Revue Agrobiologia
www.agrobiologia.net
ISSN (Print): 2170-1652
e-ISSN (Online): 2507-7627

PRODUCTION AND QUALITY EVALUATION OF SYNBIOTIC SOYMILK-OAT AND COW'SMILK -OAT YOGHURT FERMENTED WITH LACTIC ACID BACTERIA

BENMEZIANE – DERRADJI Farida[1,3*], BOUSSOUEK Lina[1], DJERMOUNE-ARKOUB Lynda [2,3] and CHERIFI Achraf [4]

1. Department of Agronomic Sciences, Faculty of Sciences of Nature and Life, Chadli BENDJEDID University of El-Tarf. BP 73. El Tarf 36000, Algeria
2. Department of Process Engineering, Faculty of Technology, University of Bejaia, Bejaia, Algeria.
3. Laboratory of Biomathematics, Biophysics, Biochemistry and Scientometry, Faculty of Sciences of Nature and Life, Bejaia University, Bejaia (06000), Algeria.
4. Research Centre in Industrial Technologies (CRTI), Thin films development and applications unit (*UDCMA*-CRTI), Industrial Zone 15A Sétif, Algeria

Reçu le 29/01/2023, Révisé le 27/11/2023, Accepté le 10/12/2023

Abstract

Description of the subject: The search for "medicinal" foods is today the objective of all countries, especially those in developing, in order to alleviate the problems of nutritional deficiencies and to prevent several health problems.
Objective: The objective of this work was to develop a new functional food product using new materials oats and soy milk.
Methods: Four yogurt samples were prepared under the same standardized conditions; two of them were made with cow's milk with or without added oats, and others with soy milk with or without added oats. The yoghurts were characterized for their physicochemical (pH, acidity and dry extract), microbiological and organoleptic qualities. Syneresis was also determined.
Results: The physicochemical characteristics of soy milk yoghurt were close to those of plain yoghurt with a pH between 4.45 and 4.95 and an acidity between 40 and 93°D. Addition of oats increased total dry extract and decreased syneresis. The absence of contamination germs was observed in all the yoghurts.
Conclusion : Soy milk and oat have been used advantageously in the manufacture of a functional food (probiotic and prebiotic) and the product has been appreciated by consumers, which supposes its possible commercialization.
Keywords : Yogurt, oats, soymilk, quality assessment.

FABRICATION ET ÉVALUATION DE LA QUALITÉ DES YAOURTS SYNBIOTIQUES AU LAIT DE SOJA-AVOINE ET AU LAIT DE VACHE-AVOINE FERMENTÉS AVEC DES BACTÉRIES LACTIQUES

Résumé

Description du sujet : La recherche d'aliments "médicaments" est aujourd'hui l'objectif de tous les pays afin de pallier les problèmes de carences nutritionnelles et de prévenir plusieurs problèmes de santé.
Objectifs : L'objectif de ce travail était de développer un nouveau produit alimentaire fonctionnel en utilisant de nouvelles matières, l'avoine et le lait de soja.
Méthodes : Deux échantillons ont été fabriqués avec du lait de vache avec ou sans ajout d'avoine, et les deux autres avec du lait de soja avec ou sans ajout d'avoine. Les yaourts ont été caractérisés pour leurs qualités physicochimiques, microbiologiques et organoleptiques. La synérèse a également été déterminée.
Résultats : Les caractéristiques physicochimiques du yaourt au lait de soja étaient proches de celles du yaourt nature avec un pH compris entre 4,45 et 4,95 et une acidité comprise entre 40 et 93°D. L'ajout d'avoine a augmenté l'extrait sec total et diminué la synérèse. L'absence de germes de contamination a été observée dans tous les yaourts.
Conclusion : Le lait de soja et les flocons d'avoine ont été utilisés avantageusement dans la fabrication d'un yaourt fonctionnel et le produit a été apprécié par les consommateurs, ce qui suppose son éventuelle commercialisation.
Mots clés : Lait de chèvre, lait de vache, fromage affiné à pâte molle, qualité.

* Auteur correspondant: BENMEZIANE – DERRADJI Farida, E-mail: benmezianefarida@yahoo.fr

INTRODUCTION

Nowadays, the discovery of foods that can serve as nutraceuticals with health-promoting effects is a growing trend. A development of new food products is observed, especially in dairy products, which each time offers new food products that combine both the improvement of health and the satisfaction of consumer expectations; fermented milks are an example, especially yogurt. Yogurt is the most popular and consumed fermented milk around the world. Its consumption has been known to have health beneficial effects of consumers for centuries and several scientific studies attest to this. Indeed, by virtue of its composition, yogurt is a product with high digestibility and availability of nutrients such as proteins, minerals and vitamins [1]. The beneficial effect of yogurt is enhanced by the presence of viable lactic fermentative bacteria, which make yogurt a functional food and add value to the product. The literature has reported that chronic consumption of yogurt can facilitate intestinal transit [2]; modulate the immune system [3]. In addition, yogurt would improve lactose tolerance [4]. Considering the beneficial effects of yogurt consumption on health, consumer demand for this product is constantly increasing and several varieties of yogurt are increasingly marketed, in particular yoghurts made from other milks, such as goat, soy and coconut milk [5]; but also, other prebiotic ingredients are used such as fruits and their juices, honey [6-7] and many others. Among so many cereals, oats are one of the least valued species. In fact, unlike other cereals and despite its excellent nutritional properties, oat exhibits poor baking properties and therefore is mainly processed into products like rolled oats or serves as raw material for its functional ingredient β-glucan which during its production, a protein-rich fraction remains as a by-product [8]. Moreover, in order to definitively overcome the problem of lactose intolerance, several scientific reports have demonstrated the possibility of substituting cow's milk with other milks, including soy milk [9-10]. In fact, soy is nowadays the most used plant protein source in food industry because of its nutritional profile and low production costs. It has been reported that fermented soymilk has various health benefits as it act as antioxidant, antiproliferative, antidiabetic, hypolipidemic, immune modulatory, memory improvement, and wound healing activities [11]. Thus, the purpose of this study was to assess and to compare the effect of the type of milk and addition of oat on pH, acidity, dry extract, syneresis, microbiological quality and general acceptability in set yogurt under refrigerated storage conditions.

