Original Research Article

Influence of Starch Content on the Sensory and RheologicalQuality of Fermented Soymilk

ABSTRACT

Fermented soymilk is depreciated by consumers for its poor consistency and vegetable aroma. To rectify this deficiency, starch of traditional sweet cassava variety, was used at different rates as thickening agent as well as four aromas (mint, strawberry, banana and pineapple), to enhance the taste in the production of fermented soymilk. The viscosity measurement was done with a Programmable BROOKFIELD DV III. The descriptive sensory analysis were carried out with 15 trained panelists.The hedonic test was conducted with 50 untrained consumers. The viscosity of fermented soymilk increase with the starch concentration. The fermented soymilk with 3% of starch has the highest viscosity with 813.4 cP than the control one with 207.4 cP.The fermented soya milks incorporated with 0.5, 1 and 1.5% starch are less consistent in the mouth. For thickness, samples with 1, 1.5 and 2 % starch were judged moderately thick than 2.5 and 3 % of starch. Panel appreciated the thickness, ropiness and mouth-coating character of fermented soymilks with 2 and 2.5% starch. The mint and strawberry aromas were the most appreciated. Fermented soymilk incorporate of 2, 2.5 % of starch with mint and strawberry as aroma could be marketed.

Keywords: soymilk, fermentation, starch, viscosity, sensorial evaluation, rheology

1. INTRODUCTION

Soya (Glycine max) is an herbaceous legume of Asian origin. It is one of the important nutritious foods largely developed and consumed by Asian, European and American people.

In these areas of high consumption, soya is rooted in the ways and customs of local populations. So people in each region developed their own unique soy foods based on tradition, and local taste preferences. In Africa, its consumption is a result of food aid programs despite the high protein contain and nutritional quality [1].

Yet, malnutrition is endemic in sub-Saharan Africa. Access to protein sources (meat and fish) is difficult because they are expensive. The use of vegetable proteins, cheap and accessible such as oilseeds and legumes remains the solution in the fight against malnutrition in Africa. In this matter, soybeans offer a wide range of products that are already known in Asia.

According to Sohouli et al. [2], incorporating soy milk into the diet might favorably affect several cardiometabolic risk factors in both healthy and unhealthy individuals. Soy milk and soy milk based products also improve the nutritional status and have a benefic effect on

therapy against hyperglycaemia [3]. Its by-products such as textured soy flour, oil, tempeh, tofu and fermented soymilk etc… are consumed in large quantities in Asian countries. However, fermented soymilk is not widely consumed by Ivorian population. It is criticized for not being very thick and its taste also not appreciated. The fermented soymilk is produced from soya milk fermented by the lactic bacteria Lactobacillus Bulgaricus and Streptococcus Thermophilus. The low consistency in thick of fermented soymilk is due to its dry matter, which varies between 6 and 11% of the total weight of the milk [4, 5]. Some research work reported the incorporation of cow milk into soymilk to improve the thickness character and taste [6, 7]. Those, used food additives such as xanthan gum and low acyl gellan gum to improve textural and sensorial qualities of fermented soymilk. Soy yogurt treated with 0.01 and 0.005% of xanthan gum increased the viscosity, the resistance to syneresis during storage and gained the highest sensory scores [8]. Low acyl gellan could stabilize the gel strength and viscosity and bring desirable sensory characteristics of fermented soymilk [9]. Indeed these initiatives to improve soy yogurt showed a satisfactory results. But with a view to valorize local products, a natural thickening agent such cassava starch has being used. Cassava starch has a very high extraction rate, cheap and low syneresis [10, 11, 12]. Its use could reduce the production cost of fermented soymilk. However, variation in the composition of the food could lead to changes in its structure, rheological properties and sensory characteristics, including mouthfeel and aroma. This could also have a significant impact on the acceptability of the product by consumers. Soymilk is characterized by a beany flavor which require a particular attention during its preparation. The use of boiled water during the process of soymilk extraction, reduce considerably this flavor [13]. Traditional Chinese-style soymilk has a distinct soy taste, with lots of beany and other green flavor notes, which are highly appreciated by Chinese and other Asian consumers but not preferred attributes for the majority of consumers in the rest of the world [14].

