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Yogurt As A Functional Drink Development From Various Local Raw Materials Using *Eucheuma Spinosum* As Natural Stabilizer

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Abstract. Along with raising public awareness about health and increasing yogurt consumption, it is critical to improve the quality of the yogurt. The innovation of yogurt producing in terms of flavor variety is critical since it can entice consumers to consume yogurt. This innovation is possible through the use of high-nutrient plant components that have not been optimally exploited in the surrounding environment. The purpose of this study was to examine the quality of yogurt produced from a variety of raw materials and stabilized naturally using *Eucheuma spinosum* seaweed. This study used a completely randomized design with a single factor: the type of raw material utilized in the production of yogurt (corn, sweet potato, pumpkin, banana and pineapple). The parameters analyzed included total lactic acid content, pH, total lactic acid bacteria, bacterial viability, viscosity, and organoleptic qualities such as homogeneity and taste were examined using scoring and hedonic methods. The data were evaluated using an analysis of variance (ANOVA) with a significance level of 5%, and the significantly different data were further tested using an additional test of an honest significant difference (HSD). Results show that yogurt made from corn was the best treatment, with pH value of 4.28, total lactic acid content was 1.67%; viscosity was 74,67cP, total lactic acid bacteria was 11.02 log CFU/ml, the bacterial viability met the concentration as a probiotic drink with the decreasing number 0.21 log CFU/ml, scoring test homogeneity score was 3,21 (slightly homogenous), taste score was 3.08 (slightly sour) and hedonic score for homogeneity and taste were 3.29 and 3.25 respectively.

1. Introduction

Yoghurt is a dairy product that is fermented by lactic acid bacteria. The bacteria transform the lactose in the milk into lactic acid [1]. The public is familiar with and frequently consumes yogurt due to its taste, nutritional and health benefits [2]. Yogurt is a good source of protein, fat, calcium, potassium, and B vitamins (B1, B2, B6, nicotinic and pantothenic acids), although it is deficient in iron, vitamin C, carotenoids, and dietary fiber. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are commonly used lactic acid bacteria, sometimes in combination with *Lactobacillus acidophilus* [3]. Due to the fact that *L. bulgaricus* and *S. thermophilus* cannot survive in the digestive tract [4], they are considered to be poor probiotic agents and should only be used as starter cultures. As a result, it is worth including probiotics that are capable of surviving in the digestive tract in order to produce probiotic content which assists the digestive system. *Lactobacillus acidophilus* is one of the probiotics that can be added and *Lactobacillus acidophilus* has been shown to be resistant to pathogens in the human gastrointestinal system [5].

Consumption of yogurt is beneficial to health because it has a number of health benefits, including the ability to improve digestive function and prevent digestive illnesses. Yogurt is often ingested by children and people with lactose sensitivity due to its low lactose level [6]. Along with raising public knowledge of health risks and yogurt use, it is vital to enhance the taste and quality of yogurt and specialty taste. The idea of flavoring yogurt is critical because it can entice people, both children and adults, to drink yogurt. This



innovation is possible through the use of local high-nutrient elements that have not been properly utilized in the surrounding environment, such as sweet potatoes, corn, bananas, pineapple, and pumpkin.

Making yogurt made from plant-based components presents a number of challenges, such that the carbohydrate is higher and the protein content is lower than that of cow's milk resulting in the fast precipitation of vegetable juices [7]. Yogurt made with vegetable ingredients will have an inhomogeneous consistency due to the separation of liquid and solid components. A stabilizer is required to maintain the consistency of yogurt. Stabilizers such as *Carboxy Methyl Cellulose* (CMC), pectin, lecithin, gum, and gelatin are frequently utilized. Certain stabilizers continue to be questioned over their halal status, necessitating the development of a natural stabilizer produced from seaweed [8].

Strains *Eucheuma cottonii* and *Eucheuma spinosum* are cultivated along coastal areas of NTB [9]. *Eucheuma sp.* has a water content of 19.55-21.27 percent, ash content of 18.70-19.55 percent, protein content of 4.5-5.74 percent, fat content of 0.06-0.1 percent, and carbohydrate content of 55.52 -56.80 percent of carbohydrates carbs [10]. This seaweed is a member of the carrageenan-producing family. Carrageenan is a calcium, sodium, and magnesium ester based hydrocolloid which has been extensively utilized as a stabilizer, emulsifier, and thickener in food industries [10]. The addition of seaweed into yogurt is intended to enhance its chemical, physical, and microbiological characteristics of yogurt.

