Yogurt-like Product from Fermented Maize: Part II: Quality Improvement

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Abstract

This study aimed to develop the method for stabilising the quality of fermented maize-based product by some technical solution. Three homogenisation pressures were applied (150, 200 and 250bar). Then suspensions were mixed with xanthan and gellan gums separately with different concentrations ranging from 0.1 to 0.2%. Two flavours were tested: corn and milk flavours at concentration between 0.1 to 0.15%. The sediment height, pH, acidity, viscosity and sensory attributes were followed during storage time until 1 month. Results showed that the use of 250bar of homogenisation pressure and 0.2% of gellan gum and with mixed corn-milk flavours at 0.1% gave the best quality of product. During one month of storage, no decantation was observed; the biochemical and sensory characteristics were maintained (pH≈4, acidity <3g/L, viscosity 25cP).

Keywords: non-dairy yogurt, fermented maize, lactic acid bacteria, high-pressure homogeniser, gellan gum

1. Introduction

Consumers worldwide are being increasingly interested in the relationship between the diet and health and the market of functional food has been drastically growing in recent years. Even though yogurts and fermented dairy products still take a majority of market share, the consumer's demand for non-dairy fermented beverages is increasing day by day [1]. This observation is the consequence of the trend extension of vegetarianism, the increasing prevalence of the lactose intolerance and the concern of cholesterol in dairy products.

Cereal grains are considered to be one of the most important sources of dietary proteins, carbohydrates, vitamins, minerals and fibre for people all over the world [2]. Nowadays, cereals alone or mixed with other ingredients are used for the production of traditional fermented beverages as well as for the development of new foods with enhanced healthy properties [2]. Amongst the main used grains, maize is the most popular raw material in South America, Central Africa and West Africa countries [3]. Maize (*Zea mays*) is considered like a non-allergenic food and suitable for lactose maldigestion on diet or protein allergenic people.

Fermentation is one of the oldest and most economical methods of producing and preserving food. In addition, fermentation provides a natural way to reduce the volume of the material to be transported, to destroy undesirable components, to enhance the nutritive value and appearance of the food, to reduce the energy required for cooking and to make a safer product [4]. Lactic fermentation plays an important role in the production of fermented maize-based products. These products contain less sugar low fat, as well as free of cholesterol and saturated fats. The fermentation and cooking process increase the flavour and the ability of carbohydrate metabolism. Beside the interest of healthy benefit of products, acceptability of foods by consumers mainly relies on their sensory attributes, among which the appearance and state of product, especially for beverages, plays an important role. Thus, the stabilisation of these criteria during transport, distribution and storage of product becomes extremely important. This phenomenon is more pronounced for fermented maize-based product which contained mainly starch. Although starch in raw material was partially liquefied and gelatinised, the fermented suspension was still physically unstable. The sedimentation was observed with accumulation of particles in the bottom of bottles [5]. To design homogeneous emulsions with small particle size and high stability under the storage condition, small molecule surfactants the blending of non-starch hydrocolloids such as gums with starch is possible to solve this problem. Gums are hydrocolloids frequently used in several foods for thickening and emulsifiers and/or emulsion stabilizers correlates to phenomena such as: retardation of precipitation of dispersed solid particles, decreased creaming rates of oil droplets and foams, prevention of aggregation of dispersed particles, prevention of syneresis of gelled systems containing oils and

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retardation of coalescence of oil droplets [6]. A common gelling agent used in the food industry is LA (low-acyl or deacylated) gellan gum [7], which is a microbial polysaccharide. The gelation mechanism for gellan gum starts by formation of double helices, and, afterwards, the ioninduced association of the double helices leads to junction zone formation. In other words, the gellan network consists predominantly of flexible, disordered chains, with few ordered junction zones between the helices, stabilising forces such as hydrogen bonds, electrostatic forces, hydrophobic interactions, Van der Waals attractions and molecular entanglement are defined by the solvent conditions and polymer structure in this zone [7]. The other hydrocolloid that is commonly used in beverage and drinks is xanthan gum, which is an extracellular polysaccharide produced by the bacterium *Xanthomonas campestris*. Xanthan gum used singely do not form gels, but forms very viscous solutions, and at sufficiently high polymer concentration, it exhibits weak gel-like properties. Xanthan is widely used in foods, because of its good solubility in either hot or cold solutions, high viscosity even at very low concentrations, and excellent thermal stability [6].

In Vietnam, study on lactic fermented cereal-based products was still limited. Few publications presented the manufacturing and stabilisation of lactic drinks from sweet potato [8]. Therefore, this study focussed on development of method for stabilising the appearance and enhancing the quality of fermented maize-based product by selecting different functional ingredients. In addition, the quality evolution of yogurt-like product was also investigated during storage time.

