American Journal of Food Technology

ISSN 1557-4571

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS American Journal of Food Technology

ISSN 1557-4571
DOI: 10.3923/ajft.2018.48.56

Research Article
Effect of Fermentation on Some Properties of Sweet Potato Flour and its Broken Composite Noodle Strand

Neti Yuliana, Siti Nurdjanah, Sri Setyani, Dewi Sartika, Yoan Martiansari and Putri Nabila

Department of Agricultural Product Technology, Faculty of Agriculture, University of Lampung, Indonesia

Abstract

Background and Objective: Utilization of sweet potato flour (SPF) in composite flour, when applied for a noodle has some drawback properties, indicating the need of properties modification. Fermentation was applied to modify sweet potato structure to improve its flour properties for composite noodles. The purpose of this study was to investigate the effect of fermentation time and starters on some properties of sweet potato flour (SPF) and its broken composite noodle. **Materials and Methods:** The sweet potato slices were fermented at 0, 12, 24, 48, 72 and 96 h with four different starters: *Lactobacillus plantarum*, *Leuconostoc mesenteroides*, a mixed of *Lactobacillus plantarum* and *Leuconostoc mesenteroides*, a mixed of *Lactobacillus plantarum*, *Leuconostoc mesenteroides* and *Saccharomyces cerevisiae* and without starter added (spontaneously). The samples were withdrawn, oven dried at 60°C for 12 h and milled into flours. Some physicochemical properties and morphology of the samples flours and the entire composite noodle strand were then determined. **Results:** The results showed that there was no significant effect on the flour among starters treatment. However, the fermentation time significantly affected SPF properties and broken composite noodle strands depending on the fermentation time. A significant change was observed in swelling power, pH, the tendency of retrogradation and whiteness scores of flour with an increase in fermentation time. Conversely, solubility and broken composite noodle strand decreased markedly with an increase in fermentation time. **Conclusion:** Fermentation of sweet potato slices for 48-72 h period with starters added could be recommended for preparation of composite SPF noodle.

Key words: Composite noodle, fermented flour, flour properties, sweet potato flour, starters

Citation: Neti Yuliana, Siti Nurdjanah, Sri Setyani, Dewi Sartika, Yoan Martiansari and Putri Nabila, 2018. Effect of fermentation on some properties of sweet potato flour and its broken composite noodle strand. Am. J. Food Technol., 13: 48-56.

Corresponding Author: Neti Yuliana, Department of Agricultural Product Technology, Faculty of Agriculture, University of Lampung, Indonesia
Tel: +62 (0721)781823

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesia considerably imports large amounts of wheat flour every year. The significant portion of these flour uses (70%) was for dry, wet and instant noodles constituent[1]. Therefore, it is essential to use new sources as a substitute for wheat to make composite flour. This utilization of composite flour as noodle ingredients would ultimately support the diversification program of local food sources.

Researchers have explored to use various composite flours based on wheat flour substitution for noodle ingredients including sweet potato flour. Soy[2], cowpea[3], chestnut[4], wheat flour[5,6] have been used in composite sweet potato flour to produce noodles. Utilization of sweet potato flour (SPF) in composite flour, however, in its nature, when applied into a noodle has some drawback properties such as a darker color, less elasticity and easily broken, indicating the need of properties modification. The lactic acid fermentation may modify the physicochemical properties of the starches and the flour[7-10]. The change of some physicochemical properties of sweet potato flour by fermentation has been reported[11-14]. However, the experiments on how potential suitability of the fermented SPF for noodle have not been extensively studied. In this study, lactic acid fermentation was aimed to improve SPF properties and then the flours were applied for noodle making. The fermentation was performed through the addition of pure starter culture and without starter added (spontaneously). This fermentation was expected to improve the physicochemical properties of the flour and thus have better properties as the main ingredient in composite flour noodle, especially decreasing the number of broken noodle strands.

MATERIALS AND METHODS

Sources of materials: The local sweet potato Ciceh variety, harvested 100 days after planting was purchased from a farm at Metro, Lampung. *Lactobacillus plantarum* FNCC0123 and *Leuconostoc mesenteroides* FNCC 0023 were obtained from Pusat Studi Pangan dan Gizi, University of Gadjah Mada.

Sample preparation: Each starter culture was prepared by inoculating 1 mL of pure culture in 9 mL MRS Broth media and incubated at a temperature of 37°C for 48 h. The amount of the cells in this preparation was approximately 10^6 CFU mL^{-1}. A yeast starter *(Saccharomyces cerevisiae*) was prepared by watering 1 g of commercial "Ragi roti" powder in sterilized bottles containing 100 mL sterilized distillate water.

