

R E S U L T S A N D D I S C U S S I O N

Part I: Effect of some pretreatments (soaking and germination) on the chemical composition and antinutritional components of soybean and faba bean cotyledons.

1. Chemical composition of raw materials:

Results of chemical analyses of the raw materials used of this investigation are shown in Table (1).

Soybean seeds has higher crude protein, non protein nitrogen, ether extract and ash contents (40.11, 0.32, 23.5 and 5.99%, respectively) than those of faba bean seeds (27.13, 0.26, 1.80 and 3.44%, respectively). Faba bean seeds has high available carbohydrates and fiber contents (62.27 and 5.36%, respectively) than those of soybean seeds (26.07 and 4.29%, respectively).

Crude protein content changed significantly ($P < 0.05$) from 40.11 and 27.13% to 42.73 and 31.72% in raw seeds and cotyledons of soybean and faba bean, respectively, but decreased significantly ($P < 0.05$) to 10.57 and 2.07% in hull of soybean and faba bean, respectively.

Non protein nitrogen content changed significantly ($P < 0.05$) from 0.32 and 0.26% to 0.37 and 0.32% in the raw seeds and hull of soybean and faba bean, respectively, but it increased insignificantly ($P > 0.05$) to 0.35% in the

Table (1): Chemical composition of raw seeds, cotyledons and hull of soybean and faba bean (g/100 g, on dry weight basis).

Components	Materials							
	Soybean		Faba bean					
	Raw seeds	Coty- ledons	Hull	L.S.D.	Raw seeds	Coty- ledons	Hull	L.S.D.
Crude protein	40.11	42.73	10.57	1.58	27.13	31.72	2.07	0.78
Non protein nitrogen	a 0.32	ab 0.35	b 0.37	0.04	a 0.26	a 0.25	0.32	0.03
Ether extract	23.54	25.50	1.47	0.53	1.80	1.94	1.03	0.11
Ash	5.99 ^a	6.04 ^a	5.41	0.26	3.44 ^a	3.05 ^a	5.56	0.42
Fiber	4.29	3.05	18.30	0.51	5.36	2.14	22.95	0.53
Available carbohydrates*	26.07	22.68	64.25	2.01	62.27	61.15	68.39	0.95

* Calculated by difference.

a-b There is no significant difference between any two means have the same letter within certain component within the same bean.

cotyledons of soybean. Non protein nitrogen decreased insignificantly ($P>0.05$) to 0.25% in the cotyledons of faba bean.

Ether extract was changed significantly ($P<0.05$) from 23.54 and 1.80% to 25.50 and 1.94% in raw seeds and cotyledons of soybean and faba bean, respectively, but decreased significantly ($P<0.05$) to 1.47 and 1.03% in hull of soybean and faba bean, respectively.

Ash content changed from 5.99 and 3.44 to 6.04 and 3.05%, in raw seeds and cotyledons of soybean and faba bean, respectively. There was no significant difference ($P>0.05$) in ash content of raw seeds and cotyledons of both of soybean and faba bean, respectively. In the same time there was significant difference ($P<0.05$) in ash content of hull and either cotyledons or raw seeds of both of soybean and faba bean. Ash content is 5.41 and 5.56% for hull soybean and faba bean, respectively.

Fiber content was changed significantly ($P<0.05$) from 4.29 and 5.36% to 3.05 and 2.14% in the raw seeds and cotyledons of soybean and faba bean, respectively, but increased significantly ($P<0.05$) to 18.30 and 22.95% in hull of soybean and faba, respectively.

Table (1) also indicated that available carbohydrates were changed significantly ($P < 0.05$) from 26.07 and 62.27% to 22.68 and 61.15% in the raw seeds and cotyledons of soybean and faba bean, respectively, but increased significantly ($P < 0.05$) to 64.25 and 68.39% in hull of soybean and faba bean, respectively. The results obtained are in agreement with the findings of Robinson and Kao (1977), Abd El-Hamid (1980), El-Gharabli et al. (1985).

2. Distribution of chemical constituents in cotyledons and hull of soybean and faba bean:

Results obtained in Table (2) summarized the distribution of chemical constituents in cotyledons and hull of the raw materials used in this study. The ratio between cotyledons and hull was found to be 91.86:8.14 and 84.53:15.47 in soybean and faba bean, respectively. Crude protein, non protein nitrogen, ether extract, ash, fiber and available carbohydrate contents were found to be distributed in higher ratio in cotyledons than in hull of soybean seeds. They distributed in soybean cotyledons in the percentage of 97.86, 90.63, 99.49, 92.65, 65.27 and 79.90%, respectively, against 2.14, 9.38, 0.51, 7.35, 37.73 and 20.06, respectively. With respect to faba bean, cotyledons has the highest distribution ratio of the different constituents except fiber which has distribution ratio of 33.77%. Distribution ratio for crude protein,

Table (2): Distribution of chemical components in cotyledons and hull of soybean and faba bean.