MATERIAL AND METHODS

1. Raw Material

Pure freeze-dried thermophilic yogurt culture - YoFlex®, for direct-to-vat set form, of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* and partially skimmed milk were procured from the state dairy industry "Edough" of Annaba – Algeria. On the other hand, oats and soymilk were purchased from supermarkets in the district of Annaba, Algeria. The total dry extract (g/L), pH, acidity expressed as Dornic degree (◦D), (1°D corresponds to 0.1 g of lactic acid per liter of milk), fat (g/L) and specific gravity of partially skimmed milk used in this study were 113.37, 6.37, 18, 15 and 1028, respectively, and were of 99.97, 7.07, 12, 13 and 1038 for the soymilk, respectively.

2. Experimental design

The yogurt samples were prepared in the dairy laboratory of the dairy industry Edough - Annaba (Algeria) according to the manufacturer's guidelines for a standard yogurt followed within the same company (Table 1; Fig. 1) with a modification relating to the use of soymilk and oats as novel raw material and ingredient.

Table 1: Experimental design for the manufacture of different types of yogurts

Formulation	Milk type (1.5 L)	Milk powder (g)	Sugar (g)	Lactic ferments (g)	Oatmeal (g)
Y1	Partially skimmed cow's milk	22.50	150	0.0045	/
Y2	Partially skimmed cow's milk	12	150	0.0045	30
Y3	Soymilk	22.50	150	0.0045	/
Y4	Soymlilk	12	150	0.0045	30

Y1: cow's milk yogurt; Y2: oat fortified cow's milk yogurt; Y3: soymilk yogurt; Y4: oat fortified soymilk yogurt

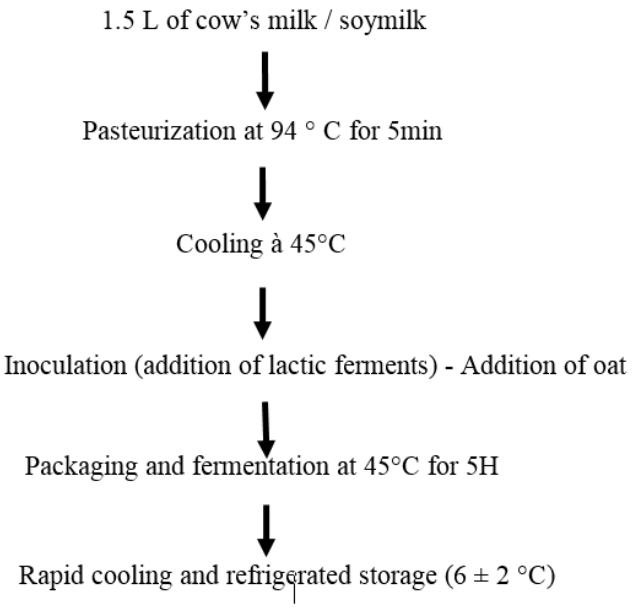

Figure 1: Flow chart of the production of yogurt

3. Quality assessment

The yogurts produced have undergone some analyzes as to their physicochemical quality (pH, acidity and dry extract), microbiological quality and sensory properties. The physicochemical quality (pH and acidity) was monitored throughout the shelf life of the yogurt (21 days) by performing analyzes every 7th day (D0, D7, D14 and D21).

3.1. Physichochemical quality

The yogurt samples were characterized for their pH, acidity and dry extracts. The pH was measured by a *Hanna* brand laboratory pH-meter; the acidity, expressed in Dornic degree (°D), was determined after titrating a portion of the yogurt with sodium hydroxide (NaOH) in the presence of a color indicator (phenolphthalein).

For the dry extract, this was measured by weight difference after oven drying of a quantity of product at 103±2°C for 3 h until constant weight and the result is expressed in g / L. The protocol of Koksoy and Kilic [12] was followed for the measurement of syneresis. This is the measurement of the volume of the serum separated on the surface of the yogurt after 15 days of refrigerated storage (4°C).

3.2. Microbiological quality assessment

The microbiological analyzes were carried out at the microbiology laboratory of the dairy company "Edough"- Annaba-. The analyzes performed in this study were carried out on total mesophilic aerobic flora, total and faecal coliforms, *Staphylococcus aureus*, *Salmonella*, yeasts and molds (Table 2).