The present study aims to improve fermented soymilk through the raising of the texture by adding cassava starch and the flavor by the incorporation of four aromas (mint, strawberry, banana and pineapple). We hypothesize that the incorporation of variable rates of cassava starch improve the rheological and sensory properties of fermented soymilk. Also the use of aromas as flavor corrector will make it more preferable by the consumer. Our found could contributed to explore the possibility to commercialize fermented soymilk.

2. MATERIAL AND METHODS

The study was conducted in Laboratory of Food Biochemical and Technology of Tropical Products of University of NanguiAbrogoua (Abdjan Côte d'Ivoire). Yellow soybeans and cassava variety "Bonoua" were purchased at the market of Abobo (Abidjan, Côte d'Ivoire). The cassava variety "Bonoua" is a traditional sweet variety widely consumed by the population. The starch of this variety have low syneresis [10]. The lactic ferments (Lactobacillus Bulgaricus and Streptococcus Thermophilus), flavors (mint, strawberry, anana, pineapple) were purchased at supermarket of Cocody (Abidjan, Côte d'Ivoire).

2.2 Starch isolation

Starch was purified according to a previously described procedure by Amani et al. [15] without adding any chemical products (sodium metabisulphite and NaCl). Cassava roots were peeled and crushed in a blender. The slurry was filtered through a 100 µm sieve. After decantation, the starch pellet is dried in an oven (MMM MEDCENTER) at 45°C for 48 hours. The dry starch obtained will be used as thickening agent at different concentrations in preparation of fermented soymilk.

2.3 Soy milk preparation

Soymilk was obtained by previous method [16] modified at level of soaking temperature and time. For one (1) kg of soybeans, seven (7) litres of water was used [17]. The soybeans were sorted and washed three times and then soaked in boiled water (100°C to accelerate the water absorption of the beans and remove the beany flavor) for 30 min. The Soybeans were then soaked in fresh water for 15 min to undergo rehydration. After this step the husk of soybeans became soft and easily removed by washing and rinsing with tap water. Further blending was done with the remaining with 3 L of water. The resulting grind is completed with the remaining 4 L of water. The whole mixture is filtered and the soymilk obtained was boiled at 100°C for 15 min.

2.4 Preparation of fermented soymilk

One litre (1L) of soymilk was then used to make each yoghurt. To improve the texture of fermented soymilk, starch was incorporated at different rates (0.5; 1; 1.5; 2; 2.5 and 3% w/v) according to the study carry out by Agyemang et al. [12] with modification by reducing the rate of starch. After homogenisation, the mixture was heated in a pressure cooker up to 90°C and kept at this temperature for ten minutes, then cooled rapidly with ice to 45°C. It is then inoculated with a commercial yoghurt (15 g) containing lactic ferments, then put in the oven (MMM MEDCENTER) for three hours at 45°C. Afterwards, it was removed from the oven and placed in the refrigerator to stop the fermentation. A fermented soymilk without starch was used as control.

2.5 Determination of dry matter and acidity of fermented soymilk

The dry matter was determined by Official Method AOAC [18]. Five (5) g of the sample was weighed into a crucible of known mass and dried in an oven (MMM MEDCENTER) at 100 °C for 24 hours. The sample was then cooled in a desiccator for 10 minutes and weighed to calculate moisture content.

The Dornic acidity was determined by titrimetric method described by Fabro et al. [19]. To ten (10) mL of soymilk, was added three drops of phenolphthalein. The mixture was titrated with NaOH (0.111 N) until the colour changed to pink.

The pH of soy milk was measured with a calibrated digital pH meter (SYMPHONY, DO 2834, SINGAPOUR). All test is done in triplicate

2.6 Flow measurement

Fermented soymilk flow was measured using a Brookfield rheoviscosimetrer (Brookfield DV-III ULTRA programmable, model RV, Chicago, United States). The test was done according to the instruction of apparatus manual giving by Brookfield. Fermented soymilk (400 mL) was transferred into 600 mL law form griffin beaker and maintained at 30° C by a water bath (Grant, UK). The disc spindle N° 3 used was dimensioned as follow; diameter 1.8477 mm and length 5.250 mm. The flow test was performed at varying speed programmed, (20 rpm to 230 rpm).The time of running at each speed was 30 s. According to running instruction, the spindle was immersed to the mark. To study the stability of the gel during the test, the viscosity ratio has being determined as follow: Viscosity ratio =Vx/V10x (Vx is the viscosity reading at speed x and V10x the one at speed 10x).

