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IMPROVING PROPERTIES OF SWEET POTATO COMPOSITE FLOUR: INFLUENCE OF LACTIC FERMENTATION

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Abstract. The use of locally grown crops such as sweet potato as raw material for composite flour is considered advantageous as it reduces the importation of wheat flour. However the use of native sweetpotato flour has drawback properties when applied in the food. This study was aimed to modify sweet potato flour through six methods of lactic fermentation (spontaneous, pickle brine, *Lb plantarum, Lc mesentereoides, a mixed of Lb plantarum and Lc mesentereoides,* and *mixed of Lb plantarum, Lc mesentereoides* and yeast) to increase its properties in composite flour. Composite flours were obtained after fermentation of sweet potato slices for 48h in the proportion of 50% sweet potatoes flour and 50% wheat flour. pH, moisture content, swelling power, solubility, and pasting properties were determined for the fermented and unfermented composite flours. The results indicated that the composite fermented flours had better properties than those of non fermented flour. Fermentation increased swelling power, moisture content, meanwhile, solubility, and pH, deacresed. Amylose leaching, however, was not significantly affected by the fermentation process.

Keywords: composite sweetpotato flour, lactic acid fermentation.

INTRODUCTION

Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops . One of the potential locally raw materials used in composite for substitute the wheat is white sweet potato (SP). This crop can be processed into white sweet potato flour and then it could be used as a substitute for wheat flour (20 %-80 %) in baked goods , cakes and noodles. However, the use of native sweetpotaoes for composite flour still has drawback properties. The uses of this root in substitution of composite flour in which the product still acceptable for consumers is generally only up to 20 % in the manufacture of vermicelli (Collado *et al*., 2001 and Lase *et al*., 2013) and noodles (Lee *et al*., 2005 and Chen *et al*., 2006). In addition, the color of SP noodles is darker and less bright, and its texture is low elastic (Sugiyono et al., 201; Chen, 2006). Addition of sweet potato flour in vermicelli making is less consumer preferences for color products (Rizal, 2012). Thus, modification of white sweet potato flour to improve its physical and sensory properties is need to pay attention.

Physical and sensory properties of white sweet potato flour can be improved in many ways such as chemistry, physics, and microbiology methods. Chemically modifying sweet potato flour could be done with the addition of sodium tri polyphosphat during the process of making dough (Retnaningtyas and Putri, 2014),or with carboxyl metyl cellulosa addition (Mulyadi et al., 2014). In physically method, modification could be done trough high-moisture treatment (Kusnandar, 2009; Lase et al.,, 2013); while in microbiologically method by using of either fermentation (Yuliana et al., 2014; Pratiwi, 2014; Dewi, 2014) or enzyme application. Chemically modifying sweet potatoes flour is relatively easy to do, however, the use of chemical additives is feared to affect the human health. In physiccally, the product is relatively safe to consume but it difficults in the use of high temperature and humidity setting, especially if the device is not adequate. While eznyme application is relatively

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expensive. In this research, fermentation was choosen to improve the physical and sensory properties of sweet potato as it was relatively easy and safety.

Fermentation as a meant to improve propeorties could be done either with or without addition of culture. Some of the examples were fermentation of casava by using *Lactobacillus plantarum* and *Saccharomyces cerevisiae* culture to improve their properties in "mocaf" (Mutia, 2011), fermentation of sweet potatoes pikel with either *Leuconostoc mesenteroides* (Yuliana et al., 2013) or a mixed cultures of *Lactobacillus plantarum* and *Leuconostoc mesenteroides* (Yuliana et al., 2013), and with addition of *Lactobacillus plantarum* (Yuliana et al., 2014), as well as fermentation of sweet potato in spontaneously method (Pratiwi, 2014). In this study fermentation was carried out by using several cultures to improve properties of sweet potatoes. The best composite flour made of fermented sweet potatoes was then determined.