Fermentation and manufacturing of sweet potato flour: The sweet potatoes were taken and divided into five representative lots. Each lot was prepared by weighing a total of1.5 kg sweet potato, then peeled and washed thoroughly in tap water. The peeled sweet potatoes were then sliced using a Hobart slicer with 1 mm thickness and dispersed in a 5 L closed plastic container. A 4 L sterile saline solution containing 3% of sodium chloride and 1% of sucrose was then added to the container. The 4 lots were then inoculated with different starters at the rate of 10% based on the volume of fermentation solution: *Lactobacillus plantarum* (Lb), *Leuconostoc mesenteroides* (Lc), a mixed of *Lactobacillus plantarum*, *Leuconostoc mesenteroides* (LbLc), a mixed of *Lactobacillus plantarum*, *Leuconostoc mesenteroides* and *Saccharomyces cerevisiae* (LbLcY), while one lot was spontaneously fermented (no starter added) was maintained as a control. The fermentation process was held at 30±2°C for 0, 24, 48, 72 and 96 h in anaerobic condition. After fermentation process was completed, the sweet potato slices were washed, drained and dried in an oven at a temperature of 60°C for 10-12 h until the moisture content reached 6-10%. The dried sweet potatoes were then powdered into the flour using a Hammer Mill and sieved using an 80 mesh sieve. All of fermented SPF were packed in sealed polyethylene bags for further analysis.

Sample analysis

Some physico-chemical properties of fermented SP flour: The pH of flour samples was measured in triplicate using a pH meter. Swelling power and solubility was determined using the method as reported previously[10] with slight modification of dispersion ratio. Flour sample (0.1 g) was dispersed in 12.5 mL of distilled water in centrifuge tubes, heated in a water bath for 30 min as the temperature was raised from 60-90°C in increments of 10°C and then centrifuged (Beckman GP, UK) at 3000 rpm for 15 min. The supernatants were collected and dried at 105°C to constant weight. The solubility was calculated as weight (%) of the dried supernatant compared to the weight of the dried flour (0.1 g). The precipitates were obtained and weighed directly to determine the swelling power.

Light transmittance (gel clarity): This was determined by the method using a UV-spectrophotometer (Thermo Scientific Genesys) as described previously[15]. One percent of sample suspensions in 10 mL cotton-plugged test tubes were heated in a boiling water bath (with occasional shaking) for 30 min. After cooling to ambient temperature, the

transmittance (%) was determined at 650 nm against a water blank. Samples were then stored at 4°C for 1-5 days and the transmittance was measured to monitor the tendency of retrogradation. The whiteness of SP flour was evaluated through the sensory test. The sensory panel consisted of 20 semi-trained students in Agro Industrial Product Technology, University of Lampung. The 5-point scoring scale for whiteness: 1-white and 5-white brown was used for the sensory assessment.

Morphology of starch granule: The morphology of starch granules was evaluated by FEI Scanning Electron Microscope (SEM) type Inspect S50, EDAX AMETEK. Selected SP sample powder was placed in a double-sidedcarbon taped holder, then coated with Au-Pd using a sputter coater (Emitech SC7620). The micrographs were obtained with an accelerating voltage of 10.00 kV with a magnification of ×2500.

Preparation and evaluation of unbroken noodle from composite flours: Preparation of noodle from composite flours followed the method[4] with modification of formulation. The dough was made from 44 g mixed flours of fermented SP flour-wheat flour with the ratio of 1:1 (10% moisture basis) by adding 1% sodium chloride solution, 5 mL egg solution, 20 mL water and mixed for 4 min. The dough was rested for 1 h in a plastic bag before sheeting, then folded and sheeted three times with a 5 mm gap at 25°C. Five sheeting reductions were applied to obtain a 2 mm sheet. When the reduction sheeting was completed, the final gap setting was adjusted for each sample to ensure the resulting noodle strands had a thickness of 1.2 mm and a width of 2 mm. The number of broken noodle strands from 34 strands was then visually evaluated.

Statistical analysis: The experiments were ordered in a randomized block design. The data were analyzed using the two ways of analysis of variance and the differences between means were determined using the Tukey HSD test. All statistical analyses were performed using the software package SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

The results obtained from various starters on fermented sweet potato flour were presented in Table 1-4.

Table 1: pH of the fermented sweet potatoes flour

Length of fermentation (h)	Spontaneous	Lb	Lc	LbLc	LbLcY
0	6.26±0.52^{a}	5.97±0.48^{a}	5.83±0.50^{a}	5.97±0.50^{a}	6.01±0.52^{a}
24	5.38±0.02^{b}	5.06±0.11^{bc}	4.54±0.18^{cd}	4.62±0.19^{cd}	4.65±0.59^{c}
48	4.70±0.08^{cde}	4.38±0.24^{cde}	4.22±0.17^{cde}	4.25±0.16^{cde}	4.25±0.20^{cde}
72	4.37±0.14^{cde}	4.16±0.06^{de}	4.14±0.08^{de}	4.15±0.04^{de}	4.27±0.25^{cde}
96	4.17±0.19^{de}	3.98±0.11^{e}	4.07±0.07^{e}	4.01±0,07^{e}	4.41±0,01^{cd}