Previously conducted research indicated that the addition of *E. spinosum* slurry to yogurt alters the syneresis, viscosity, and pH of the yogurt. Ratio of 7% *E. spinosum* seaweed slurry to 0% *Sargassum sp.* generates functional drinks with a crude fiber content of 0.33 percent, an antioxidant capacity of 1,122.9 ppm [11]. Adding 5% seaweed slurry resulted in the acceptability\ flavor, texture, scent, and preference [12]. The addition of 10% *E. spinosum* seaweed slurry into an ice cream formula resulted in protein content of 2.42%, a fat content of 12.39%, an ash level of 0.59 %, and a crude fiber content of 18.34%, which was favoured by panelists [13].

2. Materials and Methods

2.1 Material

Equipments used in this study were basins, plates, UC bottles, spoons, glass cups, and, as well as an autoclave (Hirayama, Japan), an analytical balance (ABJ, Germany), a blender (Philips, Netherlands), a vortex (Heidolph, Germany), a pH meter (Schott, Germany), an incubator (Mettler, Germany), a measuring cup, a volume pipette, and a micropipette

Sweet potato, corn, banana, pineapple, and pumpkin were obtained from the Kebon Roek market in Mataram; dried *E. spinosum* seaweed was obtained from Seriwe Village, Jerowaru District, East Lombok Regency; water minerals were obtained from Narmada, Indonesia; skim milk, granulated sugar, and starter cultures *L. bulgaricus*, *S. thermophilus*, and *L. acidophilus* powder were obtained from the Food and Drug Administration (Oxoid, UK).

2.2. Experimental

2.2.1 Starter preparation

Prepared extracts of vegetable ingredients (corn/sweet potato/banana /pineapple /pumpkin) as much as 300 ml. Pasteurized at 90°C for 15 minutes. Cooling to 37°C. Pure culture as much as 3% was put into juice that has been lowered the temperature. After inoculation, the culture was incubated at 37°C for 24 hours. Then obtained ready-to-use culture.

2.2.2 Raw Material Preparation

The materials used are sweet potato/corn/banana/pineapple/pumpkin obtained from Kebon Roek Market, Mataram. Sorting is used to select materials that are not damaged. The raw materials that have been sorted are then stripped to separate the contents and skin. The ingredients are boiled for 30 minutes at a temperature

of 100°C (special ingredients for cassava, sweet corn and yellow squash). The material that has been boiled is then weighed as much as 2 kg. The ingredients that have been weighed are then added with water with a ratio of 1:2 ingredients and water and then crushed using a blender until smooth. The crushed material is then filtered using a filter cloth to get the juice.

2.2.3 Making Seaweed Slurry

The material used was dried *E. spinosum* seaweed obtained from Seriw Village, Jerowaru District, East Lombok Regency. Sorting is used to select good quality seaweed and remove foreign objects such as sand, stones or gravel. Seaweed *E. spinosum* was soaked in lime water in a ratio of 1:2 for 10 hours to remove the fishy smell. Draining process to remove the remaining soaking water on the seaweed. Washing process to remove the dirt contained in the seaweed. The washed seaweed was then weighed according to the treatment concentration. The weighed seaweed was then added with water with a ratio of 1:1 seaweed and then crushed using a blender to obtain seaweed slurry.

2.2.4 Yogurt Making Process

Vegetable extract (sweet potato, corn, banana, pineapple, pumpkin) of 500 ml was added with 20% sugar, 10% skim milk and seaweed slurry with 5% concentration and then stirred. The mixed juice was then pasteurized using a water bath at 90°C for 15 minutes. The purpose of pasteurization is so that the extract which will be used as a medium for bacterial growth is protected from contaminants. Cooling is done by cooling the pasteurized juice until it reaches a temperature of 37°C. The inoculation process was carried out by adding 3% starter *L. bulgaricus*, *S. thermophilus* and *Lactobacillus acidophilus*. Incubation was carried out at 37°C for 16 hours.

2.3. Analytical methods

The design used in this study was a completely randomized design (CRD) with a single factor experiment, namely the type of raw material which consisted of 5 levels namely Sweet Potato, Corn, Banana, Pineapple and Pumpkin. Each treatment was performed in three replicates to achieve a total of fifteen experimental units. Co-stat software was used to analyze observational data using analysis of variance (Analysis of Variance) with a significance threshold of 5%. If a substantial difference exists, an additional test of Honest Significant Difference (HSD) is performed. Microbiological, chemical, physical, and organoleptic characteristics were all observed in this investigation.

