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Physical Characteristics of Biodegradable Foam from Mixed Hominy Feed and Cassava Starch

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Abstract. Biodegradable foam is a packaging materials made from renewable resources which is very prospective to substitute synthetic polystyrene foam. Starch is now dominantly use as a promising material to produce biodegradable foam due to its superior characteristic and availability. However, starch is preferable as food source thus it is important to looking for an alternative material such as corn hominy feed. Corn hominy is a by product of corn milling which has high content of starch and fiber. Its high fiber contents could improve the strength of the foam. This research is aimed to formulate the composition of corn hominy and starch to produce good quality of biodegradable foam. Polyvinyl alcohol (PVOH) is added for further better physical properties. The physical analysis showed that the composition of cassava starch and corn hominy feed has affected physical properties of biodegradable foam. Increasing the content of starch resulted on increasing of foam expansion. In contrast, the more contents starch in the foam, the more brittle the foam will be. The best composition is given by ratio of 80% starch and 20% hominy feed. The adding PVOH affected the physical properties of foam which it improved the hardness index of it.

Keywords: *biodegradable foam, cassava starch, hominy feed, PVOH,*

1 Introduction

Polystyrene foam is a plastic producing from petroleum styrene monomer in which now days it is known as styrofoam. The use of polystyrene foam for food and electronics packaging lately has become a trend due to various advantages offering from this material, i.e. light, easy to form, good in keeping heat, and low cost production. However, the usage of styrofoam brings negative impact to the environment due to its difficulty to be degraded. US Environmental Protection Agency (EPA) in 1986 [1] said that polystyrene foam is the fifth most dangerous garbage in USA. Furthermore, interaction between polystyrene foam and food can risk to the health due to its toxicity and carcinogenicity. The foam might leave monomer styrene in large numbers and migrate from the packaging to the food packaged. Green [2] in his report which titled Styrofoam-The Silent Killer said that polystyrene exposure can cause hormonal interference that may cause thyroid malfunction, breast cancer or even prostate cancer.

Due to it is widely used and has big negative impact; a substitution material is really needed to replace polystyrene foam. Agricultural and forestry material can be a good alternative to solve this problem and among them, starch has a good prospect to producing styrofoam. Starchy material which potential to be developed in Indonesia are corn and cassava because the two materials are abundantly available in this country. National corn production in 2009 was 16.3 million tons per year (Hadi and Elly) [3]. In 2014, national corn production is predicted can achieve more than 31.3 million tons per

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year. Unfortunately, corn and cassava is food staple thus the using of these kinds of starch is better to be avoided.

As long as the corn is milled in the factory, hominy feed will be produced as a by product. This hominy so far still has a lot content of starch and fiber thus it can be perfectly for foam producing. Its fiber will improve the strength of the foam it self. Literature (Andersen and Hodson) [4] showed that starch foam tends to be brittle and fragile. In this research, an additive of polyvinyl alcohol (PVOH) is added in the formula to improve foam characteristics. Furthermore, it necessary to examine the effect of adding PVOH and different ratio of cassava starch and corn hominy in producing biodegradable foam by microwave assisted molding. This research is aimed to examine the effect of adding PVOH and different composition ratio between cassava starch and corn hominy to physical characteristic of biodegradable foam.

2 Materials and Methods

2.1 Material and Apparatus

The main material in this research was cassava starch and corn hominy which gathered from corn flour milling. Aquadest is used as a plasticizer while PVOH is obtained from commercial chemicals shop. The equipments were rheocor mixer (rheomix) 3000 HAAKE with 200-250 g in capacity, microwave (Sharp R-8720M 1000 W), Universal Testing Machine (UTM), centrifuge, digital scale, penetrometer, erlenmeyer, and other laboratory sets.

2.2 Methodology

There were two steps of researches i.e preliminary and main research. The preliminary is aimed to dry and mill of the starch until obtaining the suitable mesh of flour. Then, the hominy feed was analyzed its moisture, ash, fat, fiber, protein, and carbohydrate content. The main research was aimed to trial the foam formulas by set different ratio of cassava starch and hominy feed such as shown in Table 1.