2.7 Sensorial evaluation

The sensory quality of the fermented soymilk was appraised according to the procedure described by Meilgaard and al. [20]. The descriptive was carried out to determine the sensory profile of the texture, followed by a hedonic test to assess it and rank the aromas in order of preference. The panel consisted of 15 students of all genders aged 18 to 30 years. Four descriptors defined by the tasters and considered relevant for texture analysis were selected. These are: thickness (The force required to push the tongue up through product against the palate and then back down), mouth-coating (ability of the product to form a film covering the mouth), smoothness (absence of solid particles) and ropy (The degree to which a strand/rope forms when a spoon is dipped into the product and slowly pulled out) [21]. The panelists were trained to use these attributes to describe the commercial yogurt as reference before the test on the fermented soymilk. A five-point scale was used to indicate the intensity perceived; from least to most intense. Coded Pots of fermented soymilk (30g) containing different rates of starch (0.5, 1, 1.5, 2, 2.5 and 3% w/v) were served to the panelists one by one randomly.

Hedonic test.

The method used is based on a five (5) point scale ranging from excellent for a score of five to poor for a score of one. The scoring is based on organoleptic characteristics such as appearance, colour, taste, texture, aftertaste, and overall appreciation of the product. The tasting panel is composed of fifty (50) untrained persons. The starch concentrations used for the test are: 1, 1.5, 2 and 2.5% based on the result of descriptive test. The coded samples are served in batches of four to each taster. To enhance the aroma of fermented soymilk, four aromas (mint, strawberry, banana and pineapple) were incorporated to the sample with 2.5% of starch. The choice of this rate is based on the result of the above test. The judges are asked to rank the samples according to the preference of the aroma. The test was conducted with a panel of 50 untrained people. The coded samples were served by set of four randomly according to the order disposition.

2.8 Statistical analysis

Statistical analysis was performed using SPSS version 11.5. One-way ANOVA was used for the comparison of means. Duncan's test at 5% level is used for the post hoc analysis.

3. RESULTS AND DISCUSSION

3.1 Biochemical parameters of fermented soymilk

The pH value of the soymilk is 6.4 (this result is not shown). The dry matter increases with the starch content of the fermented soymilk (Fig. 1a). The increase was less for the control sample (6.4% ± 0.01) and the one (6.82% ± 0.08) with 0.5% of starch. Then, the dry matter increases significantly (6.82% ± 0.08 to 9.26% ± 0.87) up to fermented soymilk with 2.5% of starch content ($p < 0.05$). The dornic acidity of soymilk increases highly from 70°D ± 0.58 to 74°D ± 0.58 corresponding in the order to the control sample and the one with 0.5 starch (Fig. 1b) ($p < 0.05$). Beyond this stage, the acidity (75°D ± 0.33) remains constant up to sample with 3% of starch.

3.2 Flow behaviour of fermented soymilk

The viscosity of soymilk increases with the rate of starch content (Fig. 2a). This increase is observed in three steps. From the control sample (207.4 cP ± 7.68) to the one with 1% of starch (288.3 cP ± 16.2), the consistency of the fermented soymilk increases slightly. In the second stage, the viscosity rises significantly from 1% (288.3 cP ± 16.2) to 2% (691.4 cP ± 20.3) of starch ($p < 0.05$). In the last one, up to 3% of starch (813.4 cP ± 11.2), the