Table 2 : Microbiological analyses

Germs sought	Culture media used	Incubation temperature (°C)	Incubation time
Total aerobic mesophilic bacteria	PCA agar	30	72 hours
Total coliform	VRBL agar	37	24 hours
Fecal coliform	VRBL agar	44	48 hours
Staphylococcus aureus	Chapman agar	37	48 hours
Salmonnella	Selenit broth	37	24 to 48 hours
Yeasts ans molds	OGA agar	25	5 days

3.3. Organoleptic evaluation

Nine trained panel between operators and laboratory assistants (both sex and age ranging from 21 to 60 years) belonging to the dairy, yoghurt section, were chosen according to their motivation to participate in the tasting test. Each yogurt is presented in a 50 g plastic container and coded with a letter (A, B, C or D) for anonymity. The sensory attributes including texture, color, taste, odor, viscosity and overall acceptability were assessed. The sensory tests were carried out after the confirmation of the microbiological safety of yogurt samples. An intensity scale between 0 and 5 was selected with 0 being the weakest and 5 the strongest feature expression.

4. Data analysis

The results obtained were processed with Minitab version 17 software (Minitab Inc., State College, PA, United States) by applying the analysis of variance (ANOVA) in order to highlight the significant differences between the yogurts produced at a 5% significance level (α = 0.05). Fisher's LSD test was used to compare and reveal differences between means.

RESULTS

1. Physicochemical quality

The physicochemical quality (pH, acidity) was monitored during the storage period of the yoghurts (21 days) with an interval of 7 days (Fig. 2). The total dry extract was determined at 1st and 21th days of storage (Fig. 3).

1.1. pH

Form the results displayed in figure 2a, it can be noted that the pH of the samples progressively decreased as the storage time lengthened from the first (D0) to the last day of storage (D21). Corresponding pH percentage decreases of 2.7%, 6.57%, 5.1% and 12.12% were observed from D0 to D21 for yogurts A, B, C and D.

1.2. Acidity

All yogurt samples experienced an increase in acidity during refrigerated storage (Fig. 2b). The acidity was varied between 60 - 92 ° D, 65 - 89 ° D, 70 - 85 ° D and 69 - 93 °D, for yoghurts A, B, C and D, respectively, with respective increase rates of 34.78, 26.97, 17.65 and 25.80 %.

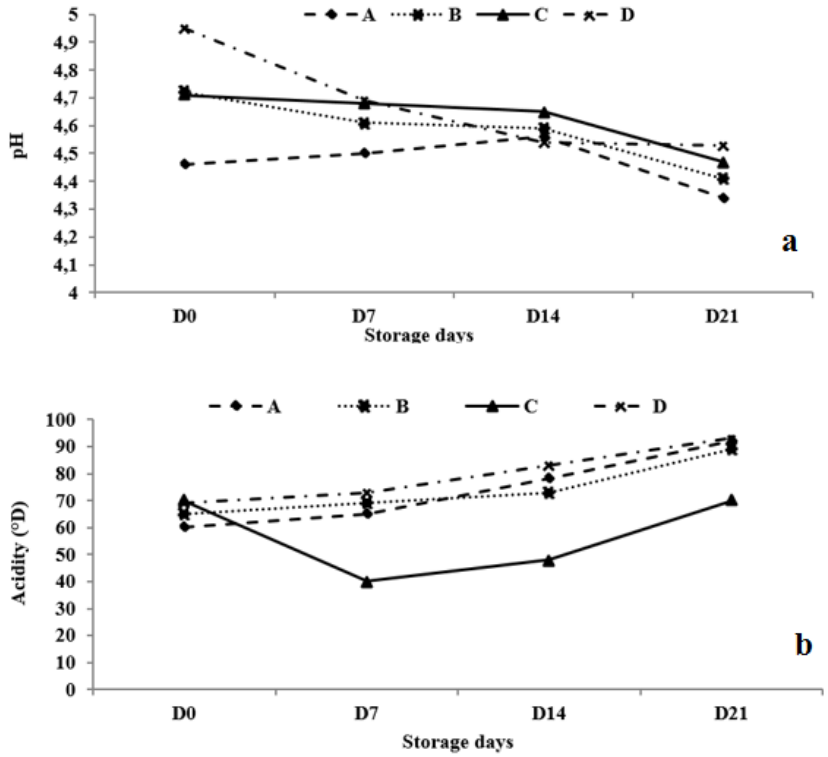

Figure 2: Evolution of pH on (A) and Acidity on (B): of samples during storage.
A: Cow's milk yogurt; B: Cow milk - oat yogurt; C: soy milk yogurt; D: soy milk + oat yogurt.

1.3. Total dry extract

It was observed that the cow's milk yoghurt (with or without oat), exhibited a quite close dry matter content at D0 and D21 of 115.22 - 130.5 g/L for sample A and 114.32 - 131.36 g/L for sample B, respectively. the inclusion of oat in the yogurts increased the dry extract. In fact, from the first to the last day of storage, the dry extract of soymilk set-yogurt varied between 93.38 - 103.22 g/L for sample C and 129.16 - 154.85 g/L for sample D (Fig.3).

