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To cite this article: A D Khoirina *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **230** 012038

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The effect of proportion of germinated brown rice and tempeh flour on the quality of instant porridge

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Abstract. This study was to investigate the nutritional composition of instant porridge that produced from germinated brown rice and tempeh flour on various proportions and to determine which proportion that gave best nutritional value of instant porridge. Various proportions of composite germinated brown rice and tempeh was extruded at 100°C and feed moisture 1% using *twin-screw extruder*. The experimental design that used in this study was Randomized Block Design using Minitab 16 software with one factor (proportion of germinated brown rice and tempeh flour) and Zeleny method with multiple attribute to determine best nutritional value. The result showed that various proportion of germinated brown rice and tempeh flour gave significant effect ($\alpha=5\%$) on crude proteint, crude fat, carbohydrate content, ash content, brightness color (L^*) and rehydration time and there was no significant effect on moisture content of the instant porridge. Instant porridge with 65% germinated brown rice flour and 35% tempeh flour was the best proportion that contain 3.57% moisture content, 27.83% crude protein, 8.9% crude fat, 57.15% carbohydrate content, 1.51% ash content, 43.6 second of rehydration time and the brightness color on 49.30.

1. Introduction

Instant porridge is quite popular as a substitute for breakfast, because it's easy to consume, quick serve and the most common product that can provide health benefits [1]. Instant porridge is usually made from serealia. In Indonesia, many instant porridge made from white rice, where most of the nutritional components of rice are wasted during the milling process.

Brown rice (BR) is an unpolished rice and still has pericarp, aleuron, embryo and endosperm which contain nutritional components and bioactive compounds [2]. Brown rice has poor cooking properties and low organoleptic quality rather than the white rice [3], it caused the least consumption of brown rice. Germination is a tool that can improve organoleptic and physicochemical characteristics of BR. It's because of germination can increase the absorption rate of water and soften the kernel, and its activates residual enzyme in BR that can lead the formation of various metabolic components that have bioactive function [4].

To enhance the content of other nutrients such as protein, there is an increment of tempeh as a protein source that is easily obtained in large quantities to adjust the nutrition of instant porridge. Whereas, tempeh also contains bioactive compounds such as genestein, daidzein, phytosterol, phytic acid, phenolic acid, lecithin and protease inhibitors [5].



Extrusion is a high temperature short-time (HTST) that can be used to produce instant porridge where the materials are exposed to high temperature (200°C), pressure (more than 20 MPa) in a short period of time [6]. The proportion of germinated brown rice and tempeh will give an effect on the physicochemical characteristic of instant porridge which is made from both ingredients. The purpose of this study is to determine the best ratio of germinated brown rice flour (GBRF) and tempeh flour (TF) which produce high quality instant porridge.

2. Materials and Methods

Ciherang brown rice was obtained from Trenggalek, East Java and fresh soybean tempeh was supplied by tempeh producers at Sanan, Malang. A solution of 0,1% NaOCl and distilled water were used for BR germination. Equipments employed in the experiment includes a cabinet, a grinding machine (PMJ-8, Indo Koyo Machinery, Co.Ltd), a set apparatus for protein analysis, the soxhlet apparatus (Gerhardt GmbH & Co.KG) , a muffle furnace (F47925-80, Termo Scientific Thermolyne). A colorimetric method was used to evaluate the color of the instant porridge powder using color reader (Konica Minolta CECF-9).

Germinated brown rice was prepared based on the previous research conducted by Wu et al. [7] with a slight modification. Brown rice kernels were washed 3 times with running water to remove unwanted material such as gravel, leftover husks and others. After that, the brown rice kernels were soaked in a solution of 0.1% sodium hypochloride (1:5 w/v) for 30 minutes at room temperature (RT) then rinsed and soaked in distilled water (1:5 w/v) for 12 hours at RT. The water was changed every 4 hours. The soaked BR kernels were then strained and distributed on tray previously covered by double layers of cotton cloths, and incubated in a modified germination cabinet at a temperature of $30 \pm 1^\circ\text{C}$, RH $95 \pm 5\%$ for 36 hours. The wet germinated BR was then dried at 60°C for 8 hours using a cabinet dryer to dryness. The dried seeds were finally ground using a grinding machine (PMJ-8, Indo Koyo Machinery Co.Ltd) to pass a 80-mesh (0.180 mm) sieve. The dried germinated BR flour (GBRF) obtained was stored in sealed plastic bags until used.