fermented soymilk becomes more slimy with a relative increase compared to the previous stage ($p < 0.05$).
The apparent viscosity of fermented soymilk decreases as the shear rate increases (Fig. 2b). Whatever the rate of starch content, the curves decrease. Nevertheless, two groups of sample can be observed according to the importance of the flow breakdown particularly at high rotational speed. The first group includes the control sample, 0.5 and 1% of starch content. It exhibits a few decreased flow and have the same apparent viscosity beyond a rotational speed of 150 rpm. The second group is constituted of fermented soymilk incorporated of 2; 2.5 and 3% of starch. The decrease of apparent viscosity is important in this group. The sample with 1.5% of starch marks-down these groups by a decrease of the apparent viscosity moderately. However, up to a rotational speed of 200 rpm, its curve merge with the second group sample ones.
Concerning the viscosity ratio of fermented soymilk, an increasing with the rate of starch content was observed (Fig. 2c). This evolution showed three steps. From control (2.41 cP ± 0.1) sample to the one with 0.5% (3.89 cP ± 0.12) of starch rate, a highly viscosity ratio was noted ($p < 0.05$). It's the same variation at 2.5 (4.9 ± 0.21) and 3% (5.88 ± 0.2) of starch rate. From 0.5 to 2.5% of starch content, a relative stability was observed.

3.3 Texture analysis

The texture analysis shows an increase of the perception of thickness, smoothness, mouth-coating and ropiness of fermented soymilks (Fig. 3). The smoothness of all fermented soymilk is judged well by the panelist according to the scores obtained (3.6 ± 0.26 for the control to 4 ± 0.79 for the one with 3% of starch). However, the fermented soymilk incorporated with 3% starch has a smoothness texture than the others.
The use of cassava starch in fermented soymilk increase considerably the perception of covering film in mouth. The control, 0.5 and 1% samples are characterized by a weak intensity (the scores obtained are inferior to two) compared to the fermented soymilk with 1.5% of starch which has a middle perception. The other fermented soymilk incorporated of 2, 2.5 and 3 % of starch form a thick layer in mouth with scores of 3.3, 4.26 and 4.9 respectively, which are above the average.
In terms of the ropiness attribute, three groups are observed. The first group, less ropy is constituted of fermented soymilks with 0.5, 1, 1.5% starch and the control. The second one is 2%, 2.5% and 3% starch have scores between 3 and 4.4. They are ropy and the samples with 2.5 and 3% starch are more. Fermented soybean milks with 0.5, 1 and 1.5% starch have lower than average scores. They are less ropy.
Regarding the thickness, the results allow three groupings. The first group includes the control and 0.5% starch fermented soya milks with scores below 2. They therefore have a fluid texture. In the second group, the 1, 1.5 and 2 % yoghurts have scores just above average. They are moderately thick. Finally, the third group (fermented soya milks with 2.5 and 3 % starch) s distinguished by scores above 4. They are therefore thickness character.

3.4 Hedonic test

The hedonic test shows that all fermented soymilk incorporated of select starch rate (1; 1.5; 2 and 2.5%) received high score for appearance and color attributes (Fig. 4). The sample with 1% starch (3.66 ± 0.62 and 3.6 ± 0.75 respectively for the attributes appearance and color) is statistically lower than others ($p < 0.05$). For the other sensory attributes, the score increased with the rate of starch content. Two groups are observed: the first was constituted by fermented soymilk with 1 and 1.5% of starch, the second one, by sample with 2 and

2.5%. The taste, texture, after taste and overall acceptance of fermented soymilk containing 2 and 2.5% of starch received the highest scores ($p < 0.05$).

3.5 Preference test of aroma

In order to reduce the vegetable aroma of fermented soymilk, four aromas were added and ranked by panelist according to their preference (Fig.5). Forty-six percentage of panelist liked the fermented soymilk with mint aroma as first choice. The second preference was the sample with strawberry (34% of favorable opinion). For the third position, the highest percentage is for the banana flavor (32%). In the fourth position, the highest percentage is 38 for pineapple flavor.