MATERIALS AND METHODS

Materials

The materials used in this study were: white sweet potatoes tubes, variety of ciceh from Sekincau Liwa, purchased in traditional markets in Bandarjaya-Lampung; starter *Lactobacillus plantarum FNCC 0123* and *Leuconostoc mesenteroides FNCC 0023* (Laboratory of Food Universitas Gajah Mada), *Saccharomyces cereviceae* in the form of commercial ragi (Fermipan), wheat flour (brand Chakra, Bogasari), eggs, sugar (Gulaku), salt (Refina) and cooking oil (brand Filma). Chemicals used in these experiments were distilled water, NaCl, NaOH, H2SO4, CaCO3, Iodine solution, 95% ethanol, acetic acid 1 N, and pure amylose.

Preparation of Starters

Lactobacillus plantarum or Leuconostoc mesenteroides starter

Two ml culture of *Lactobacillus plantarum* or *Leuconostoc mesenteroides* in 10 ml MRS Broth was taken and each was then tranfered in to 18 ml of sterile MRS broth and incubated for 24 hours ,at 37 °C. After that, each culture was taken as much as 2.5 ml and transfered into 22.5 mL sterile MRS broth and again incubated for 24 hours at 37°C. To get working starter, each culture was then tranfered into 250 ml of Erlenmeyer contained 215 ml sterile MRS broth and incubated for 24 hours, at 37°C.

Preparation of Saccharomyces cerevisiae *starter.*

One gram of *Saccharomyces cerevisiae* ragi was poured into 100 ml of steril distilled water then was homogenized. *Saccharomyces cerevisiae* culture was then ready for use.

Preparation of pikel brine starter.

The sweet potato cubes weighed as much as 40 g were inserted into 150 ml of bottle fermentation contained 110 ml of saline solution. This mixtures were then pasteurized at 72C - 73◦C and then was fermented for 4 days at room temperature. The brine of this fermented cubes was then ready for starter use.

Fermentation of Sweet Potatoes

Sweet potatoes were peeled and washed and then sliced using a slicer size of 1 mm. Sweet potatoes slices were taken as much as 1.8 kg and then were put in a sealed container volume of 6 L. Sugar solution (2.5L) contained 1% sugar and 3% salt was then added. This mixture was innocullated with a starter as much as 5% (v /v) in accordance with the treatments and then were fermented for 2 days (48 hours) at room temperature. Treatments in these study consisted of: (A) Control without fermentation, (B) Spontaneous fermentation (without starter added), C. Pikel brine starter, D. *Lactobacillus plantarum* starter with a cell density of 10^6 cells /mL, (E) *Leuconostoc mesenteroides* with a cell density of 10^6 cells/mL, (F) a mixed starter of *Lactobacillus plantarum* and *Leuconostoc mesenteroides* with a cell density of 10^6 cells /mL, and (G) a mixed starter of *Lactobacillus plantarum, Leuconostoc mesenteroides,* and *Saccharomyces cerevisiae* with a cell density 10^6 CFU/g.

Production of Sweetpotatoes Flour

The sweetpotatoes slices either fermented or non fermented as a control are washed, drained and dried in an oven blower (British foyer) at tmperature of 60◦C for 24 hours , until water content of ± 6-8 % was reached. The dried slices were then ground using a grinder (Rulb Fanc) and sieved using a 80 mesh siever. These flours were then packed in plastic lid tightly and kept for further analysis .

Composite Flours

Composite flours were made by mixing of sweet potato flour treatments above with wheat flour in the ratio of 50% : 50% by using a mixer for 5 minutes. These composite flours were then analyzed to determine moisture AOAC (1995), pH , solubility and swelling power (Deng *et al*., 2013), and amylose leaching (Kusnandar *et al*., 2009).

Research Methods

The experimental design used was the complete randomized block design (CRBD) in one factorial with four replications. The treatment consisted of 7 types of composite flour made from non fermented sweet potato-wheat flour (A) as a control, and 6 fermented sweetpotatoes-wheat flour (B,C,D,E,F,G,H). Data of modified sweet potato compsite flour were analyzed by using analysis of variance. Duncan test was used to determine differences among treatments at 5% level.

RESULTS AND DISCUSSION

Water Content and pH

Water content and pH of composite flours are presented in Table 1. Results showed that the water content of fermented flour tends to be higher than the control while the pH of fermented composite flour was lower. The increase of water content on fermented flour could be attributed to 48 hours of soaking stage during fermentation process. The water content, neverthelees, was still below of SNI maximum water content of flour (less than 13%). The water content is one of important components in the manufacture of food products because they affect the shelf life of the food product. In addition, water may affect the appearance, texture and flavor of food (Sudarmadji,1997).