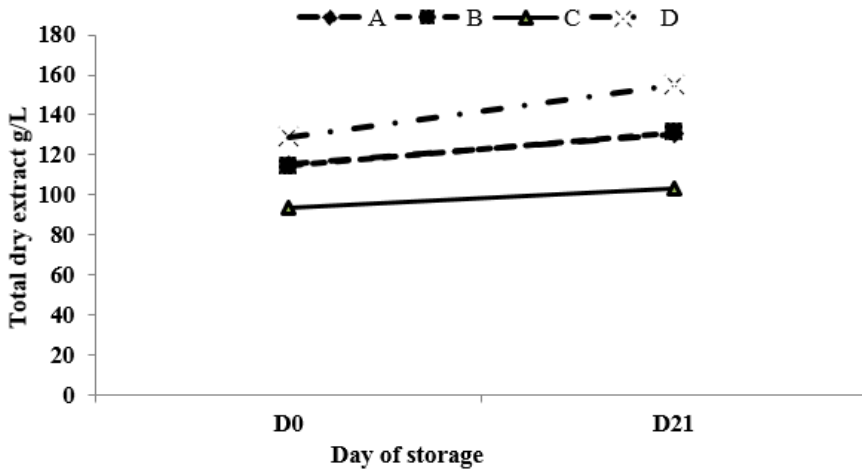

Figure 3: Total dry extract at the first and the end day of storage
A: Cow's milk yogurt; B: Cow milk - oat yogurt; C: soy milk yogurt; D: soy milk + oat yogurt.

1.4. Syneresis

The highest serum exudation rate was noted in samples of cow's milk yogurt with added oats (4mL), followed by soy milk yogurt (5mL) and finally cow's milk yogurt (2.5mL). while, no syneresis occurrence was observed in the sample D (soy milk yogurt with added oats). The acidity of the exuded serum followed the same trend recorded for yogurt acidity at the end of the storage (D21) (Fig. 4). Indeed, oat-free cow's milk yogurt recorded the highest acidity of 88 °D, followed by that of oat-based yogurt of 72 °D and finally oat-free soymilk yogurt showed a lower acidity of 34 °D. However, for sample D (oat-based soymilk yogurt) acidity could not be measured as it did not have syneresis.

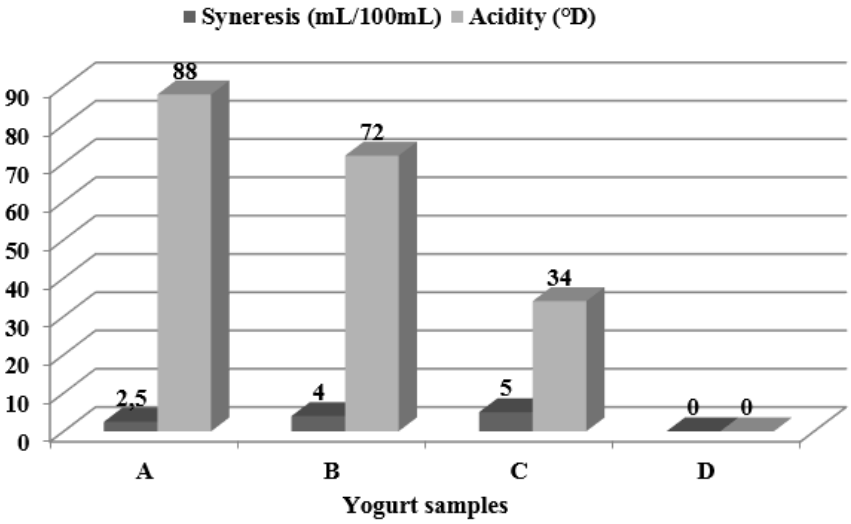

Figure 4: Syneresis rate and serum acidity
A: Cow's milk yogurt; B: Cow milk - oat yogurt; C: soy milk yogurt; D: soy milk + oat yogurt.

2. Microbiological quality assessment

Microbiological control is essential or even mandatory to assess the hygienic quality of a food product in order to protect the health of the consumer. Based on the results of the microbiological analysis (Table 3), it appears that no development of bacteria or yeasts and molds was observed in the yoghurts produced during refrigerated storage, which means that the yogurts were of a very satisfactory quality according to the standards of the Official Journal of Algerian Republic n° 35 (OJAR) (1998) [13] applied in the company.

Table 3: Microbiological properties of yogurt samples

Germes recherchés	Type de produit	Results (ufc/g of yogurt)	Standard (OJAR)
Total coliforms	**A**	Abs	**3.10^4 ufc /g**
	B	Abs	
	C	Abs	
	D	Abs	
Fecal coliforms	**A**	Abs	**30 ufc /g**
	B	Abs	
	C	Abs	
	D	Abs	
Staphylococcus aureus	**A**	Abs	**3.10^2 ufc /g**
	B	Abs	
	C	Abs	
	D	Abs	
Salmonella	**A**	Abs	**Absence in 25 g**
	B	Abs	
	C	Abs	
	D	Abs	
Yeasts and molds	**A**	Abs	**$<10^2$ ufc /g**
	B	Abs	
	C	Abs	
	D	Abs	
Total aerobic mesophic bacteria	**A**	Abs	**3.10^4ufc /g**
	B	Abs	
	C	Abs	
	D	Abs	

A: Cow's milk yogurt; B: Cow milk - oat yogurt; C: soy milk yogurt; D: soy milk + oat yogurt.
O.J.A.R: Official Journal of Algerian Republic.

3. Sensory evaluation of yogurt samples

The mean scores of sensory attributes of yogurt samples are presented in Table 4. Surprisingly, there was no significant ($p > 0.05$) differences between all samples for all sensorial attributes. The total substitution of cow's milk by soymilk and/or the fortification with oat didn't affect the panelists appreciation in terms of texture, color, flavor, aroma, viscosity even the overall acceptability despite that the judges lacked a habit or tradition of consuming fermented soymilk products. Nevertheless, the scores assigned for the soymilk yogurt were the lowest in terms of their flavor 3.00 and 2.67 for C and D samples, respectively.