4. Discussion

The pH of fermented soy milk was 6.4, which was consistent with the standard of fresh milk as stated by Jiang et al. [4] (6.3 – 6.5). The dornic acidity of the fermented soya milk incorporated with starch is 75°D ± 0.33 higher than the control one (70°D ± 0.25). This degree confirms the acidity of fermented soymilk and consequently the development of lactic bacteria during the three hours of fermentation. This possibility of the bacteria to growth in soymilk matter is an opportunity to make yogurt with soya bean. According to Boulay et al. [22], S. thermophilus can grow in soya milk by consuming sucrose, can hydrolyze soya proteins, and can produce acidification levels comparable to those in cow's milk. The addition of starch improves the acidity of the fermented soy milk. The dry matter of the fermented soymilk increases from 6.4 (control sample) to 9.49% for the yoghurt with 3% starch. Cassava starch have a weak gelatinization temperature (65-77°C) under the cooked temperature of soymilk. So an important quantity of amylose could be solubilize [11]. This phenomena could improved the fermented capacity of the medium. Also the presence of starch granules constituted a solid substance capable to enhance the dry matter of the soymilk. This increase can also be observed on the viscosity of the fermented soymilk. Cassava starch as well as other starch sources have the capacity to swell when heated in the presence of water. It's resulting an increase of the viscosity which could explained the behaviour of fermented soymilk with the rate of starch [23]. The starch granules absorb the free water in the soy milk. When the starch content is high, it results in an increase of the absorption leading to an increase of the viscosity. As a result, the yoghurt will be more viscous. This has been revealed by previous work showing that starch is a thickening agent for beverages and dairy products [11 12]. The drop of apparent viscosity during the rotation speed is inversely proportional to the increase observed with the incorporation of cassava starch. The re-fluidizing character of starch under high shear rate could justify the decrease in apparent viscosity of fermented soymilk [24]. Also according to Che et al. [25], the behavior of cassava starch suspension appeared Newtonian with a concentration of 0.2% and turned shear-thinning when the solid content was over 0.4%. Yet the starch rates used in this study are high than 0.4%.

The sensory texture profile confirms the results of the viscosity measurements in terms of thickness. It also shows that all fermented soymilks have a smooth texture but the intensity of the other characteristics (thickness, ropiness and mouth-coating) is a function of the starch incorporation rate. A similar work on milk yoghurt incorporated of starch showed an improvement in textural attributes [12]. This influence is due to the viscous and binding properties of the starch. Fermented soymilk with 3% starch has very thick texture (more viscous). It has a higher consistency and is more ropiness. The control and the 0.5% starch fermented soymilk have thin texture (less viscous), less mouth-coating and less ropiness. This is why they were not taken into account during the hedonic text.

The hedonic test shows that the 2 and 2.5% starch fermented soymilks are the most appreciated. They had the highest scores for mouth-coating (consistency) and taste. Statistical analysis also revealed that the 2 and 2.5% starch samples were significantly different from the 1 and 1.5% starch samples in texture, taste and after taste. This reflects the importance of these parameters in the choice of fermented soymilk quality. In addition, this test also reveals two groups in terms of taste. Starch is therefore not neutral. It influences the taste of the fermented soymilk. According to Kumari et al. [26], adding 0.1% of modified starch and 1% vanilla flavor could improve sensory, rheological and texture properties of both fermented soymilk and final acceptaility.

The test of aroma showed a classification in decreasing order of preference: mint, strawberry, banana and pineapple. In addition, mint was the most acceptable and pineapple the least preferred.

4. CONCLUSION

At the end of this study, it was found that starch increases the viscosity of fermented soy milk. This viscosity depends on the incorporation rate of the starch. Higher the rate of incorporation, the greater is the viscosity. The sample with 2 and 2.5% starch were more appreciated for their texture. Mint and strawberry flavours are the most appreciated and could perform well in the market.