TABLE 1. Water and Ph of sweet potato composite flour.

Treatments	Water Content (%)	pH
Control	4,25±0,30[a]	6,22±0,03[a]
Spontaneous	4,81±0,85[b]	5,35±0,06[b]
Pickel Brine	5,08±1,03[b]	4,76±0,07[c]
Lb	4,52±0,73[ab]	4,31±0,11[d]
Lc	4,70±0,80[b]	5,32±0,20[b]
Lb + Lc	3,99±0,11[a]	4,85±0,09[c]
Lb + Lc + Yeast	4,11±0,18[a]	5,39±0,14[b]

Number followed by different letters in the same column shows the difference at 5% level by Duncan test.
Lb = *Lactobacillus plantarum* ; Lc = *Leuconostoc mesenteroides*; Yeast = *Saccharomyces cerevisiae*.

Composite fermented flour had pH values (4.31 to 5.39) that lower than the compopsite control flour (6.22) and wheat flour (6.11). Lactic acid bacteria such as *Lactobacillus plantarum* and *Leuconostoc mesenteroides* may produce amylase that hydrolyzed most of the starch into monosaccharides and others metabolites as a source of energy. These were then converted to organic acid mainly as lactic acid and substantial amount of acetic acid and caused the pH to be drop (Oghonejoboh, 2012). The final pH was affected by microbial cultures used in each sample and among them, the pH of composite flour produced by *Lactobacillus plantarum* was the lowest, amounted to 4.31. *Lactobacillus plantarum* was homofermentatif lactic acid bacteria which has high amylolytic activity, and classified as a strong lactic acid producer (Sharp, 1979; Salminen and Wright, 1993). Mean while, the pH of the flour derived from a mixed culture of *Lactobacillus plantarum, Leuconostoc* *mesenteroides,* and yeast had value close to neutral, that was 5.39. This was likely due to the lactic acid produced by *Lactobacillus plantarum* and *Leuconostoc mesenteroides* was used by *Saccharomyces cerevisiae* and reformed it into a secondary metabolite such as alcohol.

Sollubility at Different Temperatures and Amylose Leaching.

Table 3 shows that fermentation deacreased sollubility and amylose leaching. The sollubility was observed to deacrease with increase in temperature (70-95C) with the composite fermented flours exhibiting significant amylose leaching when compared with the composite control SP flour, except for the pickle brine treatment. Lower sollubility in fermented flour than the control was probably due some of the starch to have been degraded into shorter polymer chains as action of enzyme produced by lactic acid bacteria. These shorter polymers e.i simple sugar were more soluble and probablly were dissolved in fermentation medium resulted in longer chain polymer retain in the flour.

TABLE 2. Solubility and amylose leaching.

Treatments	***Sollubility* 70°C (%)**	***Sollubility* 85°C (%)**	***Sollubility* 95°C (%)**	***Amylose Leaching* (%)**
Control	9,63 ± 0,36^{c}	13,01±0,50^{a}	10,52±0,35^{ab}	0,019±0,003^{b}
Spontaneous	7,35 ± 1,39^{ab}	10,39±1,26^{b}	11,42±0,45^{a}	0,014±0,002^{bc}
Pickel Brine	6,31 ± 0,20^{a}	9,65±0,67^{c}	10,85±0,86^{ab}	0,080±0,09^{a}
Lb	7,30 ± 0,91^{ab}	9,66±0,76^{c}	11,19±0,77^{ab}	0,015±0,004^{abc}
Lc	7,23 ± 0,54^{ab}	8,70±0,59^{d}	9,67±0,52^{b}	0,042±0,001^{ab}
Lb + Lc	7,13 ± 0,76^{ab}	10,16±0,64^{b}	10,11±1,19^{ab}	0,026±0,004^{abc}
Lb + Lc + Yeast	6,75 ± 0,45^{a}	9,56±0,58^{c}	10,53±1,02^{ab}	0,028±0,003^{ab}