2. Materials and Methods

2.1. Materials

Waxy maize (*Zea mays* var. *ceratina*) was directly purchased from farmer in Son Duong district, Tuyen Quang province, Vietnam. Dried maize (water content 13.92±0.12%, 100kg totally) was stocked in dry place for all the experiments. The nutritional compositions of waxy maize (in % dry basis) were as follow: carbohydrate (71.06±0.05), total protein (9.62±0.03), lipid (5.38±0.09), fibre (3.09±0.04) and ash (1.92±0.01).

Lactobacillus plantarum NCDN4 (from Institute of Food Industry - Vietnam) was used as starter for fermentation. Lactic acid bacteria were grown on MRS broth at 37°C for overnight and then centrifuged at 10,000g for 5 min. The pellet was washed two times with NaCl 9‰ then resuspended in NaCl 9‰ at appropriate concentration before inoculating.

Xanthan gum (E415) and gellan gum (E418) were purchased from Ba Dinh Foodstuff Technology Company (Hanoi – Vietnam).

Corn and milk flavours were supplied by Brenntag Vietnam Company (Ho Chi Minh City – Vietnam).

2.2. Preparation of yogurt-like product from fermented maize

The maize kernels were soaked in boiling water and kept at 30°C during 18h. The ratio of maize/water was 1/2. And then the drained grains were wet-milled with ratio 1/3 of grains/water. The obtained suspension was filtered by sieve (sieve size 0.125mm) before liquefied by enzyme (Spezyme Xtra - Genencor USA – 0.02%w/w) during 1h at 70°C then 5 minutes at 95°C for enzyme inactivation and sterilisation.

The maize suspension was added with sucrose to reach 20% dry matter content and its compositions (in % dry basis) were as follow: carbohydrate (77.70±0.05), total protein (8.70±0.02), lipid (1.20±0.03), fibre (3.10±0.02) and ash (1.70±0.01). *L. plantarum* NCDN4 was inoculated at 10^6CFU.mL^{-1}. The fermentation was conducted during 12h at 32°C.

2.3. Selection of homogeniser pressure and functional ingredients

The fermented suspensions (about 3L) were homogenised at three different pressures: 150, 200 and 250bar.

In order to select the ingredient, the most suitable for maintaining the appearance of product, fermented suspensions were mixed separately with xanthan and gellan gum at different concentrations (0.1; 0.15; 0.2%) before homogenising at pressure which was chosen in previous chapter.

Once selection of homogenisation pressure and texture ingredient, the product was added by corn, milk flavours at two concentrations for each (0.1 and 0.15%).

Suspensions were then bottled into 125mL glass bottles and sterilised at 95°C for 15 minutes before conditioned in refrigerator (4-6°C). The sediment height, pH, titratable acid was followed at 2h, 4h, 1 day, 2, 7, 10 days and 1 month of storage time.

2.4. Physical, biochemical and sensory analysis

Dry matter content was determined using the AACC Method 44-15A [9]. Titratable acidity was determined by neutralisation with 0.1M NaOH until a pH of 8.5 was obtained; results were expressed as lactic acid equivalent (0.09g lactic acid for 1mL NaOH 0.1M) [10]. Suspension’s viscosities were determined by Brookfield RVT Viscometer using spindle number 2 at rotation speed of 100rpm. Suspension's viscosities were expressed in centipoise (cP). The sediment height was measured by mm of solid matter (from interface to bottom of bottle) with the total product height was 70mm.

Products (at 20°C, identified by unique three-digit codes each) were evaluated for sensorial characteristics by 25 panellists (untrained, students and lecturers in food technology, 20–50 years old, 7 male and 22 female) in order to (i) select the suitable added flavour and (ii) measure attributes intensity and acceptability simultaneously. Three criteria: sweetness, sourness and viscosity were judged by using JAR (just-about-right) scaling with three points: "not enough", "just-about-right" and "too much" [11]. The two others: odours and overall liking were determined by using nine-point hedonic scales, where 9=extremely like and 1=extremely dislike [12].

2.5 Statistical analysis

The means and standard deviations were determined for all the measurements from at least three replicates. The significant difference of mean values was assessed with one-way analysis of variance (ANOVA) followed by Duncan's test using SPSS software at a significance level of $p < 0.05$.