Means with different letters in the same column are significantly different (p<0.05). The pH of the control flour: 6.03. Mean±standard deviation (n = 3). Lb: *Lactobacillus plantarum*, Lc: *Leuconostoc mesenteroides*, LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesenteroides*, LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesenteroides* and yeast (*Saccharomyces cerevisiae*), Spontaneous: Fermentation without starter added

Table 2: Whiteness score of fermented sweet potatoes flour

Length of fermentation (h)	Spontaneous	Lb	Lc	LbLc	LbLcY
0	1.62±0.28^{e}	1.87±0.23^{e}	2.30±0.43^{e}	2.05±0.23^{e}	1.82±0.55^{e}
24	2.33±0.30^{d}	2.55±0.75^{d}	2.87±0.35^{d}	2.57±0.47^{d}	2.72±0.20^{d}
48	3.42±0.10^{c}	3.48±0.25^{abc}	3.65±0.35^{cbc}	3.48±0.45^{abc}	3.65±0.28^{abc}
72	4.00±0.48^{ab}	3.73±0.27^{abc}	3.73±0.37^{abc}	3.72±0.42^{abc}	3.88±0.73^{abc}
96	4.27±0.29^{ab}	3.70±0.13^{abc}	3.72±0.33^{abc}	3.67±0.13^{abc}	3.75±0.36^{abc}

Means with different letters in the same column are significantly different (p<0.05). Score 1: White brown, 3 white cream, 4, white, 5 very white. Mean±standard deviation (n = 3). Lb: *Lactobacillus plantarum*, Lc: *Leuconostoc mesentereoides*, LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast (*Sacharomyces cerevisiae*), Spontaneous: Fermentation without starter added

Table 3: Swelling power (%) at 90°C of fermented sweet potatoes flour at different starters and length of fermentation

Length of fermentation (h)	90°C				
	Spontaneous	Lb	Lc	LbLc	LbLcY
0	17.30±0.53^{e}	17.56±0.75^{de}	16.50±0.38^{e}	17.38±0.97^{e}	16.42±0.37^{e}
24	18.56±0.52^{abcd}	18.69±0.40^{abc}	19.11±0.56^{abcd}	19.45±0.65^{abcd}	18.09±0.43^{c}
48	19.19±0.96^{abcd}	18.80±1.01^{abc}	18.80±1.06^{abcd}	19.20±1.07^{abcd}	17.19±0.84^{de}
72	19.21±0.80^{abcd}	19.06±0.87^{abc}	19.56±0.33^{abcd}	19.80±0.73^{abc}	19.73±0.42^{ab}
96	18.50±0.72^{abcd}	17.92±0.45^{cde}	19.12±0.76^{abcd}	18.70±0.36	19.01±0.32^{ab}

Means with different letters in the same column are significantly different (p<0.05). Lb: *Lactobacillus plantarum*, Lc: *Leuconostoc mesentereoides*, LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast *(Saccharomyces cerevisiae)*, Spontaneous: Fermentation without starter added

Table 4: Solubility (%) of fermented sweet potatoes flour at different starters and length of fermentation

	90°C				
Length of fermentation (h)	Spontaneous	Lb	Lc	LbLc	LbLcY
0	15.13±0.70^{ab}	16.86±0.21^{a}	17.00±0.85^{a}	18.40±0.15^{a}	14.36±0.37^{a}
24	15.03±0.66^{ab}	11.06±0.65^{b}	10.60±0.78^{b}	9.56±0.25^{bc}	5.63±0.60^{d}
48	7.06±0.58^{e}	5.20±0.50^{e}	7.13±0.61^{de}	6.73±0.40^{de}	3.06±0.55^{e}
72	8.03±0.80^{d}	6.40±0.30^{d}	7.43±0.94^{de}	6.83±0.37^{de}	6.56±0.37^{c}
96	9.16±0.41^{c}	7.30±0.85^{c}	9.20±0.65^{c}	9.80±0.52^{bc}	10.26±0.37^{b}

Mean±standard deviation (n = 3). Lb: *Lactobacillus plantarum*, Lc: *Leuconostoc mesentereoides*, LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast (*Saccharomyces cerevisiae*), Spontaneous: Fermentation without starter added)

Table 5: Entire noodle strands (%) made from fermented sweet potatoes flour at different starters and length of fermentation

Fermentation (h)	Lb	Lc	LbLc	LbLcY	Spontaneous
0	82.35±5.09^{e}	84.31±1.69^{e}	84.31±1.69^{c}	83.33±1.69^{de}	85.30±0.00^{cd}
24	90.20±1.69^{bcd}	92.16±1.69^{bcd}	88.24±2.94^{cd}	85.29±0.00^{cde}	80.39±1.14^{e}
48	91.18±2.94^{bcd}	92.16±1.69^{bcd}	91.18±0.00^{abc}	87.25±1.69^{cd}	89.22±1.99^{abc}
72	95.09±1.49^{ab}	96.08±3.39^{a}	94.13±2.94^{abc}	93.14±1.49^{ab}	91.18±1.88^{ab}
96	92.16±1.69^{ab}	92.16±1.69^{bcd}	92.16±1.69^{abc}	92.16±1.49^{ab}	86.27±1.49^{bcd}