Components	Soybean seeds 100%				Faba bean seeds 100%			
	g	%	g	%	g	%	g	%
Crude protein	39.25	97.86	0.86	2.14	26.81	98.82	0.32	1.18
Non protein nitrogen	0.29	90.63	0.03	9.38	0.21	80.77	0.05	19.23
Ether extract	23.42	99.49	0.12	0.51	1.64	91.11	0.16	8.89
Ash	5.55	92.65	0.44	7.35	2.58	75.00	0.86	25.00
Fiber	2.80	65.27	1.49	37.73	1.81	33.77	3.55	66.23
Available carbohydrates*	20.83	79.90	5.23	20.06	51.69	83.01	10.58	10.99

* Calculated by difference.

non protein nitrogen, ether extract, ash and available carbohydrates are in the percentage of 98.82, 80.77, 91.11, 75.00 and 83.01%, respectively, for cotyledons against 1.18, 19.23, 8.89, 25.00 and 10.99%, respectively for hull of faba bean.

3. Effect of soaking period and germination on chemical composition of soybean and faba bean:

Table (3) shows that moisture content of soaked soybean increased significantly ($P < 0.05$) from 6.24 up to 55.74, 58.38 and 61.53% after soaking for 12, 24 hr and germinating for 24 hr more. Soaking faba bean increased significantly ($P < 0.05$) moisture content from 9.25% to 55.26, 56.22 and 56.92% after soaking for 12, 24 hr and germinating for 24 hr more. Germination for more 24 hr after soaking for 15 hr had a little effect on increasing moisture content of soybean and faba bean. It may be due to continuous absorption of water and swelling of germinating seeds. Anyhow, statistical analysis indicated that this little effect was significantly ($P < 0.05$) for soybean and insignificantly ($P > 0.05$) for faba bean. These results are in agreement with findings of Chen et al. (1977) and Paredes-Lopez and Harry (1989). These results revealed also that soybean seeds absorbed more water than faba bean seeds as it was indicated previously by Krishnamurthy et al. (1958).

Table (3): Effect of soaking period and germination on chemical components of soybean and faba bean cotyledons (g/100 g, on dry weight basis).

Treatments	Soybean				Faba bean				L.S.D.	
	Zero time of soaking	Soaking for 12 hr	Soaking for 24 hr	Germi-nated	L.S.D.	Zero time of soaking	Soaking for 12 hr	Soaking for 24 hr		Germi-nated
Moisture	6.24	55.74	58.38	61.53	0.53	9.25	55.26 ^a	56.22 ^a	56.95 ^a	14.05
Crude protein	42.73 ^{ab}	44.57 ^c	43.17 ^{abc}	42.51 ^a	1.59	31.72	31.18	28.78 ^a	28.84 ^a	0.45
Non protein nitrogen	0.35	0.20 ^a	0.15	0.23 ^a	0.04	0.25	0.14 ^{ab}	0.11 ^a	0.16 ^b	0.03
Ether extract	25.50	23.53 ^a	23.84 ^{ab}	24.00 ^b	0.44	1.94	1.45 ^a	1.50 ^a	1.54 ^a	0.14
Ash	6.04	5.14	4.69	6.69	0.37	3.05 ^{ab}	2.94 ^a	3.25 ^b	4.39	0.29
Fiber	3.05	3.69 ^a	4.05 ^a	4.29 ^a	0.63	2.73 ^a	2.86 ^{ab}	3.08 ^{bc}	3.21 ^c	0.26
Available carbohydrate*	22.28 ^a	23.07 ^{ab}	24.25 ^b	22.51 ^{ab}	1.79	60.56	61.57 ^a	63.39	62.02 ^a	0.61

* Calculated by difference.
a-c There is no significant difference between any two means have the same letter within certain component within the same bean.

Crude protein content increased significantly ($P < 0.05$) from 42.73% at the zero time of soaking to 44.57% after soaking for 12 hr, but it was increased insignificantly ($P > 0.05$) after soaking for 24 hr which was 43.17%. Crude protein decreased significantly ($P < 0.05$) from 31.72% at the zero time of soaking to 31.18, 28.73 and 28.84% after soaking for 12, 24 hr and germinating. Data indicated also that germination process has insignificant effect ($P > 0.05$) on crude protein content which was 42.51% in germinated soybean.