3. Result and Discussion

3.1 Total Lactic Acid

Figure 1 illustrates the difference in raw materials leading to considerably different total acid values of yogurt. The difference in acidity value is highly dependent on the raw materials used to make yogurt. Pineapple yogurt contained the highest acid content compared to the other treatments that might be resulted from the natural composition of pineapple. Fruit has a total titrated acid content of 5.327%, which is higher than that of other fruits such as papaya and tomatoes [17]. Along with the raw materials of yogurt, pineapple yogurt's acid content can be increased through a fermentation step using numerous types of lactic acid bacteria as the total lactic acid in fermented pineapple beverages can reach between 2.0% and 3.50% [18].

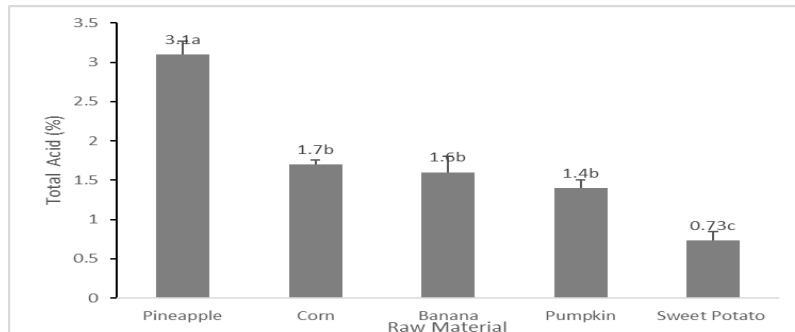


Figure 1. The Effect Of The Type Of Raw Material On The Total Lactic Acid Of Yogurt.

The Total lactic acid value of either corn, banana, and pumpkin yogurt is almost the same. The range of total acid value between 1,4 % - 1,7%. Corn yogurt added with varying quantities of seaweed as a stabilizer yielded a total lactic acid value of between 0.9 and 1.35 % [19]. Yogurt supplemented with Ambon banana juice contained between 0.81 and 0.97 percent total lactic acid [1]. Generally, pumpkin yogurt has a total acidity of roughly 1% [20]. This number is somewhat less than the obtained total acid value. This could be owing to the variety of corn and bananas utilized. Additionally, differences in treatment can result in variances in the total acid value achieved.

Sweet potato yogurt provided the lowest total lactic acid value compared to other treatments, but was still within the range of the BSN's total lactic acid standard, which is between 0.5 and 2%. Further supports the low total acidity of sweet potato yogurt, stating that the total acidity of sweet potato yogurt ranges between 0.06 percent and 0.29 percent [21]. Sweet potato is a carbohydrate-dense tuber. Carbohydrates can be converted to lactic acid during the fermentation process; however, the complex carbohydrates found in sweet potatoes will be utilized after lactose and simple sugars are utilized. As a result, during the brief fermentation time of yogurt, the carbohydrates in sweet potatoes cannot be converted to lactic acid.

3.2 pH

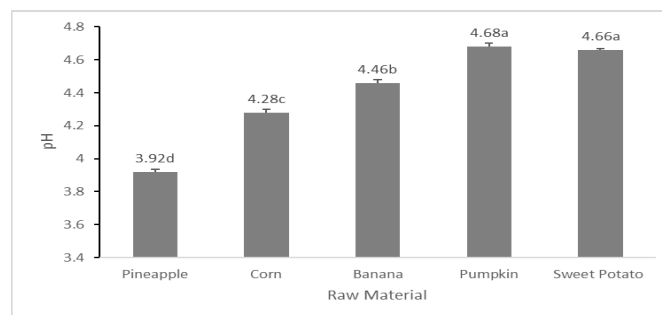


Figure 2. The effect of the type of raw material on pH of yogurt

Figure 2 illustrates the various raw ingredients resulting in dramatically variable pH values of yogurt. The yogurt made of pineapple juice had the lowest pH value (3.92) compared to the others. This is proportional to the overall amount of lactic acid obtained, which also happens to be the largest. Corn yogurt had a pH value of 4.28, followed by banana yogurt at 4.46, sweet potato yogurt at 4.66, and pumpkin yogurt at 4.68. Numerous earlier investigations also corroborate the pH range found. The pH value of the pineapple