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FIGURES

Figure 1

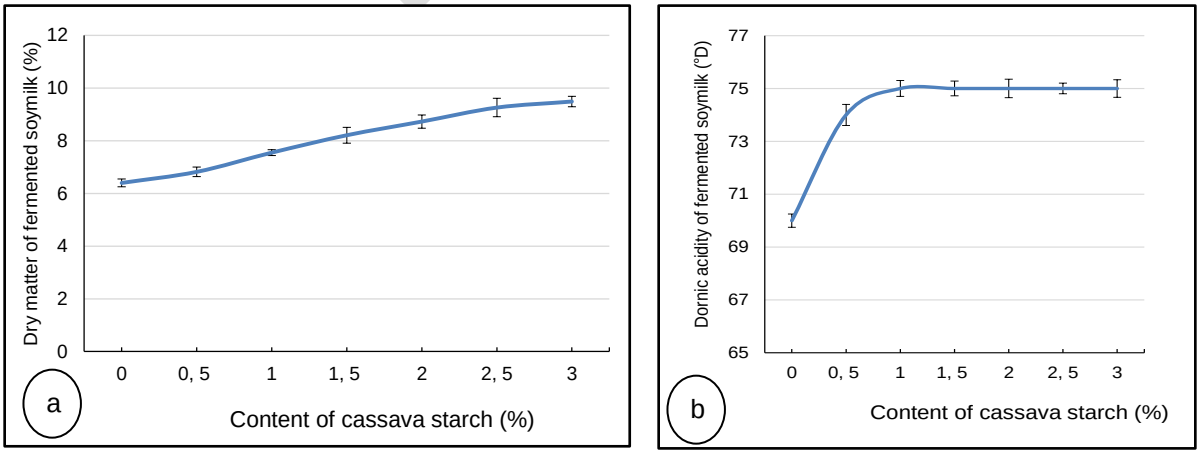

Fig. 1. Biochemical parameter of fermented soymilk incorporated of cassava starch at different rate: (a) Dry matter, (b) Dornic acidity