Fresh soybean tempeh was first sliced to about ± 1 mm thick, and steamed at approximately 95°C for 15 minutes. The steamed tempeh chips were dried at 60°C for 8 hours using cabinet dryer. The dried tempeh chips was then ground using the grinding machine and sieved to pass a 80 mesh sieve. The obtained tempeh flour (TF) was stored in sealed plastic bags until used.

The KEI-25 twin screw extruder (Kowa Kogyo, Co. Ltd) was used. The screw speed, die diameter, barrel temperature, feed rate, and feed water content were 150 ppm, 3mm, 110°C , 14.1 kg/h and 2%, respectively. Both flours (GBR and tempeh) were mixed using a mixer before extruded. Extrudates were cooled at room temperature, packed in polyethylene bags, and later milled using the grinding machine. Finally, the ground extrudate was stored at room temperature in sealed plastic bags until used.

A single factor randomized block design was used for the experiment. A total of five respective ratios of GBRF to TF were examined, namely: 60:40 (F1), 65:35 (F2), 70:30 (F3), 75:25 (F4) and 80:20 (F5). The experiment was conducted in triplicates. The parameters of the experiment were proximate, time of rehydration and brightness color (L^*). Statistical analyses were performed using Minitab version 16.0 and statistical significance was defined at the level of $P < 0.05$.

Proximate analysis of instant porridge was conducted by standard methods in AOAC [8], including moisture content by oven drying at 105°C (AOAC method 925.10), ash content by incineration at a temperature of 600°C (AOAC method 942.05). The level of crude protein was analysed using the Kjeldahl method with a factor of 6.25 and the Soxhlet method was used to determine the content of crude fat. The carbohydrate level was estimated by difference. A rehydration time was carried out according to method of Munawar [9] with a slight modification. The powder sample of porridge (1 g) was added with hot water ($60 - 70^\circ\text{C}$) until the powder perfectly immersed perfectly and then stirred it until a thick porridge was formed. The time required was calculated. Color testing is done by placing the sample in a clear plastic container, then a color reader (Konica Minolta CECF-9) is placed on the surface of the sample. The data collected was statistically analysed using Minitab 16 software.

3. Results and Discussion

3.1. Proximate analysis

The result showed that moisture content of the instant porridge were quite low and similar ranging from 3.16%-3.95%, a typical of extruded products. Extrudates are mostly low in moisture content, as SNI with standard number 2886-2015 said that maximum moisture content in extrudate is 4%. It was not surprising since tempeh flour had moisture content with range 2.50%-3% on three different *Rhizopus* species, while germinated brown rice flour had 7.74%-9.29% moisture content [10].

The result of protein analysis in this study was in the range 21.10%-29.13% (Table 1). The crude protein increased with increasing proportion of tempeh compared to the control (GBR flour instant porridge) (11.38%). It's due to tempeh as source of protein contribute on increasing protein content. Tempeh flour crude protein was in range 44.27%-44.85% on three different *Rhizopus* species, depending on the type of soybean cultivars and the length of tempeh fermentation [11]. The protein content of instant porridge is lower than raw material, it's because of during extrusion, shear forces plays an important role in changing the proteineous materials.

Crude fat in instant porridge was ranged from 4,96 – 10,34%. The fat content of soybeand tempeh was ranged between 21.35 -24.06%, depending on the type of soybean and the length of fermentation process on three different *Rhizopus* species. So, the addition of tempeh flour into instant porridge will increase the fat content. While, SNI 2886-2015 said the maximum of crude fat in extrudate is 30%. The crude fat is lower than raw material, it's because the higher starch content in product causing the loss of lipid. High temperature reduces the lipase and lipoxygenase activity that can decreasing the factor favoring free fatty acid development and oxidation of fatty acid [12].