Means with different letters in the same column are significantly different ($p<0.05$). Mean±standard deviation (n = 3). Lb: *Lactobacillus plantarum*, Lc: *Leuconostoc mesentereoides*, LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast (*Saccharomyces cerevisiae*), Spontaneous: Fermentation without starter added)

Flour pH: The pH level decreased rapidly from 48 h of continuously dropped afterward until the end of fermentation (Table 1). In spontaneous fermentation, however, the pH decreased gradually and reached the pH of 4.37 after 72 h fermentation. Meanwhile, in LbLcY, after the drop at 48 h fermentation, the pH then increased steadily at 96 h of fermentation and showed highest final pH.

Whiteness score: The whiteness score of flour was illustrated in Table 2. There was an increase of whiteness score of SP flour by the fermentation time from brownish white to white. There were, however, no significant score among the five fermentation treatments. All of the samples after 96 h of fermentation had a count close to 4 (white).

Swelling power and solubility: Swelling power properties of fermented SPF were shown in Table 3. The swelling power of SPF from either four starters or no starter added had a similar pattern ranging from 15-18%. All fermented flours were to have swelling power pattern that tended to increase gradually and stabilized afterward along with fermentation time. Fermentation time was found to make a difference in solubility of sweet potato fluor as shown in Table 4, meanwhile, the four starters were found to had similar pattern. The solubility of flour decreased during 48 h fermentation and increased after ward for all the starters treatments. Meanwhile, the decrease of solubility on the spontaneous fermentation (no starter added) was running slow and was significant after 48 h.

Transmittance (%): The transmittance (%) of all fermented SPF during five storage days was shown in Fig. 1a-e. The results showed that starters and fermentation time affected the transmittance (%) of the flour. A decrease in transmittance (%) at 650 mm until certain days of storage was observed and then it remained constant. These changes indicated that the retrogradation of starch gels was fast in the early stage of refrigeration and then reached saturation. Pronounced rapid reduction in transmittance (%) was observed in day-3 for LbH48, LcH72 and LcH96, LbLcYH96, while that for Sp H72,H96 and LbLcH48, H72, H96 was observed in 4 and 5 days, respectively. These indicated that increase of fermentation time until a certain point, the more tendency retro-gradation of starch occurred and high retrogradation tendency depended on the starter involved.

Morphology of granules: Scanning electron micrographs of control (unfermented SP) and 48 h fermented flour showed slight structural differences. All flours contained round, spherical starch granule surrounded by cell wall material (Fig. 2a-f), with mild shallow pits on several starch granule of fermented flour. These indicated that during 48 h fermentation the progress of degradation was slow and the proportion of granule displaying enzymatic attack to be fairly small. Nevertheless, the starch granule of fermented flour (Fig. 2b-f) seems to have little more swollen and smoother surface angle than those of control (unfermented SP) treatments.

Entire noodle strands: Mean scores of the entire noodle strands parameter were shown in Table 5. The number of whole noodle strands had an increasing trend with the increasing of fermentation time until 48-72 h and it remained