3. Results and discussion

3.1. Effects of homogenisation pressure on physical stability of yogurt-like product

High-pressure homogenisation is commonly used in food technology, especially in beverage and dairy industries, in order to stabilize the state of product by reducing particle size in heterogeneous suspensions which involves the decrease of settling velocity of particles. In this study, three pressures were tested: 150, 200, 250bar and the sediment height of bottled products were followed and the results were presented in Fig. 1. No decantation was observed just after homogenising. However, the sedimentation started after 2h of storage and became increasingly pronounced as a function of storage time. Increasing the homogenisation pressure enhanced the efficiency of suspension stability. After 2h of storage, for homogenised suspension at 250bar, the sediment height was only 15±2mm while this value was 34±2mm for homogenised suspension at 150bar. The sediment height increased regularly before reached a steady value about 50mm for all homogenisation pressures. The same tendency was observed for beverage made from sweet potato [8]. Only pressure homogenisation was not enough to stabilise physical properties of products.

For other beverages which contained mainly protein and/or lipid, high-pressure homogeniser exhibited more efficiency. The product stabilisation was achieved when a minimum pressure of 200bar was applied in the case of pine nut and soybean beverages [13]. That can be explain by (i) the intrinsic density of starch was higher than those of protein and lipid and (ii) the hydrophobic liaisons of protein and lipid were stronger than those of starch. Be that as it may, in our case, homogenisation presented certain effect comparing to untreated suspension (Fig. 1) and pressure at 250bar was the condition the most suitable for stabilising fermented suspension. This pressure was chosen for the next study of selection of functional ingredients.

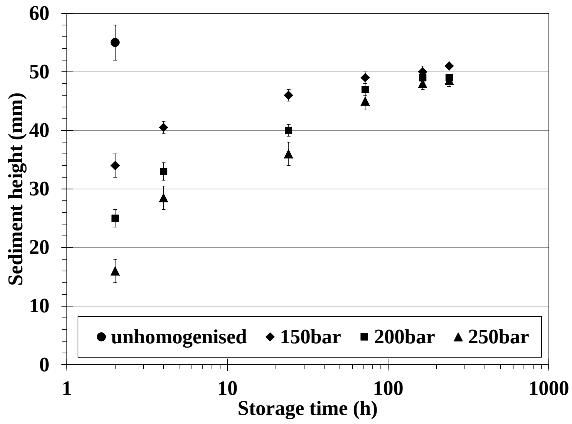

Fig. 1. Sediment height of maize suspension as a function of storage time

3.2. Effects of thickening agents on stabilities of yogurt-like product

This section aimed to select the suitable functional ingredients in order to (i) stabilise physically suspensions and (ii) enhance the product flavour. For the first objective, two gums were used: xanthan and gellan at different concentrations and obtained results of sediment height as a function of storage time were presented in Fig. 2. From Fig. 2, it was observed that the functional ingredients improved the suspension stabilisation comparing to samples without gums. After 2h, the maximal sediment height was 20±2mm when suspension added with xanthan 0.1%. Increasing the concentration of gums decreased the sedimentation. Gellan gum presented more efficiency comparing to xanthan gum. No decantation was observed after 1 month with suspension added with 0.2% of gellan gum while adding xanthan gum, the sediment height ranged from 35 to 44mm after 1 month. In fact, xanthan gum was a heteropolysaccharide that has 1,4-linked β-D-glucose residues as the primary structure. Either the high positive effect for stabilisation of several cereal starch suspensions, the blend of corn starch-xanthan gum had low thickening effects. This could be due to thermodynamically incompatibility of maize and xanthan as both are anionic polymers [14]. The basic unit of gellan gum consists of 1,3–connected glucuronic acid residues and 1,4–connected rhamnose residues. This ingredient made waxy maize starch granules more swollen and strengthened the network. Thus, it enhanced the physical state of suspension. From these results, the suitable texturizing ingredient was gellan gum with concentration of 0.2%w/w.

3.3. Effect of flavour on sensory evaluation of yogurt-like product

For the selection of flavour ingredient, the hedonic points were recorded by 25 panellists with five samples added by different additive concentrations. The obtained results were presented in Table 1. Considering odour attribute, there was a significant difference between five samples which can be divided into three groups. The sample which was liked the most was added with 0.1% of mix corn flavour and milk flavour. All products supplemented with only milk flavour had a low acceptability (<5). This observation was not accorded with the results presented by Akissoe et al. 2015 [15] who studied the acceptance of African consumers on fermented maize beverage. These consumers preferred the flavour and taste of milk. This difference can be explained by the difference of dietary habit between two population groups. For overall liking attribute, the results showed that in general, the judges neither disliked nor liked the different beverages. This was an important result which confirmed the fermented maize beverage (yogurt-like product) was a potential non-dairy product and the lactose-intolerant persons may consume them.