The ash content in this study was in the range 1.20%-1.62% and it's higher compared to control (1.11%). The increasing of ash content might be due to both of GBRF and TF had high ash content. Tempeh flour had higher ash content than GBRF and it affected on this product when the proportion of tempeh flour increased. The ash content of tempeh flour was 5.61%-5.72% on three different *Rhizopus* species and germinated brown rice had 2.06% of ash content. The ash content in this study was lower than literature; it might be due to several factors, such different variety, production process and analyze procedure.

Carbohydrate was the major component in this porridge because it was produced from one of carbohydrate sources, germinated brown rice. Total carbohydrate in this study was in the range 56.64%-70.05% that was calculated by difference. GBR had 77.7% of total carbohydrate and tempeh flour has 33.52%-33.57% on three different *Rhizopus* species. The total carbohydrate in this study was lower than literature, it might be due to several factors, such as varieties, production process, and analyze procedure.

Rehydration time was related to the ability of porridge particle to absorb water and it depends on the ingredients and water temperature. The rehydration time in this study was in the range 29.07 second/1g – 74.67 second/1g. Table 1 shows that formulation with higher proportion of GBRF had lowest rehydration time. The rehydration time related with water holding capacity that related with starch contained on this instant porridge. According to [13], amylose had capacity to effectively bind water molecule, so when the product contained high starch then it can have faster rehydration time. Beside, in this study was used extrusion to pregelatinise the starch. Extrusion of food with high starch can make gelatinization, partial or complete destruction of crystalline structure and molecular fragmentation of starch polymer [14].

The result of brightness analysis of instan porridge ranged from 47.0 – 52.1. According to Chaiyakul et al. [15], high protein content in raw materials during extrusion cooking process using high temperatures causes the maillard reaction will increase. The higher protein content cause the greater chance of maillard reaction and browning will faster and causes the product brightness to decrease.

Table 1. Characteristics of instant porridge made up from germinated brown rice flour and tempeh flour.

Parameter	GBRF	TF	GBRF:TF Ratio					p-value
			60% : 40%	65% : 35%	70% : 30%	75% : 25%	80% : 20%	
Moisture (%)	8.32	4.20	3.95±0.003	3.57±0.005	3.35±0.001	3.29±0.001	3.16±0.005	0.09
Crude Protein (%)	15.96	41.03	29.13±0.062	27.83±0.107	25.68±0.041	23.19±0.074	21.10±0.024	0.00
Crude Fat (%)	3.01	21.78	10.34±0.004	8.91±0.003	7.36±0.003	6.45±0.001	4.96±0.001	0.00
Ash (%)	2.04	1.74	1.62±0.003	1.51±0.012	1.32±0.012	1.28±0.012	1.20±0.002	0.00
Carbohydrate By Diff (%)	70.66	31.26	56.64±0.151	57.15±0.603	62.99±0.365	66.98±0.181	70.05±0.294	0.00
Rehydration Time (min)	-	-	74.67±1.53	43.60±3.31	42.73±0.45	38.57±0.51	29.07±0.90	0.00
L* value	-	-	47.8±0.208	49.3±0.252	50.4±0.611	51.0±0.153	52.1±0.173	0.00

3.2. Selection of best treatment

Zeleny method with multiple attribute was used to determine best nutritional value in this study. Best nutritional value was obtained in the parameters with smallest L1, L2 and Lmax values of the characteristics. Based on the calculation of the best values, the best proportion of the parameters was obtained in formulation B with proportion of GBRF is 65% and tempeh flour is 35% that contain 3.57% water content, 27.83% protein content, 8.9% fat content, 57.15% carbohydrate content, 1.51% ash content, 43.6 second of rehydration time and the brightness color on 49.30.

4. Conclusion

Various proportion of germinated brown rice and tempeh flour gave significant effect ($\alpha=5\%$) on crude protein, crude fat, carbohydrate content, ash content, brightness color (L*) and rehydration time and there was no significant effect on water content of the instant porridge. Instant porridge with 65% germinated brown rice flour and 35% tempeh flour was the best proportion that contain 3.57% water content, 27.83% protein content, 8.9% fat content, 57.15% carbohydrate content, 1.51% ash content, 43.6 second/1g of rehydration time and the brightness color on 49.30. This proportion can be used to develop the variation of instant porridge with good nutritional value, however its needed to study about the sensory characteristic of this instant porridge.

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