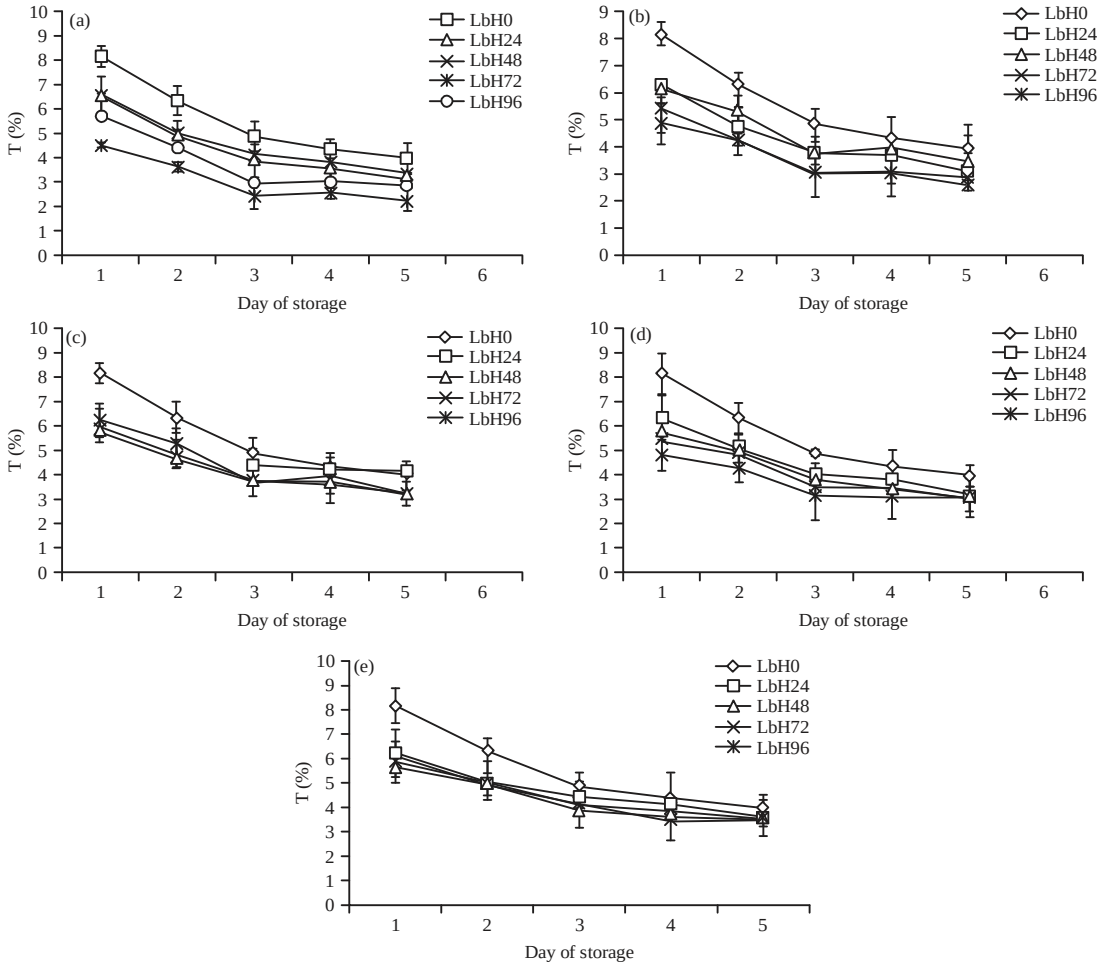

Fig. 1(a-e): Transmittance (T %) of fermented sweet potatoes flour at five days of cool storage (Mean±standard deviation (n = 3), with treatment of (a) Lb: *Lactobacillus plantarum*, (b) Lc: *Leuconostoc mesentereoides*, (c) LbLc: Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, (d) LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast (*Saccharomyces cerevisiae*) and (e) Sp: Spontaneous, fermentation without starter added. H0: Initial fermentation, H24: 24 h, H48: 48 h, H72: 72 h, H96: 96 h

constant afterward. This means the broken noodle strands decreased markedly with increase in fermentation time. In line with data of percent transmittance, the tendency to retrograde increased with increase in fermentation time.

DISCUSSION

The fermentation influenced the properties of sweet potato flour by this research study. By changing the pH, the fermentation treatments showed a similar pattern except for LbLcY and the spontaneous fermentation. This phenomenon probably attributed to a suppression effect of yeast on lactic acid bacteria (LAB) growth. Consequently, the lactic acid produced in this sample lesser than those of sample with LAB only. Besides, deacidification process may occur during fermentation that involved yeast. *Saccharomyces cerevisiae* is classified as K(-) yeasts that can weakly degrade L-malate[16]. Thus, this may reduce the total amount of organic acid in the flour and consequently the pH slightly increased.

Fermentation time improved the whiteness score of SP flour from brownish white to white. During fermentation of white-fleshed sweet potatoes, there was a decrease of ash, protein and sugar free content[11,17] and these constituents affect the flour whiteness[18,19]. A lower protein and free sugar content in flour may reduce the non-enzymatic browning during flour drying, which results in a whiter color of flour.

Swelling power properties represent evidence of interaction between the amorphous and crystalline areas[20,21]. The extent of this interaction is influenced by the amylose-amylopectin proportion and the characteristic of