Table 1 Foam producing formulas

Code of sample	Cassava (g)	Hominy feed (g)	NaCl (g)	PVOH (g)	Water (g)
A1B1	120	80	21	10	76
A2B1	140	60	21	10	75
A3B1	160	40	21	10	74
A1B2	120	80	21	-	76
A2B2	140	60	21	-	75
A3B2	160	40	21	-	74

Thermoplastic pellet of starch was produce by mixing the cassava starch and corn hominy, then together mixed in rheocor mixer (rheomix) 3000 HAAKE on 65 rpm for 5 minutes. The temperatures were set in three different barrel i. 90-100-90°C for 5 minutes. The foaming tests were carried out in a combined microwave oven (Sharp R-8720M, 1000W), which allows a combination of convection hot air and microwave heating. The closed mould loaded with pellets was positioned at the centre of the rotating dish in the microwave oven and heated by microwave at 100% power of 1kW. About 45 s was required to foam the pellets depending on their compositions. The foam produced and

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then measure for its properties included glass transition temperature by differential scanning calorimeter (DSC), strengthness, expansion ratio, bulk density (ASTM D1895-65) [5], compression Index (ASTM D1621-73) [6].

3 Results and Discussion

3.1 Preliminary research

The results of proximate analysis of hominy starch were shown in table below. Based on these results, the water was added in the solution for foam producing as much as 25%, 35%, and 45% with the moisture contents of cassava starch of 11.82% and hominy feed of 8.20%. However, 35% was the best and gave good dough which was easy to be palletized using rheometer and foamed using oven. It was also founded that 5 min of plasticize process was the optimum time.

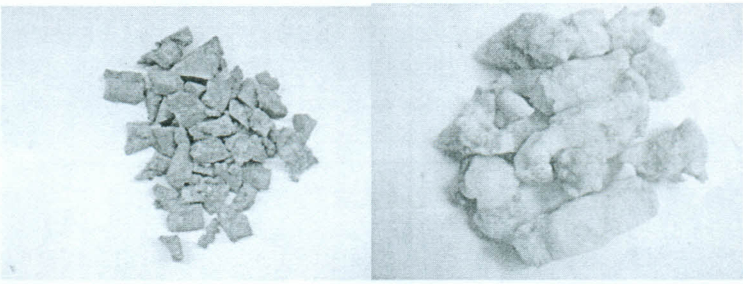
Table 2. Proximate analysis of hominy feed starch

Component (%b/b)	**Hominy feed starch** (%)
Kadar Air	8.20
Kadar Abu	2.96
Kadar Serat Kasar	9.68
Kadar Lemak	14.93
Kadar Protein	9.85
Kadar Karbohidrat (*by difference*)	54.38

3.2 Main research

3.2.1 Glass Transition Temperature

A thermoplastic is kind of plastic properties in which soft when it is heated and back to hard when it is colded (Corradini *et al.*, 2007). Pellet thermoplastic of starch was produced by mixed the dough (cassava starch and hominy feed as well as additives) with rheometer. The best composition of trial is given by ratio of 80% cassava starch and 20% hominy feed. This ratio has given the highest expansion ratio and water absorption index with acceptable strengthness of the foam. Figure 1 show the photograph of visual of the pellet and foam.



(a) (b)

Figure 1. Cassava – hominy starch pellet (a) and foam (b)

Base on the best composition (80:20), the thermal properties of glass transition temperature of pellet and foam was measured as displayed in Table 3. It is shown that the extrudes, either from plasticize and expansion process, both, have been reached their glass transition temperatures. PVOH added in this sample has been affected on the increasing of the temperature of glass transition. It is believed that PVOH will improve the toughness of foam thus directly will also improve its glass transition temperature.

Tabel 3 Glass transition temperature

Sample	Glass transition temperature (°C)	
	Pellet	Foam
80:20 without PVOH	71.81	80.14
80:20 with PVOH	73.21	87.75

SEM analysis of the foam showed in Figure 2. It can be seen that all formulas used in this research has foamed perfectly indicating by none of starch granules remaining in the foam materials.