Figure 2

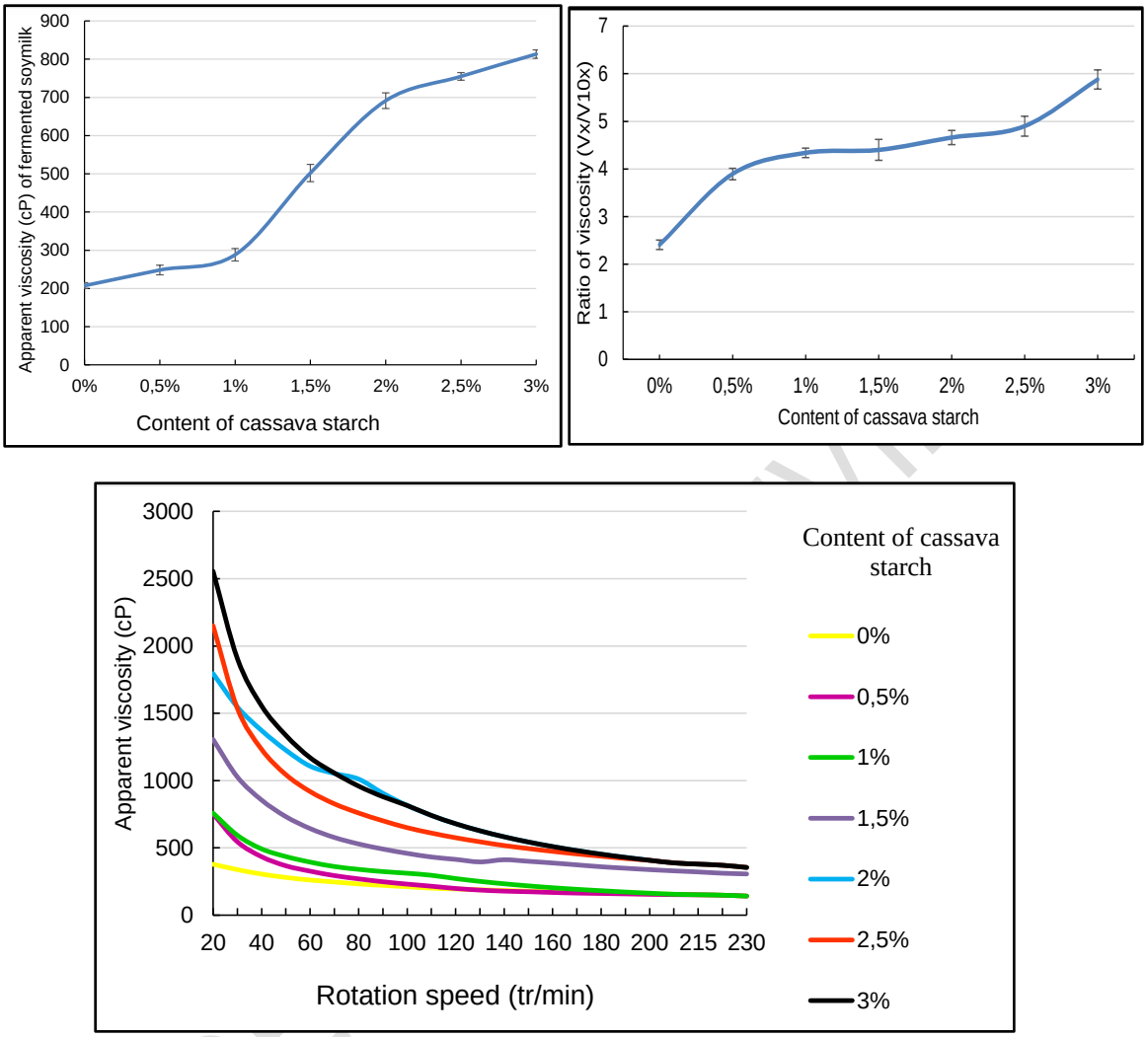

Fig. 2. Rheological test: (a) Evolution of viscosity of fermented soymilk incorporated of cassava starch at different rate, (b) Flow behaviour of fermented soymilk during the rotation speed, (c) Viscosity ratio of fermented soymilk incorporated of cassava starch at different rate.

Figure 3

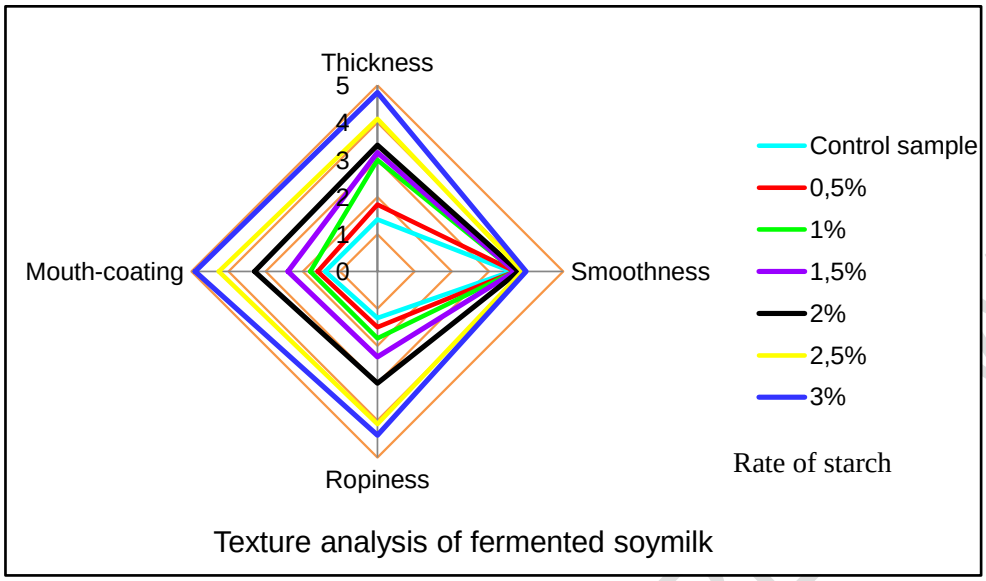

Fig. 3. Texture analysis of fermented soymilk incorporated of different rate of cassava starch.