Number followed by different letters in the same column shows the difference at 5% level by Duncan test. Lb = *Lactobacillus plantarum* ; Lc = *Leuconostoc mesenteroides*; Yeast = *Saccharomyces cerevisiae.*

Among the fermented flours, the sollubility of fermented flour treated by mixed culture of *Lactobacillus plantarum*, *Leuconostoc mesenteroides*, and *Saccharomyces cerevisiae* showed the lowest and stable. According to Collado *et al*., 2001, flour with low solubility and stable values is best flour for raw material noodles use. Starch structural such as chain length distribution of amylose and amylopectin might caused differences of starch solubility among samples. Bello-Perez *et al*. (2000) reported that the distributions of chain length in the starches cause differences in Solubility. According Fleche (1985), when the starch molecule was completely hydrated, these molecules began to spread to the media on the outside. Molecules that first came out were molecules that had shorter chain e.i amylose. The higher the temperature the more the starch molecules will out of the starch granules.

Table 3 shows that amylose leaching of fermented and control was comporable low, except for pickle brine treatment. Amylose leaching (release amylose) was the process of release of amylose during the gelatinization process. High amylose on the surface of the noodles after cooking can increase the level of stickiness as reported in corn moodles (Kusnandar, 2009). The low amount of amylose off during the heating due to the large number of well-amylose forms complexes with amylose, amylopectin, or fat. Complex bond formation caused the starch had a bond that was compact and tight, so that the amount of amylose off lower (Gunaratne and Hoover, 2001).

Swelling Power.

The swelling power of composite SP flour at different temperatures is shown in Table 4. Generally, the swelling power was observed to increase with increase in temperature (70 to 95◦C) with the composite fermented samples exhibiting significant ability to swell when compared with the composite control flour. Nevertheles, there was no significant different value among the fermentation treatments. Increase in swelling power of flour as a result of fermentation treatment is in conformity with earlier reports for fermented white sweet potatoes (Yuliana, 2014) and fermented moringa flour (Oleyede et al.,2016).

TABLE 3. Swelling power of compposite SP flour

Treatments	Swelling Power 70°C (%)	Swelling Power 85°C (%)	Swelling Power 95°C (%)
Control	10,46±0,05[a]	9,36±0,32[c]	10,82±0,46[c]
Spontaneous	9,82±0,11[b]	10,90±0,75[b]	12,84±0,42[a]
Pickel Brine	9,31±0,36[c]	11,93±0,77[ab]	12,80±0,27[a]
Lb	9,41±0,39[bc]	11,16±0,58[ab]	12,03±0,64[b]
Lc	9,52±0,45[bc]	11,78±0,46[ab]	12,28±0,84[ab]
Lb + Lc	9,53±0,35[bc]	10,87±0,55[b]	12,23±0,15[ab]
Lb + Lc + Yeast	10,22±0,41[a]	12,20±0,25[a]	12,87±0,32[a]

Number followed by different letters in the same column shows the difference at 5% level by Duncan test.
Lb = *Lactobacillus plantarum* ; Lc = *Leuconostoc mesenteroides*; Yeast = *Saccharomyces cerevisiae.*

Hydrolysis of starch granules during fermentation, leading to a lesser structural rigidity in comparison to fermented sweet potato flour. Shorter starch chains as result of these hydrolysis process then tend to be easy absorbed water. Claver *et al*., (2010) reported that when temperature increase and vigorous starch break intermolecular bonds, allowing hydrogen bonding sites to accommodate more water molecules. Water absorbed of each starch granule would make the starch granules swell and increase the swelling power (Odedeji and Adeleke, 2010).

CONCLUSIONS

Fermentation showed beneficial effects on the physicochemical and pasting properties of SP flour. Fermentation significantly increased the swelling power, moisture content, meanwhile, solubility, and pH deacresed. Amylose leaching, however, was not significantly affected by the fermentation process. The best fermentation treatment in this study was either a mixed culture of *Lactobacillus plantarum* , *Leuconostoc mesenteroides* and y*east* or mixed culture of *Lactobacillus plantarum* and *Leuconostoc mesenteroides*.

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