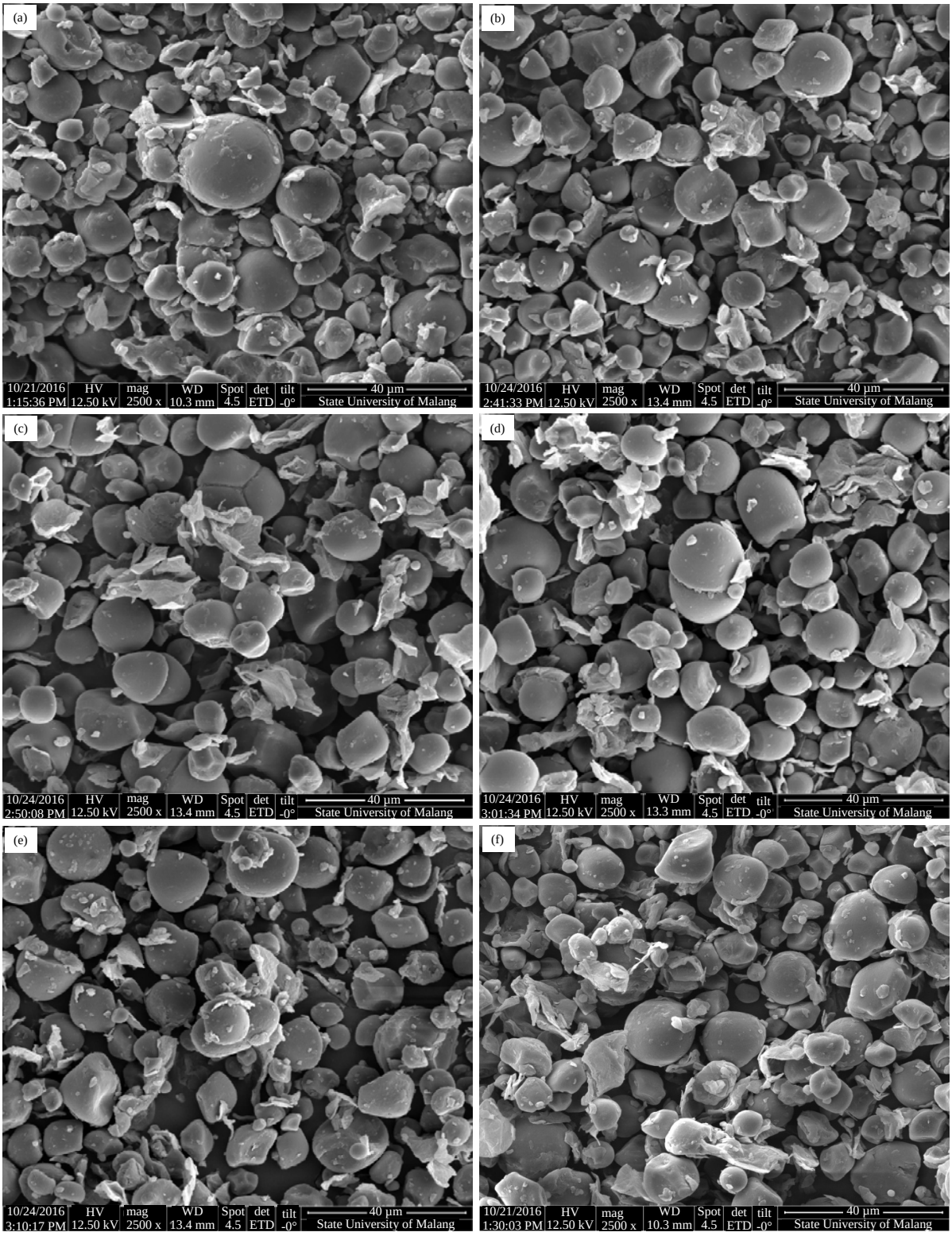

Fig. 2(a-f): Micrographs of sweet potatoes flour, (a) Control (unfermented treatment), (b) *Lactobacillus plantarum*, (c) *Leuconostoc mesentereoides*, (d) Mixed of *Lactobacillus plantarum* and *Leuconostoc mesentereoides*, (e) LbLcY: Mixed of *Lactobacillus plantarum*, *Leuconostoc mesentereoides* and yeast (*Saccharomyces cerevisiae*) and (f) Spontaneous

each molecule is dependent on the polymerization degree, length and grade of chain branching, molecular weight and molecular conformation[21,22]. During fermentation, lactic acid bacteria would produce amylases and when starches were treated with amylases there was an initial attack on the amorphous regions of the starch granule. These finally reduce the amylose content and strength of micellar granule network. According to the previous study[21], the strength and character of the micellar system within the granule are the significant factors that control the swelling behavior of a starch. Thus, the fermented flour samples may have a lesser structural rigidity in comparison to initial sweet potato flour and would be easier to swell when heated in excess water. However, at 96 h of fermentation, the swelling power tended to decrease slightly. This pattern at 96 h probably due in-depth degradation of amylopectin resulted in a higher amount of dextrins. John *et al.*[23] stated that increase in a high proportion of soluble dextrins of both small and medium chain lengths in starch granules would reduce swelling power.

The changes of solubility might be attributed to the different starch structure of SP flour as resulted from different starters and length of fermentation time. When starch is heated in the presence of excess water to temperatures above the gelatinization temperature, the granules imbibe water and swell. This disruption of the granular structure caused starch molecules to disperse in solution[21,24]. Degree by the amount of this solubilization depends on some factors such as inter-associative forces within the amorphous and crystalline domains[20], the chemical binding within the granules and the chain length distributions in the starches[25] and the size of starch granule[26]. Solubility may also be influenced by an increase of potential surface area available for reaction penetration in the granule[27].

Light transmittance indicates clarity in cooked starch and the marked reduction in transmittance is a result of retro-gradation tendency of starch pastes[28]. A remarkable decrease in transmittance (%) in fermented flour can be attributed to significantly decrease of amylose content and the change of amylose-amylopectin chain length as the effect of the fermentation process. Lactic acid bacteria would produce starch degrading enzyme that degraded amylose and amylopectin short chain so that the amount of short-chain amylopectin and high amylose molecular weight would be less, leaving a reduced amylopectin chain length in a more proportion. According to Ishiguro *et al.*[29] retrogradation of sweet potato starch was promoted by amylose and extremely long chains of amylopectin and was inhibited by extra short chains of amylopectin. Reducing short branch density of amylopectin branches would make the amylopectin chain length move more freely and facilitates the process of retrogradation[30]. Further, retrogradation tendency of starch pastes in cooked starch resulted in marked reduction in light transmittance[28]. In this study, all the percentage transmittance of the flour was reduced as the storage day's increased. This indicated that these starches in the flour have a tendency to retrograde under refrigerated storage. This implies that the flour may be suitable for products in which retrogradation of components is desired, such as in noodles.