yogurt obtained is nearly identical to the results of Rahayu's (2015) research, which indicates that the pH of pineapple yogurt using various commercial cultures ranges between 4-5 [22]. Corn yogurt's pH value is also consistent with Mutia's research, which indicates that corn yogurt with varied quantities of seaweed has a pH value ranging from 4.58-5.11 [19]. The pH value of plantain yogurt fluctuates between 3.88 and 3.97 [23]; this lower pH value may be related to the differing contents of wood bananas and plantains. The pH of pumpkin yogurt is between 3.4 and 4.4. Depending on the duration of storage and the conditions of storage [20]. Sweet potato yogurt has a pH value of between 3.67 and 5.03, depending on the type of sweet potato used and the length and location of storage [24]. During the fermentation process, the starter culture's catabolic response produces lactic acid [25]. This buildup of lactic acid can cause the pH to drop to a point where coagulation develops. The degree of acidity (pH) and total acid are related; a lower pH suggests an increasing amount of acid, and vice versa.

3.3 Total Lactic Acid Bacteria

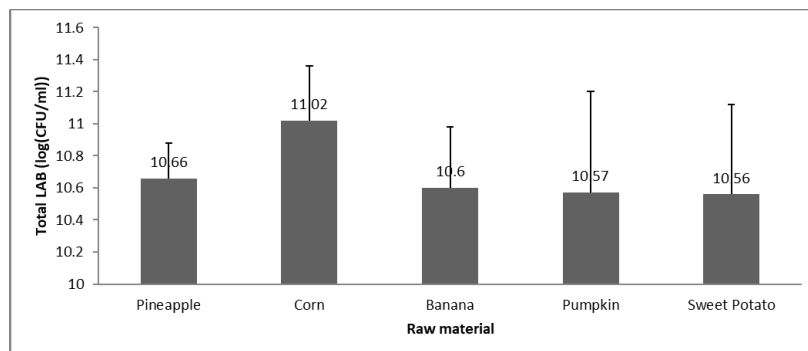


Figure 3. The effect of the type of raw materials on total lactic acid bacteria count of yogurt

As illustrated in Figure 3, the type of raw material used has no discernible effect on the overall LAB content of yogurt. This is apparently because all ingredients, including pineapple, corn, banana, pumpkin, and sweet potato, include prebiotics that promote LAB growth, particularly the starters required to make yogurt, including *Lactobacillus bulgaricus*, *S. thermophilus*, and *Lactobacillus acidophilus*. LAB metabolizes substances in the fermentation medium needed for cell growth, such as carbs, fiber, and other nutrients [26]. According to figure 7, yogurt prepared with corn as the raw material has the highest total LAB at 11.02 log CFU/ml, followed by yogurt made with pineapple at 10.66 log CFU/ml. Yogurt made from banana, pumpkin, or sweet potato had a total LAB of 10.6 log CFU/ml, 10.57 log CFU/ml, and 10.56 log CFU/ml, respectively. Apart from the prebiotics present in the raw material, the high total LAB content of yogurt is due to the addition of *E. spinosum* seaweed as a natural stabilizer. This is consistent with study (Ariyana et al., 2021) indicating that the higher *E. spinosum* seaweed concentration added, the higher the total LAB value in yogurt [19]. Carrageenan is a polymer that makes up the cell wall of the seaweed *E. spinosum*. Carrageenan is composed of a variety of carbohydrates, including oligosaccharides. Oligosaccharides are simple carbohydrates composed of short-chain polysaccharides (3-10 glucose chains) that are often isolated from natural sources, chemically hydrolyzed polysaccharides, or synthesized chemically/enzymatically from disaccharides. Oligosaccharides are categorized as prebiotics because they have the ability to stimulate the growth of healthy bacteria in the intestines, which is excellent for health [27]. The results indicated that the total LAB value for all treatments met the standards of SNI 2981:2009, which stipulates that yogurt must contain a minimum of 10^7 CFU/ml or 7 log CFU/ml of total LAB.