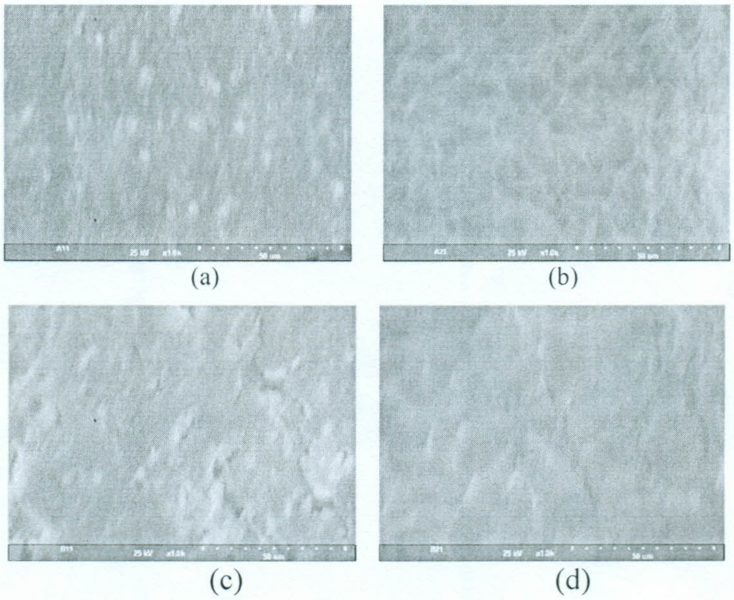


Figure 2 SEM of (a) 80:20 without PVOH before expansion; (b) 80:20 without PVOH after expansion; (c) 80:20 with PVOH before expansion and (d) 80:20 with PVOH after expansion (magnificent 1000×)

3.2.2 Strengthness

The strengness of the starch foam was shown in Figure 3. PVOH have been decreased the strength of the foam linearly. Ratio of 80 : 20 had the highest value of 3.86 mm/150 g 5s, in mean while, the strengthness of starch foam with PVOH was fluctuate. Starch can increase the strengthness of foam. In this case, starch acted as filler thus it made the foam hard. The more hard of foam the more strength will be.

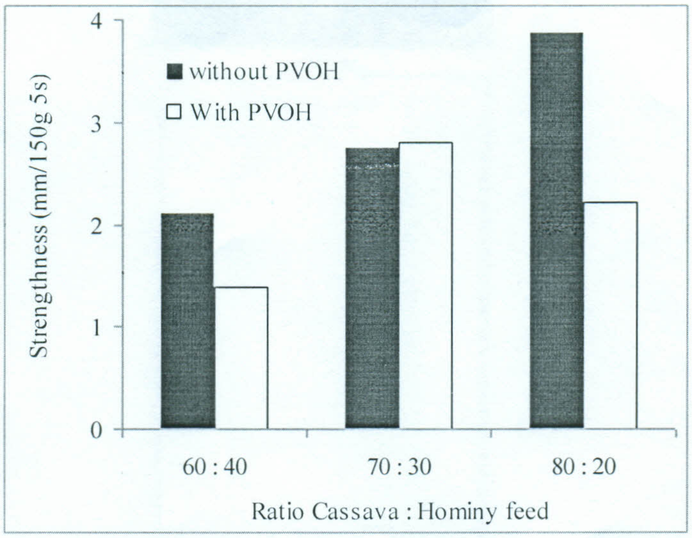


Figure 3. Strengthness of starch foam

3.2.3 Expansion ratio

Expansion ratio is defined by ratio of volume between extrudat after expansion (foam) and extrudat before expansion (pellet). Expansion ratio of samples with PVOH increased linearly to less cassava starch composition. The less content of the cassava starch, the higher the expansion ratio (Figure 4). Clearly, high starch content will increase density of pellets as well as their volume. Thus, with the same volume of expanding of foams, it will decrease the expansion ratio. However, from the statistical analysis, the effect of different composition of cassava starch between them did not result significantly different on the expansion ratio. It also can be seen from the figure that PVOH added in that formula has resulted on less expansion ratio. In can be understand that adding additive of PVOH will increase the mass of pellet and it will burden the pellet expanding to be foam.

