CHAPTER IV

RESULTS

Proximate analysis

The results of proximate analysis of unfermented and fermented soybean residue and soybean calculated in % weight/dry weight basis are shown in Table 1.

Moisture :

The moisture content of soybean residue tooa-nao was the highest (7.2%), whereas those of unfermented soybean residue, soybean tempeh, and soybean tooa-nao were similar. The moisture content of soybean residue tempeh and unfermented soybean were the lowest. There was no significant difference in moisture content between soybean residue tempeh and unfermented soybean.

Crude protein :

From data obtained, it was found that the protein contents of unfermented and fermented soybean were significantly higher than those of unfermented and fermented soybean residue ($p<0.05$). The protein contents of soybean residue tempeh and tooa-nao were significantly higher than that of unfermented soybean residue. The crude protein contents were increase 2.40% and 1.65% in soybean residue tempeh and tooa-nao, respectively. There was no significant difference in protein content between soybean residue tempeh and tooa-nao. We also found that the protein contents of soybean tempeh and tooa-nao increased significantly (2.55% and 1.85%, respectively). However, the increase in protein content of soybean tempeh was higher than that of soybean tooa-nao.

Table 3.1: Proximate composition (%weight/ dry weight basis) of unfermented and fermented soybean residue and soybean

Product	Proximate composition (%w/w) *					
	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate
Soybean residue						
- unfermented	5.67 ± 0.21 [b]	25.45 ± 0.24 [e]	14.97 ± 0.10 [d]	3.33 ± 0.04 [d]	22.93 ± 0.32 [a]	27.65
- tempeh	3.97 ± 0.35 [c]	26.06 ± 0.04 [d]	13.44 ± 0.26 [e]	3.44 ± 0.01 [c]	19.90 ± 0.12 [b]	33.19
- tooa-nao	7.20 ± 0.22 [a]	25.87 ± 0.15 [d]	13.23 ± 0.05 [e]	3.33 ± 0.06 [d]	23.01 ± 0.20 [a]	27.36
Soybean						
- unfermented	4.17 ± 0.27 [c]	38.82 ± 0.11 [c]	22.33 ± 0.15 [b]	4.35 ± 0.01 [b]	7.74 ± 0.23 [d]	22.59
- tempeh	5.41 ± 0.20 [b]	39.81 ± 0.07 [a]	20.52 ± 0.30 [c]	4.41 ± 0.02 [b]	5.49 ± 0.05 [e]	24.36
- tooa-nao	5.28 ± 0.10 [b]	39.54 ± 0.07 [b]	26.58 ± 0.34 [a]	4.57 ± 0.04 [a]	8.44 ± 0.31 [c]	15.59

* Data represent the means of the three replications ± standard deviation

Values bearing different letters in each column differ significantly ($p < 0.05$)

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Crude fat :

As depicted in Table 1, the fat contents of unfermented soybean residue and fermented soybean residue were significantly lower than those of unfermented and fermented soybean. The results showed that the fat contents of soybean residue tempeh and tooa-nao decreased significantly after fermentation. However, there was no significant difference in fat content between soybean residue tempeh and tooa-nao. In addition, we found that the fat content of soybean tempeh was lower than that of unfermented soybean. On the other hand, the fat content of soybean tooa-nao increased significantly from 22.33% to 26.58% after fermentation.

Ash :

Ash contents of unfermented and fermented soybean residue were slightly lower than those of unfermented and fermented soybean. The results showed that ash content of soybean residue tooa-nao was similar to that of unfermented soybean residue. There was slightly increase in ash content when soybean residue were fermented to be soybean residue tempeh. The ash content of soybean tempeh remained unchanged after fermentation. However, the ash content of soybean tooa-nao was slightly higher than those of unfermented soybean and soybean tempeh.

Crude fiber :

As displayed in Table 1, the crude fiber content of unfermented and fermented soybean residue were significantly higher than those of unfermented and fermented soybean. There was a slightly decrease in crude fiber content after fermentation of soybean residue tempeh. However, crude fiber content of soybean residue tooa-nao was not different from the unfermented soybean residue. The crude fiber content of soybean tooa-nao was slightly higher than those of unfermented soybean and soybean tempeh, respectively.