3.4 Viability of Bacteria

Table 1. The effect of the type of raw material on bacterial viability of yogurt

Raw Material	Number of initial colonies(Log CFU/ml)	Final colony count after incubation with bile salts(Log CFU/ml)	Decreased Viability of Lactic Acid Bacteria(Log CFU/mL)
Pineapple	9.48	9.06	0.39
Corn	10.15	9.94	0.21
Banana	9.91	9.14	0.77
Pumpkin	9.66	9.02	0.63
Sweet potato	9.87	9.54	0.32

The number of colonies survived following incubation in bile salts is shown in Table 1. The observations indicate that the colony count is still extremely high, ranging between 9.02 log CFU/ml and 9.94 log CFU/ml. It was discovered that following incubation, LAB retained its viability, however the number of surviving cell populations reduced somewhat but remained within the WHO's viability criterion of 7 log CFU/g while passing gastric acid. The yogurt manufactured using sweet corn as the raw material had the highest number of surviving LAB that, at 9.94 log CFU/ml, followed by yogurt made with purple sweet potato, which had a number of LAB that survived 9.54 log CFU/ml. LAB survival rates were 9.02 log CFU/ml, 9.06 log CFU/ml, and 9.14 log CFU/ml for yoghurt made with pumpkin, pineapple, and banana as raw materials, respectively. Thus, the starter LAB used in yogurt was able to pass through the digestive tract, which contains bile salts excreted by the liver and stomach acid conditions. The survivability of LAB seen in yogurt with the different raw materials might be attributed to the presence of prebiotics in the form of Inulin and FOS components, which provide nourishment for LAB growth. By bringing the gut pH down to an appropriate level, the prebiotic inulin can stimulate probiotic growth. Additionally, the high concentration of prebiotic inulin reduces the solubility of bile salts, lowering the level of toxicity to LAB [28]. Based on the data in table 1, the highest reduction in LAB viability occurred in yogurt with banana as raw material, namely 0.77 log cycles, while the lowest reduction viability occurred in yogurt with corn as raw material, namely 0.21 log cycles. In general, yogurt from all types of raw materials produces LAB viability that meets the requirements of less than 3 log/ml [29].

3.5 Viscosity

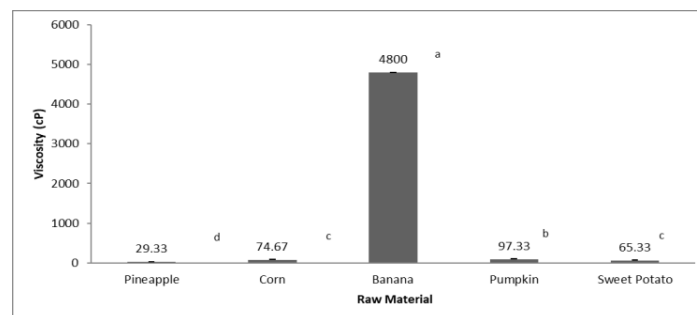


Figure 4. The effect of the type of raw material on viscosity of yogurt.

As illustrated in Figure 4, different raw materials have a considerable effect on the viscosity of yogurt. The viscosity of banana yogurt is the highest compared to the other treatment, reached in 4800 cP. Banana yogurt has a very higher viscosity when compared to yogurt made from other raw materials, especially pumpkin yogurt (97.33 cP), corn yogurt (74.67 cP), which are not statistically different from sweet potato yogurt (65.33 cP), and pineapple yogurt (29.33 cP).

The viscosity differential is highly impacted by the raw material used to make yogurt. When the material was processed into an intermediate product in the form of fruit juice, the difference in viscosity was seen. Fruit juices with varying viscosities are produced using a variety of source components. One reason for this variance is that the materials have different water content. A liquid's viscosity is determined by its water concentration [30]. If the material has less water, the resultant viscosity will increase [31]. In addition to water content, the viscosity of fruit juice is also influenced by the total solids contained in the material and the pectin content. Based on the report of Ningsih et al. [32] a decrease in total solids results in a decrease in viscosity. Meanwhile, the pasteurization process during processing causes the formation of gel by pectin so that the viscosity of the fruit juice increases. Pectin forms a gel under conditions of high sugar content and low pH at a temperature of 60-90 C [33]

Banana yogurt has the highest viscosity due to the low water content of bananas in comparison to other raw components, particularly pineapple. Bananas, particularly the wooden bananas utilized in this study, had a water content ranging from 59.1 to 72 percent whereas pineapples had a substantially greater water content of 82.86-85.3 percent [34]. Apart from the low water content of bananas, the high viscosity of banana yogurt may be attributable to their pectin level. Bananas are one type of fruit that contains a significant amount of pectin. Bananas contain 22.4 percent pectin [35]. The higher the pectin concentration, the greater the viscosity. Due to the ability of pectin to bind and absorb water, it can form a stronger gel and enhance its viscosity value [36].