Non protein nitrogen decreased significantly ($P < 0.05$) from 0.35 and 0.25% at the zero time of soaking to 0.20, 0.15, 0.23 and 0.14, 0.11, 0.16% after soaking for 12, 24 hr and germination for 24 hr more of soybean and faba bean, respectively.

With respect to ether extract content, soaking process for 12 hr led to significant decrease ($P < 0.05$) in ether extract from 25.50 and 1.94% to 23.53 and 1.45% for soybean and faba bean, respectively. Increasing soaking to 24 hr has significant effect ($P < 0.05$) on ether extract content which was 23.84 and 1.50% in soybean and faba bean, respectively. Germination process for more 24 hr has significant effect ($P < 0.05$) on ether extract content of soybean, compared to 12 hr soaking, which increased

significantly ($P < 0.05$) to 24.00%. In the same time, germination process for more 24 hr, has insignificant ($P > 0.05$) effect on ether extract content of faba bean which increased insignificantly to 1.54%.

Ash content decreased significantly ($P < 0.05$) from 6.04% in zero time of soaking to 4.69% after soaking for 24 hr of soybean, but it increased significantly ($P < 0.05$) to 6.69% after germination. With respect to faba bean, soaking for either 12 hr or 24 hr has no significant effect ($P > 0.05$) on ash content, while the germination process led to significant increase ($P < 0.05$) in ash content from 3.05 to 4.39%.

Fiber content increased significantly ($P < 0.05$) from 3.05 and 2.73% in zero time of soaking to 4.05 and 3.08% after soaking for 24 hr of soybean and faba bean, respectively. After 24 hr germination fiber content increased to 4.29 and 3.21% of soybean and faba bean, respectively. This increasing is significantly ($P < 0.05$) compared to raw faba bean and it is insignificantly ($P > 0.05$) compared to faba bean soaked for 24 hr.

Available carbohydrates increased significantly ($P < 0.05$) from 22.28 and 60.56% at zero time of soaking to 24.25 and 63.39% after soaking for 24 hr of soybean

and faba bean, respectively. Available carbohydrates increased insignificantly ($P>0.05$) to 22.51% and increased significantly ($P<0.05$) to 62.02% after germination for 24 hr of soybean and faba bean, respectively. The results obtained are in agreement with findings of Suparmo and Markakis (1987), Paredes-Lopez and Harry (1989).

4. Effect of cooking for 30 minutes at 100°C on chemical composition of soybean and faba bean cotyledons:

Data in Table (4) indicated that moisture content increased significantly ($P<0.05$) from 6.24 and 9.25% at zero time of soaking (cotyledons) to 65.98 and 68.22% after cooking without soaking of soybean and faba bean cotyledons, respectively, and increased significantly ($P<0.05$) to 55.22 and 63.55% for soybean cotyledons and 64.57 and 64.37% for faba bean cotyledons after cooking soaked for 12 and 24 hr, respectively. Also moisture content increased significantly ($P<0.05$) to 62.42 and 67.72% of cooked germinated soybean and faba bean cotyledons, respectively.

The increasing in moisture content may be attributed to high absorbed of water of soybean and faba bean during cooking due to coagulation and denaturation of proteins, which were characterized by high water absorption ratio during germination (Abul-Seoud, 1984).

Table (4): Effect of cooking for 30 minutes at 100°C on chemical components of soybean and faba bean cotyledons (g/100 g on dry weight basis).

Treatments Components	Soybean				Faba bean				L.S.D.			
	Coty- ledons without soaking	Cooked without soak- ing	Cooked after 12 hr soaking	Cooked after 24 hr soaking	Coty- ledons without soaking	Cooked without soak- ing	Cooked after 12 hr soaking	Cooked after 24 hr soaking				
Moisture	6.24	65.98	55.22	63.55	62.42	0.49	9.25	68.22	64.57	64.37	67.72	0.85
Crude protein	42.73	42.61	44.19	44.43	44.59	1.60	31.72	32.13	30.12	29.43	28.16	1.47
Non protein nitrogen	0.35	0.29	0.17	0.11	0.18	0.05	0.25	0.20	0.11	0.09	0.13	0.03
Ether extract	25.50	27.87	28.64	28.99	28.62	0.37	1.94	2.28	2.14	2.09	2.47	0.20
Ash	6.04	4.32	4.34	4.39	3.76	0.26	3.05	3.05	2.94	3.18	2.80	0.21
Fiber	3.05	3.78	4.09	4.43	4.62	0.20	2.73	2.98	3.24	3.51	3.76	0.25
Available carbohydrates*	22.28	21.42	18.74	17.76	18.41	2.04	60.56	59.56	61.56	61.79	62.81	1.61

* Calculated by difference.

a-c There is no significant difference between any two means have the same letter within certain component within the same bean.