Table 4: Sensory evaluation of yogurt samples

Formulation	Texture	Color	Flavor	aroma	Viscosity	Global acceptability
A	4.00±0.89[a]	4.33±0.52 [a]	3.33±1.37 [a]	4.67±0.52 [a]	4.67±0.52 [a]	4.33±0.52 [a]
B	3.83±0.41[a]	4.67±0.52 [a]	3.33±0.52 [a]	4.83±0.41 [a]	4.83±0.41 [a]	4.00±0.63 [a]
C	4.00±0.63[a]	4.33±0.52 [a]	3.00±1.26 [a]	4.67±0.52 [a]	4.67±0.52 [a]	4.00±0.63 [a]
D	3.67±1.03[a]	4.33±0.52 [a]	2.67±1.63 [a]	4.83±0.41 [a]	4.83±0.41 [a]	4.00±0.63 [a]

A: Cow's milk yogurt; B: Cow milk - oat yogurt; C: soy milk yogurt; D: soy milk + oat yogurt. ; Means that do not share the same letter in the same column are different ($p<0.05$).

DISCUSSION

Lactic acid production marks the pH changes that occur in fermented milk products. Lactic acid results from the transformation of lactose in milk by the lactic flora of the product. A slight decrease in pH, by 0.02 units, during storage of plain soy yogurt were obtained by Al-Nabulsi et *al.* [14];

Park et *al.* [15] reported a decrease in pH of soy-based yoghurt and strawberry soy based yogurt refrigerated and stored at 4°C for 10 days, from 5.36 to 5.13 and from 5.18 to 4.50 for 0 to and 10^{th} day of storage, respectively.

Similar tendencies were observed in previous researches of Mahrous et *al.* [16] and Cui et *al*. [17] on soymilk yogurt and yogurt added with oat whom noticed a decrease of pH from the first day of the production to the end of the storage. In contrast, pH stability during 28 days of cold storage in refrigerator of fermented soymilk was noted by Božanić et *al*. [18]. From the current study, it was noted that the greatest percentages of decrease were found in samples B and D supplemented with oats. This can be explained by the sugar intake of oats in cow's milk and soymilk which has contributed to the acceleration of the fermentation process. The same observation was made by Park et *al*. [15] with soy-based strawberry yogurt which was more acidic than plain soy yogurt. The pHs found in this study were higher than those recorded in probiotic and oat-based synbiotic yogurts varying between 3.71 and 4.11 for probiotic yogurt fermented with *L. brevis* SBP49 and between 3.58 and 4.00 for probiotic yogurt fermented with *L. acidophilus* SBP55 [19]. These differences between results are probably due to the nature of the raw material, ingredients used and the manufacturing conditions. Nevertheless, the use of soymilk and the addition of oat affected the pH of the yogurts as the corresponding samples have noted pH values higher than that of plain yogurt just after preparation (day zero). On the whole, results of the present work are comparable to previous reports, corroborating the residual acidification during storage. Similar trend on the influence of lentil flour on pH yogurt was noted by Benmeziane et *al.* [20].

The level of lactic acid production, expressed as acidity, in yogurt is widely used for the quality inspection of yogurt. An increase in acidity was experienced in the current study and was concomitant with a decrease in pH. This situation can be explained by the low buffering ability of both soymilk and cow's milk and even soymilk proteins. These outcomes were not in line with those reported by Fatima and Hekmat [21] who deduced that soymilk has lower buffering capacity as compared to cow milk. Similarly, previous reports have indicated an increase in yogurt acidity during refrigerated storage [20, 22]. All yogurt treatments have exhibited acidity less than 100 °D during all storage period. According to Lee et *al*. [23], the most suitable acidity to improve the quality of yogurt is 1.0–1.1 % (100- 110 °D). However, the acidity of all yogurt samples was slightly lower than the recommended level during all the storage period. Therefore, it is necessary to lengthen the fermentation time. A trend contrary to the results of the present study was observed by Lim [19] with an acidity ranging from 1.32 to 1.82 % in probiotic yogurt fermented with *L. brevis* SBP49 and *L. acidophilus* SBP55 added with oat slurry at different concentrations. The authors recommended to reduce the fermentation time and to use additives that can neutralize the acid in the yogurt.

In general, results of the current study were in agreement with the work performed by Alqahtani et *al*. [24] who studied the impact of oat flour addition (0, 1, 2 and 3 %) on the quality of goat milk yoghurt regarding pH and acidity evolution.

It’s known that addition of flours in yogurt increase the total dry extract. Previously, Benmeziane – Derradji et *al*. [20] and Ahmad et *al.* [25] have noticed that the addition of prebiotic (lentils flours and apple peel polyphenol extract, respectively) increased the total solids in the fortified yogurt. Nevertheless, our outcomes were not in line with those of Sharma et *al*. [26] who indicated that the total solid content soymilk was reduced substantially upon lactic fermentation from 4.9% to 2.3%. The authors attributed this trend to the consumption, denaturation and precipitation of the proteins triggered by lactic acid accumulation. However, many researchers considered that the more the total solids content raises the less of whey drainage [27, 28]. The differences recorded between the physicochemical properties of the yogurts produced can be explained by the substitute of the milk used (soy milk) which can cause considerable changes in the course of the fermentation process, linked to a protein and carbohydrate composition such as the absence of lactose, the availability of micronutrients and the potential presence of inhibitors (eg, antimicrobial protein compounds, polyphenols) as explained by Montemurro et *al*. [29].