With respect to granular morphology, there was some cell wall materials still attached to starch granules in the control flour, meanwhile there were starch granules that being released in fermented flour. As a result, some of the granular surfaces on the fermented flour appeared smoother. In addition, the starch granule in the fermented flour became more swollen than those in the non-fermented control containing holes in the some starch granules. This suggested that there has been degradation of starch by lactic acid bacteria during fermentation even though it was slow. Fermentation may alter the amorphous area of the starch grain, grain size as well as the chemical component and thereby modify the physical properties.

There was a marked decrease of the broken noodle strands with an increase in fermentation time. This is in line with data of transmittance (%), where the tendency to retrograde increased with increase in fermentation time. During the fermentation process, amylopectin short-chain in the amorphous starch was hydrolyzed and density of branches of amylopectin reduced. As a result, the amylopectin chain length moved more freely and this facilitates the process of retrogradation[30]. It was further reported that long-chain amylopectin had a strong tendency to form a gel and the mixture of long-chain amylopectin to low molecular weight amylose produced the most potent gel when stored at low temperatures. This indicated that raw materials containing starch with long-chain amylopectin and low molecular weight amylose would produce noodles with a firm, good texture and less broken noodle strands. Among treatments, however, spontaneous treated noodle has more broken noodle strands.

CONCLUSION

Fermentation time affected some physicochemical properties of sweet potato flour and the number of broken noodle strands. Solubility was reduced significantly; the most considerable reduction was observed at 48 h fermentation and in a mixed of *Lactobacillus plantarum*, *Leuconostoc mesenteroides* and *Saccharomyces cerevisiae* (LbLcY) treatment. Swelling power, pH, tendency of

retrogradation, whiteness of flour and the entire composite noodle strand of the fermented sweet potatoes increased markedly, along with longer fermentation. The enormous increase was observed at 72 h of fermentation for all starters treatment. Based on the results, fermentation at 48 and 72 h with starters added could be considered as the best treatment for making fermented flour as raw material for composite noodle.

SIGNIFICANCE STATEMENTS

The research elucidated on the increase composite noodle strand from the fermented sweet potatoes among others. This finding elucidated that fermented SP flour are potential ingredient for making composite flour to produce noodle and ultimately support the diversification program of local food sources.

ACKNOWLEDGMENT

The authors thank to The Ministry of Research, Technology and Higher Education of The Republic of Indonesia for funding this project through Competitive Research Grant (Hibah Strategis Nasional Ristek Dikti 2015/UN26/8/PL/2015). The authors also thank Dr. Sihem Aouabdi who edited the English language of the paper on behalf of the Science Edit For The Developing World.