Carbohydrate :

The carbohydrate content of soybean residue tempeh was the highest of all products in this experiment. The carbohydrate contents of unfermented soybean residue and soybean residue tooa-nao were similar. The results also showed that the carbohydrate content of unfermented and fermented soybean residue were higher than those of unfermented and fermented soybean. The carbohydrate content of soybean tooa-nao was lower than those of unfermented soybean and soybean tempeh, respectively.

Moisture (fresh weight basis)

Moisture contents (fresh weight basis) of unfermented and fermented soybean residue and soybean are shown in Table 2. Moisture contents presented in this table were calculated from % weight by fresh weight basis. The results indicated that the moisture contents of unfermented and fermented soybean were significantly higher than those of unfermented and fermented soybean residue. The moisture content of soybean tooa-nao was higher than those of soybean tempeh and unfermented soybean, respectively. However, there were no significant differences in moisture content between unfermented and fermented soybean residue.

Amino acids composition

Amino acids composition of unfermented and fermented soybean residue and soybean were illustrated in Table 3. The data indicated that the contents of all amino acids of soybean products were higher than those of soybean residue products. Most amino acids contents were slightly changed after fermentation (less than 5-10%). It was observed that valine, tyrosine, and phenylalanine contents in soybean residue tempeh increased about 15%, 9%, and 16%, respectively. However, valine contents of soybean residue tooa-nao decreased 13% after fermentation. Despite the decrease in methionine content of soybean

Table 2 : Moisture content (%weight/ fresh weight) of unfermented and fermented soybean residue and soybean

Product	Moisture content (%w/w)*
Soybean residue	
- unfermented	51.73 ± 0.08 [d]
- tempeh	51.86 ± 0.42 [d]
- tooa-nao	51.61 ± 0.16 [d]
Soybean	
- unfermented	56.10 ± 0.18 [c]
- tempeh	56.68 ± 0.20 [b]
- tooa-nao	58.02 ± 0.33 [a]

* Data represent the means of the three replications ± standard deviation
Values bearing different letters in each column differ significantly ($p < 0.05$)

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Table 3 : Amino acids composition (mg/ g protein) of unfermented and fermented soybean residue and soybean

Amino acid	Soybean residue			Soybean		
	unfermented	tempeh	tooa-nao	unfermented	tempeh	tooa-nao
Aspartic acid	33.82	35.36	34.80	55.58	53.76	50.17
Threonine	13.27	13.87	13.61	19.34	19.34	17.20
Serine	17.02	17.66	17.43	25.97	25.16	22.53
Glutamic acid	53.33	54.91	55.12	93.26	90.07	86.03
Proline	26.46	24.46	27.95	40.39	42.29	40.97
Glycine	13.78	14.37	14.45	19.29	19.63	18.27
Alanine	14.05	15.06	14.86	20.04	26.41	19.22
Cystine	5.00	5.33	5.56	8.16	8.21	7.78
Valine	15.05	17.36	12.99	18.26	19.48	23.05
Methionine	4.42	4.67	4.67	6.45	5.67	6.12
Iso-leucine	12.68	13.34	13.40	19.78	20.01	19.35
Leucine	24.55	25.62	25.48	36.41	35.98	36.18
Tyrosine	10.48	11.50	10.36	16.97	15.96	15.68
Phenylalanine	18.05	20.97	18.33	27.64	31.76	27.61
Histidine	7.99	8.31	8.36	12.59	11.62	11.44
Lysine	17.91	18.69	18.42	28.30	26.59	31.60
Arginine	20.80	20.87	20.87	34.57	31.36	29.29
Tryptophan	5.08	5.30	5.30	8.08	7.47	8.35

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tempeh (12%), alanine and phenylalanine contents increase 31% and 15% respectively. We also found that valine and lysine contents of soybean tooa-nao increased 26% and 11% respectively. On the other hand, arginine content of soybean tooa-nao decreased 15%.