3.6 Homogeneity

Figure 5 illustrates the several raw ingredients used to make yogurt together with the addition of *E. spinosum* as a natural stabilizer, which has a marked effect on the uniformity of the yogurt. The average panelist assigned a value for the homogeneity of yogurt with a preference level ranging from 2.37 to 3.41 based on the findings of hedonic criteria of homogeneity test (dislike to slightly like). The highest value (3.41) was obtained from pumpkin yogurt raw materials with preference criteria as slightly like while the lowest value of 2.37 was obtained from honey pineapple yogurt with the preference criteria as dislike moderately.

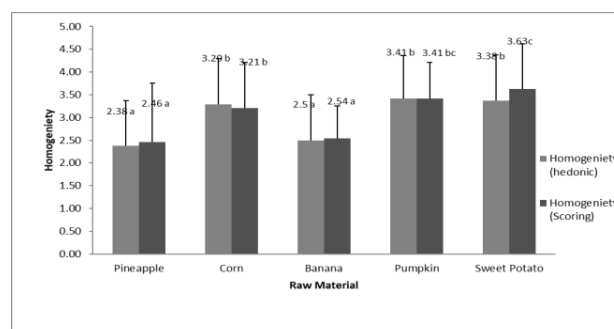


Figure 5. The effect of the type of raw material on homogeneity of yogurt (Hedonic and Scoring) (hedonic scale 1 = dislike very much, 2 = dislike moderately, 3 = like Slightly, 4 = like moderately, 5 = like very much, scoring test 1 = did not homogeneous very much, 2 = did not homogeneous, 3 = slightly homogeneous, 4 = homogeneous, 5 = very homogeneous).

According to the results of the homogeneity scoring test, the average panelist assigned a yogurt homogeneity value between 2.45 and 3.41 (did not homogeneous to slightly homogeneous), with the highest value of 3.41 corresponding to the treatment of pumpkin raw materials with slightly homogeneous criteria and the lowest value of 2.45 corresponding to the treatment of honey pineapple raw materials with non-homogeneous criteria. The disadvantage of vegetable ingredients is that they contain more carbohydrates than protein, resulting in inhomogeneous yogurt. *E. spinosum* contributes to the homogeneity of yogurt when added to contain hydrocolloid molecules with ability to bind to and retain water within the matrix space produced [37].

3.7 Taste

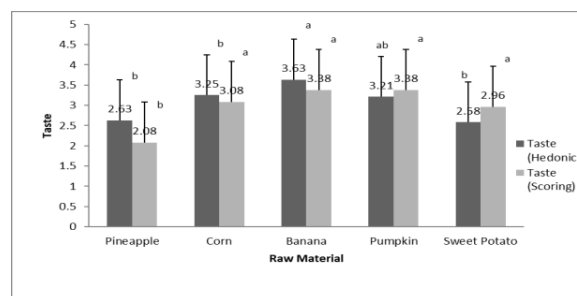


Figure 6. The effect of the type of raw material on taste of yogurt (Hedonic and Scoring). (Hedonic scale 1 = dislike very much, 2 = dislike moderately, 3 = like Slightly, 4 = like moderately, 5 = like very much, soring test 1 = very sour, 2 = sour moderately, 3 = sour Slightly, 4 = did not Sour, 5 = did not sour very much).

Figure 6 demonstrates that the type of raw materials highly affected the hedonic and scoring points of yogurt. This is consistent with Desnilasari and Lestari's (2014) assertion that, in addition to lactose breakdown into acid, the flavor of yogurt is impacted by the raw materials used to make it [38]. In general, the hedonic value achieved with the criteria of somewhat liking to like is 2.63-3.63, while the scoring value obtained with the criteria of sour taste to slightly sour taste is 2.08-3.38.

The highest hedonic and score values were obtained following treatment with bananas as raw materials. Banana yogurt obtained a hedonic rating on the liking scale from panelists because its taste was not very sour, as determined by a scoring assessment. Banana yogurt has a less sour flavor due to the natural sweetness of the banana.

4. Conclusion

Yogurt made from sweet corn was the best treatment, with a pH of 4.28, a total lactic acid concentration of 1.67, a viscosity of 74,67cP, and a total lactic acid bacteria concentration of 1,24x10¹¹ CFU/ml; the viability of lactic acid bacteria met the concentration as a probiotic drink, with a number of live bacteria of 4.7x10⁹ CFU/ml, a slightly sour taste, a slightly homogeneous and the hedonic value of organoleptic quality of homogeneity and taste were all acceptable to the panelists.

Acknowledgments

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