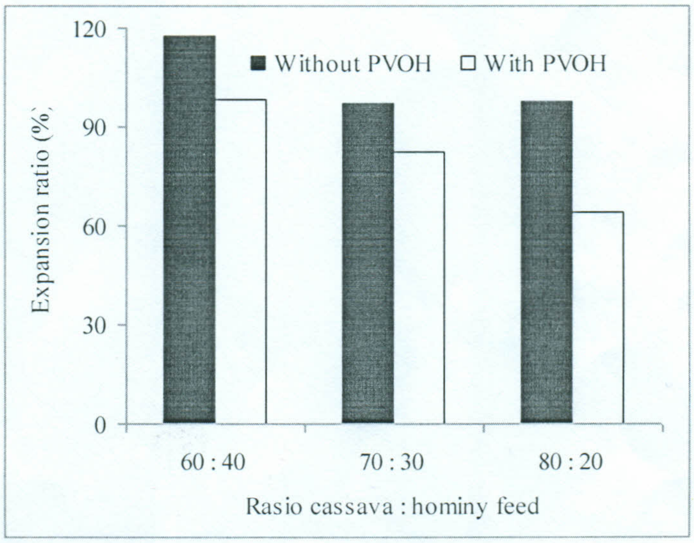


Figure 4 Expansion ratio of starch foam

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3.2.4 Bulk density

Bulk density is weight of foam (g) per unit volume (cm^3). Small number of bulk density mean that the foam has a small weight, however the foam has placed in high volume. The bulk density of starch foam resulted in this research is figured in Figure 4. The higher cassava starch content in that foam, the less bulk density of foam. PVOH has also impacted this properties. PVOH-starch foam has higher bulk density than non PVOH-starch foam. That phenomenon was as same explanation as expansion ratio value.

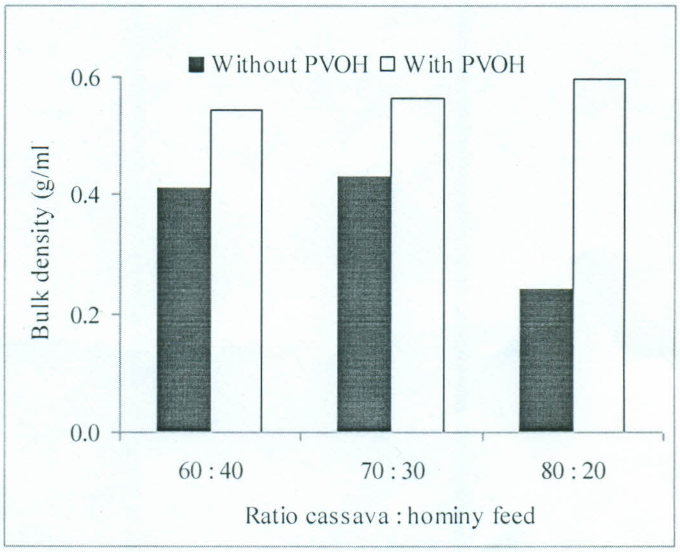

Figure 5 Bulk density of starch foam

3.2.5 Compression

Compression value is a result of the subjection of a material to compressive stress (in kg), which results in reduction of volume. Compression is physical properties and it is important if the foam is purposed as packaging material because in somehow, package product will stacked in the warehouse. The high compression value of the foam the more load could be detained. Figure 5 shows the compression value of this foam in different composition of cassava starch and hominy. Statistically, there was no significantly different in the compression value due to the different of starch composition, either for PVOH starch foam and non PVOH starch foam. However, in the same composition of starch, PVOH foam generally has good compressibility compare to non PVOH foam, except for composition of 80% (b/b) cassava starch and 20% (b/b) hominy feed. The highest compressibility was about 25.985 kgf. This value is still low to meet the standard as about 99.046 kgf of SNI 01-4853-2006 [7].

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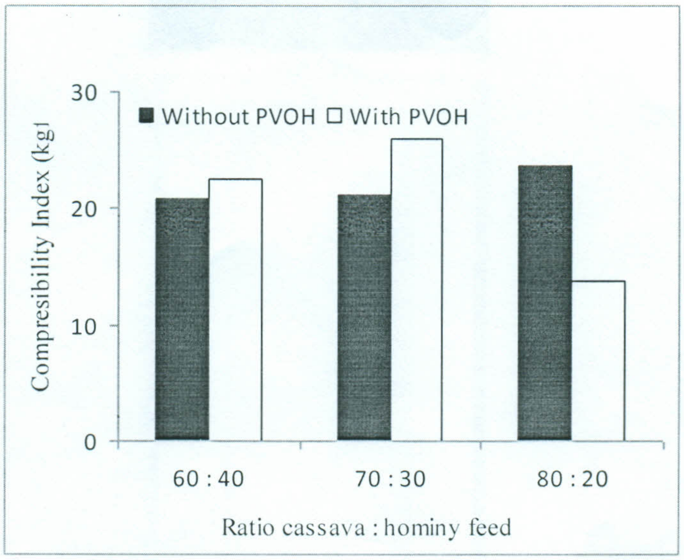

Figure 6 Compressibility of starch foam

4 Conclusion

It was concluded that physical properties of foam resulted in this research was affected by composition of cassava starch and the adding of PVOH. Increasing cassava starch containing in that foam has improve its strengthness and expansion ratio. Contrary, high starch content has decreased the bulk density and compressibility of the foam. PVOH adding in the foam was good to increase the strengthness and compressibility, however less properties in the expansion ratio and bulk density.

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