The whey separation (wheying-off or syneresis) which is a common defect in fermented milk products like yogurts during storage is due to the rearrangements of the gel molecular matrix or the mechanical damage of the casein network [30]. The presence of whey, containing nutrients, on the surface of yogurts can be the source of product contamination and negatively impacts the yogurt quality.

The absence of syneresis in sample D can be explained by the solids content which was the highest compared to the others yoghurt samples (154.85 g/L), since Brückner-Gühmann et al. [8] stated that by increasing the dry matter content, typical problems like syneresis and low gel strength will be reduced. The absence of syneresis can also be explained by the water-holding capacity of the oat fibers that have absorbed the whey released by the gel structure as indicated by Dabija et *al*. [31] which was not the case for the cow's milk yogurt supplemented with oats where a rate of 4 mL/100mL was observed. This rate was very close to the highest rate noted for sample C, oat-free soymilk yogurt (5 mL/100 mL). While, cow's milk yogurt without the addition of oats resulted in an exudation of 2.5 mL/100mL. The suppression of syneresis in sample D may be due to some oat ingredients namely polyphenols and β-glucan. Since plant polyphenols could interact with milk casein leading to increase stability of casein networks and water retention capability and consequently lower or disappearance of syneresis will be obtained [24]. From the results of the serum acidity, it can be judged, once more, of the low buffering capacity of soy proteins. The acidity of whey was first reported in this work. According to Zanhi and Jideani [32], proteins present in the enriched yogurt can act as buffers in food systems by their ability to release or accept free hydrogen atoms.

As for the microbiological quality, the compliance of the results with standards demonstrates the compliance with hygienic conditions with regard to the raw materials used, the handling personnel, the working environment and the equipment used during handling and the proper conduct of the pasteurization heat treatment. This was responsible for the microbiological stability of the product and provided assurance for the health of the consumer. This conformity is also due to the good progress of the fermentation which promotes the growth of lactic acid bacteria producing on their part substances which inhibit unwanted microorganisms [33]. These findings were in line with the previous results of Benmeziane et *al.* [20] who found no bacterial development in terms of total aerobic mesophilic bacteria, total and fecal colifroms, *Staphylococcus aureus* in their yoghurt samples with or without lentil flour. Whereas, Ugwona et *al*. [34] did not detect mold in their soy milk yogurt samples, while coliforms were detected at 2.0×10 and 1.0×10 cfu/mL but not in all samples. The total flora was noted between 1.43×10^5 and 2.91×10^5 cfu/mL. High bacteria count (1.90×10^7 - 11.60×10^7 cfu/mL) and very high number of total coliform ($0.50 \times 10^7 – 3.90 \times 10^7$ cfu/mL) were found in yogurts produced with different ratios of powdered cow milk, soy milk and cornstarch which indicates heavy contamination considered that yogurt are not safe for consumption [35]. Authors explained this situation by a poor sanitary practice during production and post pasteurization contamination during handling and packaging of the samples.

Sensory science is a discipline to measure and evaluate people's appeal to products perceived through the 5 senses such (sight, smell, touch, taste and sound). In food product development, sensory evaluation not only supplies a clear comprehension of consumer acceptability but also minimizes the risk of product failure [36], a sensory analysis of any new food product is then necessary. Contrariwise to the results of this study, there was a significant difference ($p<0.05$) on the sensory scores of color and aroma of carrot yoghurt and plain yoghurt. However, there was no significant difference ($p>0.05$) between the acceptability of the plain yoghurt, 1% and 2% carrot yoghurt and a significant difference ($p<0.05$) was there between 3% [37]. Generally, all the samples were accepted by the judges which joins the conclusions of Ademosun et *al*. [38] on yogurt fortified with tomato juice.

CONCLUSION

The study was carried out to develop a new functional food, cow’s milk oat fortified yogurt and soy milk yogurt oat fortified, and assessing its physicochemical, microbiological and sensory properties. Results have shown that commercial soymilk was a good substrate for the growth and the development of the yogurt starters, *Lb. delbrueckii* and *Str. Thermophilus* as the yogurt obtained had a quality criteria comparable to that made from cow’s milk and that oats have been used advantageously in yogurt preparation. Hence, oat could be an attractive cereal ingredient in the production of prebiotic yogurts for health-conscious consumers. Moreover, yogurts obtained were of very satisfactory microbiological quality with a total absence of germs of contamination as well as pathogenic germs.

The panelists have appreciated all yogurt samples. Finally, it can be concluded that we have been able to develop a new functional food that is both probiotic and prebiotic by advantageously using soy milk and oat. This new product can be consumed in particular by people suffering from lactose intolerance. Also, it would be preferable to make this soymilk yogurt fortified with oat known to the general public of Algerian consumers as a ″health food" and to encourage its use and introduction into various food products, in particular widely consumed such as cookies, dairy products, chocolate and spread.

REFERENCES

[1] Weerathilake W. A. D. V., Rasika, D. M. D., Ruwanmali, J. K. U., Munasinghe, M. A. D. D. (2014). The evolution, processing, varieties and health benefits of yogurt. *International Journal of Scientifi and Research Publications* **4(4)**, 1–10.

[2] Adolfsson O., Meydani S. N., Russel, R. M. (2004).Yogurt and gut function. *American Journal of Clinical Nutrition* **80**, 245–256.

[3] Ruiz-Ojeda F. J., Gil-Campos, M., Gil, A. (2019). Mechanisms of action of probiotics. *Advances in Nutrition* **10**, S49–S66. https://doi.org/10.1093/ advances/nmy063.

