05, respectively. The yogurt from the mixture of these milks had a pH value of 4.64± 0.01. These findings are in accordance with those reported in literature emphasizing that during acidification of milk, the pH decreases from 6.7 to ≤4.6, and the gelation occurs at pH 5.2 to 5.4 for heated milk (Lee and Lucey, 2010).

The decrease of milk pH to the isoelectric point of casein (pH 4.6) reduces the net negative charge on casein resulting in declined electrostatic repulsion between casein molecules and increased casein-casein attractions due to increased hydrophobic interactions (Horne, 1998).

According to literature the amounts and proportions of caseins dissociated from the micelles are pH-dependent. More caseins are dissociated from micelles into the serum as pH decreases from 5.6 to 5.1. Caseins dissociation is probably due to a partial loosening of bonds within and between caseins due to loss of colloidal calcium phosphate (Dalgleish and Law, 1988).

Furthermore, the low pH values observed were accompanied with high increase in titratable acidity over 81.66±1%. The acidity value of mixed milk-based yogurt was close to 82.2±0.57. O'Donnell and Butler (2002) reported that decrease in the pH of the milk occurs during fermentation process and lead to protein gel development which is necessary for yogurt production.

In cow-milk-based yogurt and mixed milks-based yogurt, an appreciable increase in acidity was recorded after the fermentation due probably to conversion of total lactose (47.1 ± 0.76 g/l in cow milk) in lactic acid by lactic bacteria.

According to the results obtained, highest titratable acidity was observed in all samples of yogurt processed. However, titratable acidity of soymilk-based ypgurt is slightly lower than those of cow-milk-based yogurt and mixed milk-based yogurt. Our results are in accordance with those reported by Kazemi et al. (2014).

In addition, our results showed that cow milk yogurt displayed higher fat and total solids content, about 31±1 and 106.6±0.2 g/l, respectively, while the values of protein content was higher for soymilk-based yogurt (3.47±0.01 g/l). Some studies demonstrated that total solids content of the milk, especially protein, influence positively the proprieties of yogurt such as viscosity increase and gelation time decrease (Lucey and Singh, 1998; Uduwerella et al., 2017).

In comparison with yogurts from soymilk and cow milk, mixed milk-based yogurt demonstrated an appreciable viscosity (23900±200 Cps). Lee and Lucey (2010) reported that the physical attributes of yogurts, including perceived viscosity, are crucial aspects of the quality and overall sensory consumer acceptance of yogurts.
According to Sahan et al. (2008), the high viscosity of yogurt could be explained by the rearrangement of protein and protein-protein contacts. While, Lucey and Singh (1998) reported that apparent viscosity is affected by the strength and number of bonds between casein micelles in yogurt, as well as their structure and spatial distribution.

Yogurt sensory attributes

The average scores of sensory attributes of processed yogurts and commercially available yogurt evaluated by all panelists are shown in Figures 1 to 5.

Appearance of yogurts

Results showing panel scores of yogurt appearance are presented in Figure 1.
Results shown in Figure 1 indicated that 65% of panelists demonstrated that yogurts from soymilk and mixed milks were smooth. The mixture of milks was revealed to enhance yogurt appearance in comparison to cow milk-based yogurt and commercially available yogurt.
The appearance of yogurt is affected by gel formation. Yogurt gel consists of network of casein particles linked together in clusters, chains and strands. The network has pores or void spaces in which the aqueous phase is confined (Harwalkar and Kalab, 1980).

Color of yogurts

The panel scores achieved for yogurt color are reported in Figure 2.
Interestingly, color evaluation by 60% of panelists revealed that soymilk-based yogurt was normal, while slight differences of color were found between cow milk and mixed milk-based yogurts. These results are in accordance with those reported by Yang and Li (2010) demonstrating that the color of yogurts prepared from reconstituted skimmed milk differed slightly from color of soymilk-based yogurt. Drake et al. (2000) demonstrated that the addition of soy protein (soymilk) to cow milk decrease the lightness of yogurt processed.