For evaluating the intensity and acceptability of several sensory attributes: viscosity, sourness and sweetness were judged by JAR (just-about-right) scaling. Considering the results in Fig. 3, the majority of responses (>50%) were "just-about- right" for two sensory attributes: sourness and sweetness. Especially for sweet taste, this value was 72% which signified that the product was sweet enough for consumer and not necessary to adjust these criteria. There was only one sensory attribute: viscosity which needs to be adjusted. 56% of responses evaluated that the product was not enough viscous while 28% perceived "just-about-right". Therefore, the viscosity of final product (actually was 25cP) should be raised to higher level. The increase of viscosity can be realised by adding several functional ingredients such as pectin or a combination of xanthan-gellan gum. However, in the literature, previous studies reported various results for the acceptable viscosity of cereal-based beverages. Koyama et al. 2014 concluded that the ideal viscosity of rice-milk drink was 15±5 mPa.s [5]. Lee et al. 2003 reported a higher value for viscosity of rice and pine nut beverage as about 100mPa.s [13]. The highest value was about 300-400mPa.s reported for fermented maize-based and fermented sweet potato beverages [8, 15]. This contrary story suggests a necessity of extended and detail study on sensory analysis of acceptability and preference of Vietnamese consumers of yogurt-liked product made by fermented maize.

Finally, the different physical-biochemical characteristics were followed during 1 month of storage. Table 2 presented clearly that these factors kept quasi-static during storage time. After 1 month, the product had the same value of viscosity (25cP) and pH (≈4.0). The titratable acidity increased very slightly by 0.1 and reached 2.82g lactic acid.L^{-1}. The physical and biochemical stability of product was maintained after one month and will be still evaluated for longer storage time until 6 months.

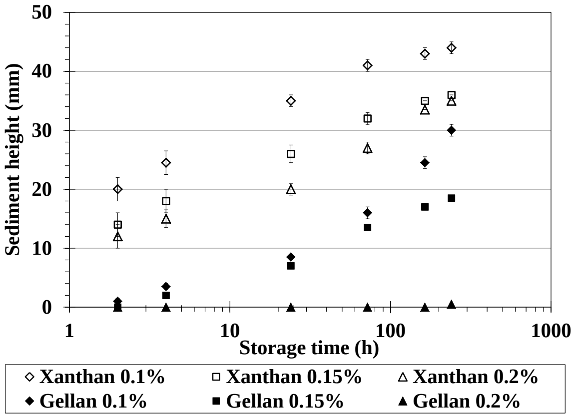

Fig. 2. Impact of functional ingredients on stability of suspensions

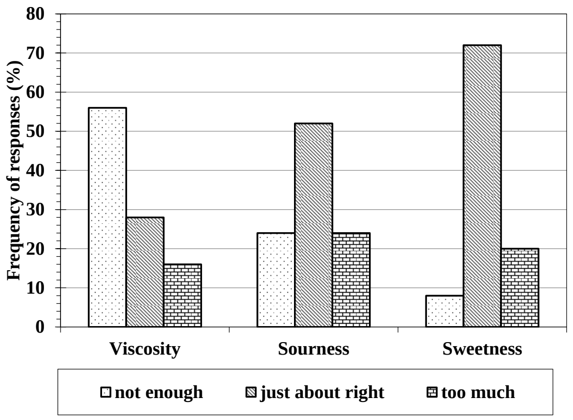

Fig. 3. Frequency of responses in JAR scaling for viscosity, sourness and sweetness of product

Table 1. Acceptance of fermented maize-based products with added flavour ingredients (using nine-point hedonic scale)

Flavour ingredients (%)	Sensory attributes	
	Odours	Overall liking
CF 0.1	5.96^{c}	5.44^{a}
CF 0.15	5.68^{bc}	5.52^{a}
CF 0.1+MF 0.1	6.08^{c}	4.96^{a}
MF 0.1	4.52^{a}	4.56^{a}
MF 0.15	4.96^{ab}	4.64^{a}

Values with a different letter are significantly different ($p < 0.05$) according to Duncan's test. CF: corn flavour, MF: milk flavour.

Table 2. Evolution of physical-biochemical characteristics of product during storage time

Storage time (day)	pH	Titratable acidity (g lactic acid.L^{-1})	Viscosity (cP)
0	4.07	2.73	25
1	4.07	2.73	25
4	4.05	2.74	26
7	4.09	2.80	25
14	4.02	2.82	25
21	4.01	2.82	25
30	4.01	2.82	25

4. Conclusion

This study has determined the suitable conditions to stabilise the product appearance and enhance the quality of fermented maize-based yogurt-like product: 250bar of homogenisation pressure with 0.2% of gellan gum and 0.1% of mixed corn and milk flavours. The physico-chemical and sensory characteristics were maintained during storage time until 1 month (pH ≈ 4.0, titratable acidity <3 g lactic acid. L^{-1}, viscosity 25cP).

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