[4] Savaiano D. A. (2014). Lactose digestion from yogurt: Mechanism and relevance. American *Journal of Clinical Nutrition* **99(5)**, 1251S–1255S. https://doi.org/ 10.3945/ajcn.113.073023 (suppl).

[5] Ladokun, O., Oni, S. (2014). Fermented milk products from different milk types. *Food and Nutrition Sciences* **5(13)**, 1228–1233. https://doi.org/10.4236/fns.2014.513133.

[6] Ammar T. M. A., Ismail M. M. E., Khalil A. E., Eid, M. Z. (2015). Impact of fortifiation with honey on some properties of bio-yoghurt. Journal of Microbiology, *Biotechnology and Food Sciences* **4**, 503–508. https://doi.org/10.15414/ jmbfs.2015.4.6.503-508, 06.

[7] Fernandez M. A., Marette, A. (2017). Potentiel health benefis of combining yogurt and fruits based on their probiotic and prebiotic properties. *Advances in Nutrition*, **8 (Suppl.)**. https://doi.org/10.3945/an.115.011114, 155S–64S.

[8] Brückner-Gühmann M., Benthin A., Drusch, S. (2019). Enrichment of yoghurt with oat protein fractions: Structure formation, textural properties and sensory evaluation. *Food Hydrocolloids* **86**, 146 - 153. https://doi.org/10.1016/j.foodhyd.2018.03.019.

[9] Ugwona, F.U, Obeta, N.A, Ejinkeonye, U.B and Aliyu, S.A. (2018). Production and quality evaluationof soymilk yoghurt. Nigerian Journal of Nutritional Sciences, 39(1), 127 – 133.

[10] Horáčková Š, Mühlhansová A., SlukovÁ M., Schulzová V., Plocková M. (2015). Fermentation of Soymilk by Yoghurt and Bifidobacteria Strains. *Czech Journal of Food Science*, **33(4),** 313–319. DOI: 10.17221/115/2015-CJFS.

[11] Kesika, P., Sivamaruthi, B.S., & Chaiyasut, C. (2021). A review on the functional properties of fermented soymilk. *Food Science and Technology, Campinas,* 1 – 7. DOI: https://doi.org/10.1590/fst.10721.

[12] Koksoy A., Kilic M. (2004). Use of hydrocolloids in textural stabilization of a yoghurt drink, ayran. *Food Hydrocolloids, 18(4),* 593–600. https://doi.org/10.1016/j. foodhyd.2003.10.002.

[13]. Arrêté interministériel du 24 janvier 1998 modifiant et complétant l'arrêté du 23 Juillet 2994 du Journal officiel n° 35 du 27 Mai 1998 relatif aux spécifications microbiologiques de certaines denrées alimentaires.

[14] Al-Nabulsi A., Shaker R., Osaili T., Al-Taani M., Olaimat A., Awaisheh S., Abushelaibi A., Holley R. (2014). Sensory evaluation of flavored soy milk-based yogurt: A comparison between Jordanian and Malaysian consumers. *Journal of Food Science and Engeneering* **4**, 27.

[15] Park S.Y., Lee D.K., An H.M., Kim J.R., Kim M.J., Cha M.K., Lee S.W., Kim S.O., Choi K.S., Lee K.O., Ha N.J. (2012). Producing Functional Soy-Based Yogurt Incubated with Bifidobacterium Longum SPM1205 Isolated from Healthy Adult Koreans. *Biotechnology & Biotechnological Equipment* **26(1)**, 2759-2764, DOI: 10.5504/BBEQ.2011.0152.

[16] Mahrous H., Kholy W.M.E., Elsanhoty R.M. (2014) Production of New Synbiotic Yoghurt with Local Probiotic Isolate and Oat and Study its Effect on Mice. *Journal of Advances Dairy Researche* **2**, 121. doi:10.4172/2329-888X.1000121

[17] Cui L., Chang S.K.C., Nannapaneni R. (2021). Comparative studies on the effect of probiotic additions on the physicochemical and microbiological properties of yoghurt made from soymilk and cow's milk during refrigeration storage (R2). *Food Control* **119**, 107474. https://doi.org/10.1016/j.foodcont.2020.107474.

[18] Božanić, R., Lovković, S., & Jeličić I. (2011). Optimising fermentation of soymilk with probiotic bacteria. *Czech Journal of Food Scien* **29**, 51–56.

[19] Lim ES. (2018). Preparation and functional properties of probiotic and oat-based synbiotic yogurts fermented with lactic acid bacteria. *Applied Biological Chemistry* **61(1)**, 25–37. https://doi.org/10.1007/s13765-017-0333-5.

[20] Benmeziane F., Raigar R.K., Ayat N.E., Aouf D., Djermoune-Arkoub, L., Chala A. (2021). Lentil (*Lens culinaris*) flour addition to yogurt: Impact on physicochemical, microbiological and sensory attributes during refrigeration storage and microstructure changes. LWT - *Food Science and Technology* **140**, 110793. https://doi.org/10.1016/j.lwt.2020.110793.

[21] Fatima SM, Hekmat S. (2020). Microbial and Sensory Analysis of Soy and Cow Milk-Based Yogurt as a Probiotic Matrix for *Lactobacillus rhamnosus* GR-1. *Fermentation* **6**, 74; doi:10.3390/fermentation6030074.