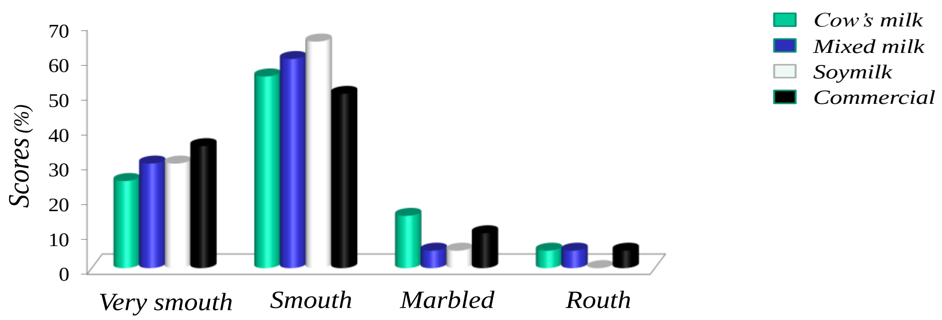

Figure 1: Appearance attributes of processed yogurts versus commercially available yogurt

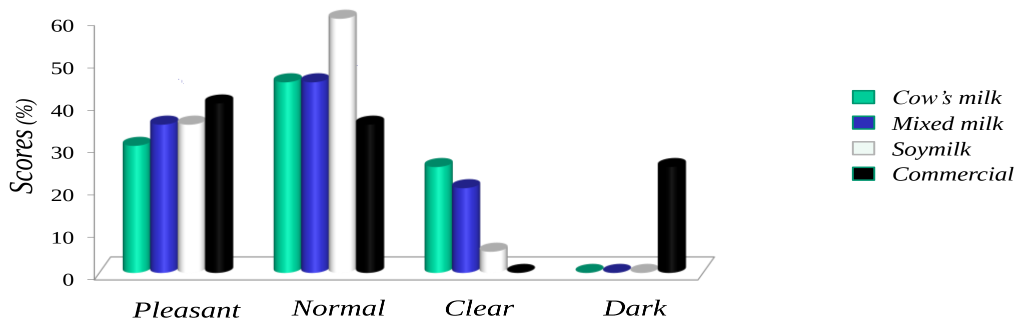

Figure 2: Color attributes of processed yogurts versus commercially available yogurt

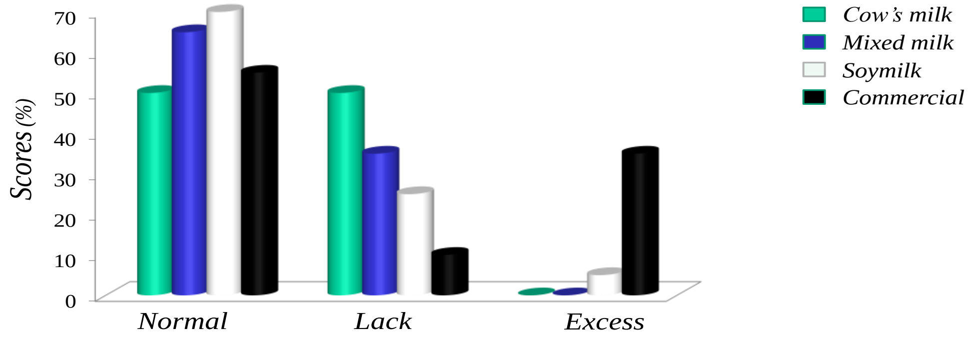

Figure 3: Aroma attributes of processed yogurts versus commercially available yogurt

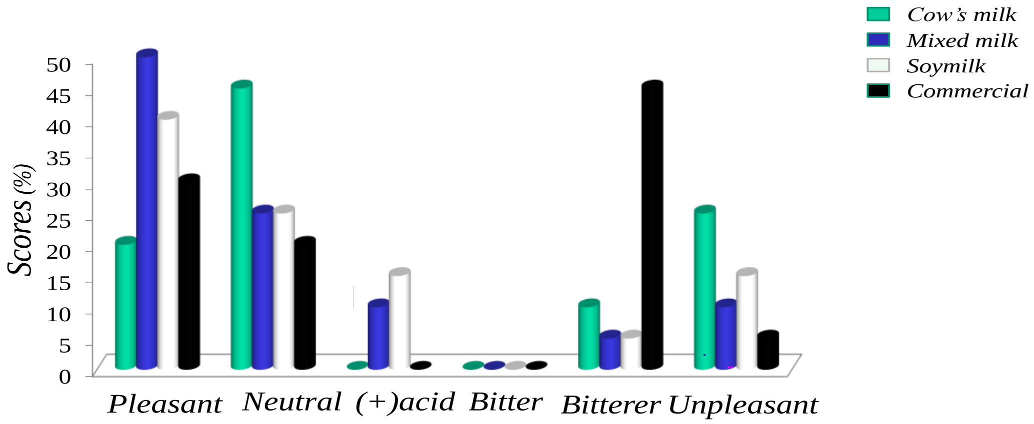

Figure 4: Taste attributes of processed yogurts versus commercially available yogurt

Aroma of yogurts

Results for the aroma scores of yogurts are presented in Figure 3.