Figure 4

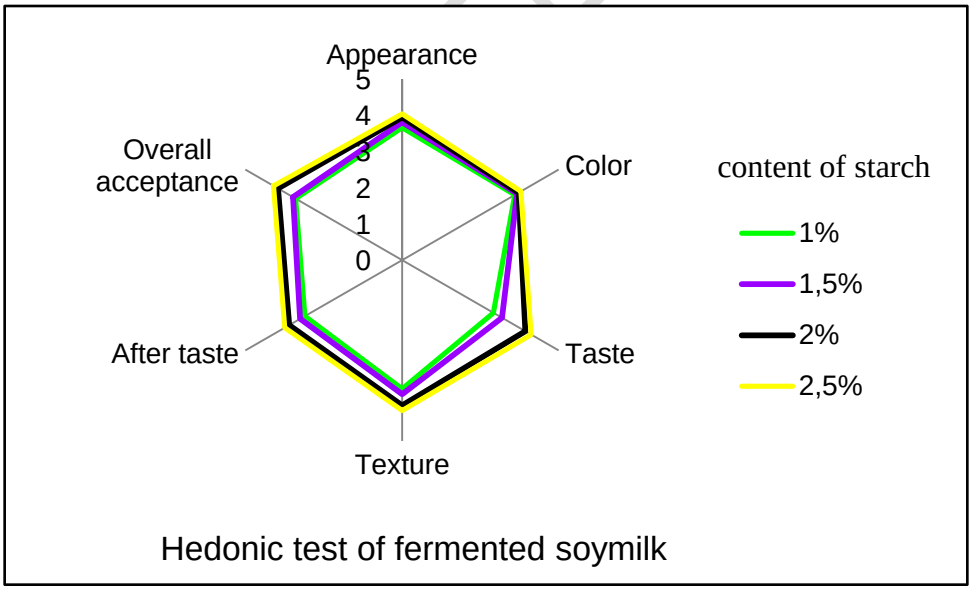

Fig. 4. Evolution of hedonic test of fermented soymilk incorporated of cassava starch at different rate

Figure 5

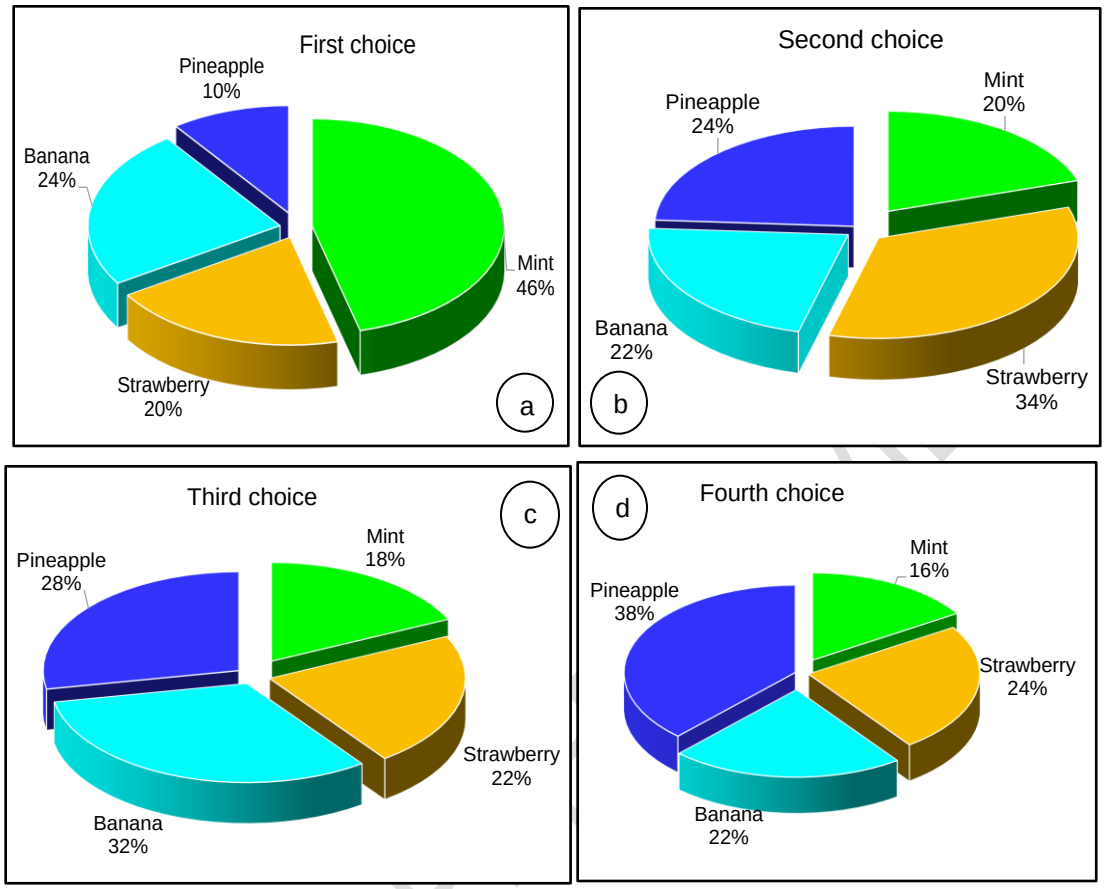

Fig. 5. Evolution of panellist preference on aromas of fermented soymilk containing 2.5% of cassava starch, (a) first choice, (b) second choice, (c) third choice, (d) fourth choice.