To relate the amino acid composition of soybean residue products and soybean products to their nutritive value, the amino acid scores were calculated. The calculated values are shown in Table 4. Amino acid scores of all essential amino acid in soybean residue tempeh were higher than that of unfermented soybean residue. The similar results also were found in soybean residue tooa-nao, except amino acid scores of valine which decreased after fermentation.

For soybean tempeh, the amino acid scores of cystine and methionine, leucine, lysine, and tryptophan decreased during fermentation. However, the amino acid scores of valine, iso-leucine, tyrosine+phenylalanine increased after fermentation. We also found that most of essential amino acid in soybean tooa-nao decreased after fermentation, except valine, lysine, and tryptophan.

Protein digestibility

Protein digestibility of unfermented and fermented soybean residue and soybean are shown in Table 5. The process affected the protein digestibility of soybean residue tempeh significantly. The protein digestibility of soybean residue tempeh rose significantly from 67.68% to 74.95% ($p<0.05$). However, the protein digestibility of unfermented soybean residue, soybean residue tooa-nao, soybean tempeh, and soybean tooa-nao were similar (67.68%, 64.65%, 68.18%, and 66.92%, respectively), and slightly higher than that of unfermented soybean (59.65%).

Table 4 : Amino acid scores of unfermented and fermented soybean residue and soybean

Amino acid	Soybean residue			Soybean		
	unfermented	tempeh	tooa-nao	unfermented	tempeh	tooa-nao
Threonine	33.18	34.68	34.03	48.35	48.35	43.00
Cystine + Methionine	26.91	28.57	29.23	41.74	39.66	39.71
Valine	30.10	34.72	25.98	36.52	38.96	46.10
Iso-leucine	31.70	33.35	33.50	49.45	50.03	48.38
Leucine	35.07	36.60	36.40	52.01	51.40	51.69
Tyrosine + Phenylalanine	47.55	54.12	47.82	74.35	79.53	72.15
Lysine	32.56	33.98	33.49	51.45	48.35	57.45
Tryptophan	50.80	59.50	53.00	80.80	74.70	83.50

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Table 5 : Protein digestibility of unfermented and fermented soybean residue and soybean*

Product	%Related peptide bond hydrolysis**
Soybean residue	
- unfermented	67.68 ± 4.63 [b]
- tempeh	74.95 ± 4.84 [a]
- tooa-nao	64.65 ± 3.64 [bc]
Soybean	
- unfermented	59.65 ± 1.83 [c]
- tempeh	68.18 ± 3.34 [b]
- tooa-nao	66.92 ± 1.07 [b]

* Data represent the means of three replications ± standard deviation

** % Related peptide bond hydrolysis

$$= \frac{\%\text{ peptide bond hydrolysis of sample}}{\%\text{ peptide bond hydrolysis of BSA}} \times 100$$

Values bearing different letters in each column differ significantly ($p<0.05$)

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Vitamins

Vitamin contents of soybean residue tempeh and tooa-nao are presented in Table 6. Thiamin and pantothenic acid contents of soybean residue were not change after fermentation. However, riboflavin, niacin, pyridoxine, and cobalamine contents of soybean residue tempeh increased after fermentation. While niacin content of soybean residue tooa-nao decreased with fermentation, riboflavin, pyridoxine, and cobalamine contents increased during fermentation.

Table 6 : Vitamins of unfermented and fermented soybean residue (weight/ 100 g dry weight)

Vitamins	Soybean residue		
	unfermented	tempeh	tooa-nao
Vitamin B_1 (Thiamin), mg	0.12	0.15	0.10
Vitamin B_2 (Riboflavin), mg	0.17	0.58	0.25
Niacin, mg	0.85	1.41	0.50
Vitamin B_6 (Pyridoxine), mg	0.48	0.77	0.70
Vitamin B_{12} (Cobalamine), mcg	0.99	1.66	1.10
Pantothenic acid, mg	0.37	0.33	0.31

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