According to results presented in Figure 3 a normal smell was noticed for soymilk based yogurt by more than 70 % of panelists. Likewise, 50 % or more of panelists noticed normal aroma for cow milk-based yogurt, mixed milk-based yogurt and commercially available yogurt. Kazemi et al. (2014) demonstrated that addition of 40% and 60% soymilk to cow milk significantly decreased scores of texture, aroma, and flavor of the samples.

Our results are different from those reported by Masamba and Ali (2013) emphasizing that yogurt made from cow milk had higher sensory quality scores in all the attributes followed by goat and soy milk-based yoghurt. The difference observed could be attributed to the difference in yogurt formulation and processing. However, depending on the rate of soymilk addition to cow milk, the aroma of yogurt processed from their mixture could be affected by the presence of 2-isopropyl-3-methoxypyrazine, the key aroma compound in soybean (Kaneko et al., 2011).

Taste of yogurts

Results of panel scores corresponding to taste attributes of processed yogurts versus commercially available yogurt are reported in Figure 4.

According to results presented in Figure 4 there were significant difference in taste attributes of soymilk-based yogurt (added with lactose), cow and mixed milk-based yogurt. The taste of yogurt produced from mixed milks was found pleasant by 50% and neutral by 25% of panelists. Whereas, the taste of cow milk-based yogurt was revealed neutral by 45% and unpleasant by 30% of panelists. Interestingly, yogurt from soymilk was found pleasant by 40% and neutral by 25% of panelists.

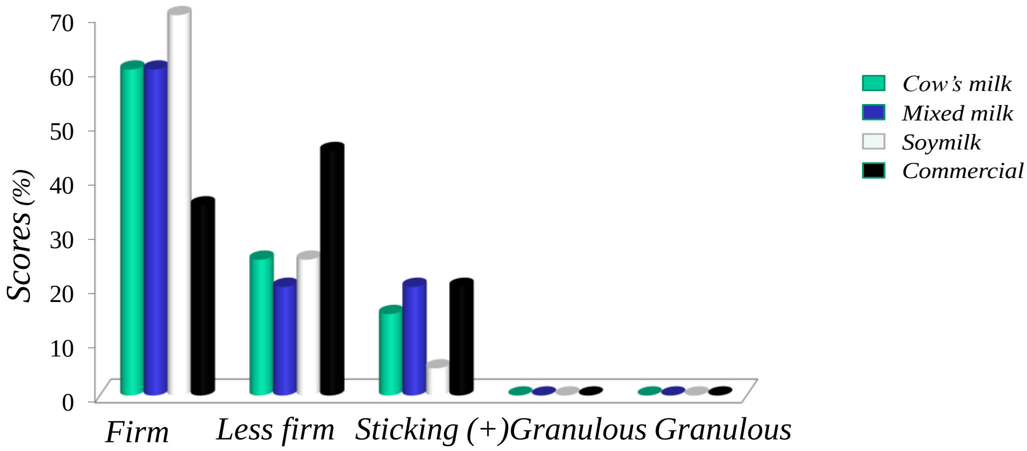

Figure 5: Texture attributes of processed yogurts versus commercially available yogurt

During fermentation, the content of lactose naturally present in cow milk or added to soymilk decreased due to its conversion in lactic acid by lactic bacteria; and addition of soymilk to cow milk decreases concentration of lactose (Fiocchi et al., 2003). Lactose content reduction decreased sweetness and palatability of milk (Kazemi et al., 2014)

Texture of yogurts

Panel scores obtained for texture attributes of processed yogurts versus commercially available yogurt are shown in Figure 5.

Soymilk-based yogurt displayed a high firmness revealed by more than 70% of panelists, while no difference was detected in firmness between yogurts processed from cow milk and mixed milks. Commercially available yogurt appeared to be fewer firm.

The firmness is one of the most important textural characteristics of yogurt. According to Tamime et al. (1991), the difference in firmness could be explained by the protein matrix structure of the yogurt gel. Positive interactions among emulsifier, soy oil droplets and casein micelles enable components in gel network formation (Aziznia et al. 2008). Conversely, Kailasapathy and Chin (2006) reported that textural properties of cow milk could be altered following addition of soymilk due to the decrease of casein concentration which consequently reduces gelling potential of the product.

4. CONCLUSIONS

This study demonstrated physicochemical and sensory properties of yogurt made from cow milk and soymilk and mixed milks, and alterations in sensory properties that occur with combination of both milks. Overall results revealed that the addition of soymilk to cow milk did not affect negatively physicochemical properties as well as sensory attributes of yogurt. Based on physicochemical and sensory characteristics, ours findings suggested that yogurt from soymilk suits well as a candidate for use as non-dairy yogurt alternative. Soymilk-based yogurt could be attractive as a good substitute for commercial production and as product processed with simple processing technology.

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