REFERENCES

1. Lyddon, C., 2015. The grain and grain processing information site. Focus on Indonesia. World Grain, October 6, 2015.
2. Akubor, P.I., S.U. Onoja and E.C. Umego, 2013. Quality evaluation of fried noodles prepared from wheat, sweet potato and soybean flour blends. J. Nutr. Ecol. Food Res., 1: 281-287.
3. Antarlina, S.S. and J.S. Utomo, 2000. The quality improvement of noodle prepared from blended of sweet potato flour and cowpea protein concentrate. J. Penelitian Pertanian Tanaman Pangan, 19: 39-45, (In Bahasa Indonesia).
4. Yadav, B.S., R.B. Yadav, M. Kumari and B.S. Khatkar, 2014. Studies on suitability of wheat flour blends with sweet potato, colocasia and water chestnut flours for noodle making. LWT-Food Sci. Technol., 57: 352-358.
5. Taneya, M.L.J., M.M.H. Biswas and M. Shams-Ud-Din, 2014. The studies on the preparation of instant noodles from wheat flour supplementing with sweet potato flour. J. Bangladesh Agric. Univ., 12: 135-142.
6. Akonor, P.T., C. Tortoe, E.S. Buckman and L. Hagan, 2017. Proximate composition and sensory evaluation of root and tuber composite flour noodles. Cogent Food Agric., Vol. 3. 10.1080/23311932.2017.1292586.
7. Liao, L. and W. Wu, 2017. Fermentation effect on the properties of sweet potato starch and its noodle's quality by lactobacillus plantarum. J. Food Process Eng., Vol. 40. 10.1111/jfpe.12460.
8. Putri, W.D.R., D.W. Haryadi and C. Marseno, 2011. Effect of biodegradation by lactic acid bacteria on physical properties of cassava starch. Int. Food Res. J., 18: 1149-1154.
9. Putri, W.D.R., D.W. Marseno and M.N. Cahyanto, 2012. Role of lactic acid bacteria on structural and physicochemical properties of sour cassava starch. Proc. APCBEE., 2: 104-109.
10. Deng, F.M., T.H. Mu, M. Zhang and O.K. Abegunde, 2013. Composition, structure and physicochemical properties of sweet potato starches isolated by sour liquid processing and centrifugation. Starch-Starke, 65: 162-171.
11. Koubala, B.B., G. Kansci, L.B.E. Enone, O.D. Ngrong, V.Y. Ndjidda and M.A.Z. Essame, 2014. Effect of fermentation time on the physicochemical and sensorial properties of gari from sweet potato (*Ipomoae batatas*). Br. J. Applied Sci. Technol., 4: 3430-3444.
12. Yuliana, N., S. Nurdjanah, R. Sugiharto and D. Amethy, 2014. Effect of spontaneous lactic acid fermentation on physico-chemical properties of sweet potato flour. Microbiol. Indonesia, 8: 1-8.
13. Ajayi, O.I., J. Ehiwuogu-Onyibe, O.B. Oluwole, A.A. Jegede and T.A. Salami *et al*., 2016. Production of fermented sweet potato flour using indigenous starter cultures. Afr. J. Microbiol. Res., 10: 1746-1758.
14. Yuliana, N., S. Nurdjanah, S. Setyani and D. Novianti, 2017. Improving properties of sweet potato composite flour: Influence of lactic fermentation. Proceedings of the AIP Conference, Volume 1854, June 26, 2017, AIP.
15. Achille, T.F., A. Nrsquo, G. Georges and K. Alphonse, 2007. Contribution to light transmittance modelling in starch media. Afr. J. Biotechnol., 6: 569-575.
16. Saayman, M. and M. Viljoen-Bloom, 2006. The biochemistry of malic acid metabolism by wine yeasts: A review. S. Afr. J. Enol. Viticult., 27: 113-122.
17. Yuliana, N., S. Nurdjanah and Y.R. Dewi, 2018. Physicochemical properties of fermented sweet potato flour in wheat composite flour and its use in white bread. Int. Food Res. J., 25: 1051-1059.
18. Sobowale, A.O., T.O. Olurin and O.B. Oyewole, 2007. Effect of lactic acid bacteria starter culture fermentation of cassava on chemical and sensory characteristics of fufu flour. Afr. J. Biotechnol., 6: 1954-1958.

19. Fetuga, G., K. Tomlins, F. Henshaw and M. Idowu, 2014. Effect of variety and processing method on functional properties of traditional sweet potato flour ("elubo") and sensory acceptability of cooked paste ("amala"). Food Sci. Nutr., 2: 682-691.
20. Zhang, P., R.L. Whistler, J.N. BeMiller and B.R. Hamaker, 2005. Banana starch: Production, physicochemical properties and digestibility: A review. Carbohydrate Polym., 59: 443-458.
21. Ratnayake, W.S., R. Hoover and T. Warkentin, 2002. Pea starch: Composition, structure and properties: A review. Starch Starke, 54: 217-234.
22. Hoover, R., 2001. Composition, molecular structure and physicochemical properties of tuber and root starches: A review. Carbohydr. Polym., 45: 253-267.
23. John, J.K., K.C.M. Raja, S. Rani, S.N. Moorthy and A. Eliasson, 2002. Properties of arrowroot starch treated with aqueous HCl at ambient temperature. J. Food Sci., 67: 10-14.
24. Nelles, E.M., J. Dewar, M.L. Bason and J.R.N. Taylor, 2000. Maize starch biphasic pasting curves. J. Cereal Sci., 31: 287-294.
25. Bello-Perez, L.A., S.M. Contreras-Ramos, A. Jimenez-Aparicio and O. Paredes-Lopez, 2000. Acetylation and characterization of banana (*Musa paradisiaca*) starch. Acta Cientifica Venezeula, 51: 143-149.
26. Moorthy, S.N., 2002. Physicochemical and functional properties of tropical tuber starches: A review. Starke, 54: 559-592.
27. Kaur, R., B.S. Gill and D.S. Sogi, 2007. Studies on the effect of aqueous hydrochloric acid on properties of wheat starch. J. Food Sci. Technol.-Mysore, 44: 386-390.
28. Sandhu, K.S. and N. Singh, 2007. Some properties of corn starches II: Physicochemical, gelatinization, retrogradation, pasting and gel textural properties. Food Chem., 101: 1499-1507.
29. Ishiguro, K., T. Noda, K. Kitahara and O. Yamakawa, 2000. Retrogradation of sweetpotato starch. Starch Starke, 52: 13-17.
30. Jane, J., Y.Y. Chen, L.F. Lee, A.E. McPherson, K.S. Wong, M. Radosavljevic and T. Kasemsuwan, 1999. Effects of amylopectin branch chain length and amylose content on the gelatinization and pasting properties of starch. Cereal Chem., 76: 629-637.