[22] Lee B.S., Resende S.R., Souza A.K., Silva M.A.P., Plácido G. R. (2014). Sensory, physicochemical and microbiological characteristics of Greek style yogurt flodoredite qui (Caryocar Brasiliense, Cambess). *African Journal of Biotechnologie* 3797-3804, Article number 090897647390.

[23] Lee M.J., Kim K.S., Kim Y.K., Park J.C., Kim H.S., Choi J.S., Kim K.J. (2013). Quality characteristics and antioxidant activity of yogurt added with whole barley flour. *Korean Journal of Food Science and Technology* **45**, 721–726. http://dx.doi.org/10.9721/KJFST.2013.45.6.721.

[24] Alqahtani N.K., Darwish A.A., El-Menawy R.K., Alnemr T.M., Aly E. (2021). Textural and organoleptic attributes and antioxidant activity of goat milk yoghurt with added oat flour, *International Journal of Food Properties* **24(1)**, 433-445, DOI: 10.1080/10942912.2021.1900237.

[25] Ahmad I., Khalique A., Shahid M. Q., Rashid A. A., Faiz F., Ikram M. A. (2020). Studying the inflence of apple peel Polyphenol Extract fortification on the characteristics of probiotic yoghurt. *Plants* **9(1)**, 77. https://doi.org/10.3390/ plants9010077.

[26] Sharma A., Noda M., Sugiyama M., Ahmad A., Kaur B. (2021). Production of Functional Buttermilk and Soymilk Using *Pediococcus acidilactici* BD16 (*alaD*+). *Molecules* **26**, 4671. https://doi.org/ 10.3390/molecules26154671.

[27] Park Y. W., Oglesby J., Hayek S. A., Aljaloud S. O., Gyawali R., Ibrahim S. A. (2019). Impact of different gums on textural and microbial properties of goat milk yogurts during refrigerated storage. *Foods* **8(5)**, 169. https://doi.org/10.3390/ foods8050169.

[28] Henriques M. H. F., Gomes D. M. G. S., Borges A. R., Pereira C. J. D. (2020). Liquid whey protein concentrates as primary raw material for acid dairy gels. *Food Science and Technology, Campinas* **40(2)**, 361–369. https://doi.org/10.1590/fst.43218.

[29] Montemurro M., Pontonio E., Coda R., Rizzello C.G. (2021). Plant-Based Alternatives to Yogurt: State-of-the-Art and Perspectives of New Biotechnological Challenges. *Foods* **10**, 316. https://doi.org/ 10.3390/foods10020316.

[30] Saleh A., Mohamed A. A., Alamri M. S., Hussain S., Qasem A. A., Ibraheem M. A. (2020). Nonfat set yogurt: Effect of okra gum and various starches on the rheological, sensory, and storage qualities and wheying-off. *Journal of Chemistry* **11**. https://doi.org/10.1155/2020/5091970 (2020), Article ID 5091970.

[31] Dabija A, Codină GG., Gâtlan A.M., Rusu L. (2018). Quality assessment of yogurt enriched with different types of fibers. *CyTA - Journal of Food* **16(1)**, 859-867, DOI: 10.1080/19476337.2018.1483970.

[32] Zanhi N. K., Jideani I. A. (2012). Physico-chemical and sensory qualities of soy and milk solids fortified low fat yoghurt. *African Journal of Agricultural Research* **7(38)**, 5336-5343. DOI: 10.5897/AJAR11.449.

[33] Katinan R., Aw S., Chatigre K.O., Bohoussou K.M., Assidjo N.E. (2012). Evaluation de la qualité chimique et microbiologique des laits caillés artisanaux produits et consommés dans la ville de Yamoussoukro, Côte d'Ivoire . *Journal of Applied Biosciences* **55**, 4020–4027.

[34] Ugwona F.U., Obeta N.A., Ejinkeonye U.B., Aliyu S.A. (2018). Production and quality evaluation of soymilk yoghurt. *Nigerian Journal of Nutritional Sciences* **39(1)**, 127 – 133.

[35] Obiora C. U., Igwe E.C., Udeagha U.C., Orjiakor S.N., Anarado C.S. (2020). Production and Quality Evaluation of Yogurts from Composites of Powdered Cow Milk, Soy Milk, and Cornstarch. *European Journal of Nutrition & Food Safety* **12(10)**, 54 - 67. DOI: 10.9734/ejnfs/2020/v12i1030302.

[36] Rana M.S., Yeasmin F., Khan M.J., Riad M.H. (2021). Evaluation of quality characteristics and storage stability of mixed fruit jam. *Food Research* **5 (1)**, 225 – 231. https://doi.org/10.26656/fr.2017.5(1).365.

[37] Madora E. P., Takalani T. K., Mashau M.E. (2016). Physicochemical, microbiological and sensory properties of low fat yoghurt fortified with carrot powder. International *Journal of Agricultural and B*iological Engineering **9(1)**, 11 8—124. DOI: 10.3965/j.ijabe.20160901 .1874.

[38] Ademosun O. T., Ajanaku K. O., Adebayo A. H., Oloyede M. O., Okere D.U., Akinsiku A. A., Ajayi S. O., Ajanaku C. O., Dokunmu T. M., Owolabi A.O. (2019). PhysicoChemical, Microbial and Organoleptic Properties of Yoghurt Fortified with Tomato Juice. *Journal of Food and Nutrition Research* **7(11)**, 810-814. DOI: 10.12691/jfnr-7-11 -9.