Cooking of soybean cotyledons without soaking or after soaking for 12 hr has not significant effect ($P>0.05$) on crude protein which is 42.61 and 44.19%, respectively, compared to 42.73% for soybean cotyledons. In the same time cooking of soybean cotyledons after soaking for 24 hr or germination has the same significant effect ($P<0.05$) on crude protein which is 44.43 and 44.59%, respectively. Crude protein of faba bean treatments decreased significantly ($P<0.05$) from 31.72 at zero time of soaking cotyledons to 30.12, 29.43 and 28.16% after cooking of soaked for 12, 24 hr and germinated faba bean cotyledons, respectively, but increased insignificantly ($P>0.05$) to 32.13% after cooking without soaking.

Non protein nitrogen decreased significantly ($P<0.05$) from 0.35 at zero time of soaking of soybean cotyledons to 0.29, 0.17, 0.11 and 0.18% and from 0.25% at zero time of soaking of faba bean cotyledons to 0.20, 0.11, 0.09 and 0.13% after cooking beans without soaking, soaking for 12, 24 hr and germination, respectively.

Ether extract increased significantly ($P<0.05$) from 25.50% at zero time of soaking soybean cotyledons to 27.87, 28.64, 28.99 and 28.62% after cooking without soaking, cooking after soaking for 12 and 24 hr and cooking after germination

respectively. Ether extract of faba bean cotyledons increased significantly ($P < 0.05$) from 1.94% at zero time of soaking faba bean cotyledons to 2.28 and 2.47% after cooking without soaking and cooking after germination, respectively, but there were no significant differences ($P > 0.05$) in ether extract of soybean cotyledons and cooked faba bean cotyledons after soaking for either 12 or 24 hr.

Ash content decreased significantly ($P < 0.05$) from 6.04% of soybean cotyledons to 4.32, 4.34, 4.39 and 3.76% after cooking without soaking, cooking after soaking for 12, 24 hr and cooking after germination soybean cotyledons, respectively. While ash content increased insignificantly ($P < 0.05$) from 3.05% of soybean cotyledons to 3.18% after cooking of soaked 24 hr, but there were no significant differences ($P > 0.05$) between soybean cotyledons and cooked faba bean cotyledon without soaking and after soaking for hr. Germination decreased significantly ($P < 0.05$) to 2.80% after cooking germination faba bean cotyledons.

Fiber content increased significantly ($P < 0.05$) from 3.05% of soybean cotyledons to 3.78, 4.09, 4.43 and 4.62% after cooking without soaking, cooking after soaking for 12, 24 hr and germination, respectively. While fiber content increased significantly ($P < 0.05$) from 2.73% of

faba bean cotyledons to 3.24, 3.51 and 3.76% after cooking of soaked faba bean cotyledons for 12, 24 hr and germinated, respectively, but there was insignificant difference ($P>0.05$) between faba bean cotyledons and cooked faba bean cotyledons without soaking.

Available carbohydrates decreased significantly ($P<0.05$) from 22.28% for soybean cotyledons to 18.74, 17.76 and 18.41% after cooking of soaked for 12, 24 hr. and germinated soybean cotyledons, respectively, while there was no significant difference ($P>0.05$) in available carbohydrates between soybean cotyledons and cooked soybean without soaking. Available carbohydrates increased significantly ($P<0.05$) from 60.56% for faba bean cotyledons to 62.81% after cooking of germinated faba bean cotyledons. Statistical analysis indicated that there are insignificant differences ($P>0.05$) between faba bean cotyledons and cooked one without soaking or after cooking for either 12 hr or 24 hr of soaking. These results obtained as agreement with the findings of Paredes-Lopez and Harry (1989).

5. Antinutritional factors (phytic acid, trypsin inhibitor activity and total vicine):

5.1. Antinutritional content of raw seeds, cotyledons and hull of soybean and faba bean:

Antinutritional substances such as phytic acid, trypsin inhibitor activity and total vicine play an important role in decreasing nutritional value of legume foods. These inhibitors are vary in distribution in anatomical parts of seeds. The effects of dehulling on the rate of phytic acid, trypsin inhibitor activity and total vicine contents were studied that they were determined in raw seeds, cotyledons and hull of soybean and faba bean.

Results in Table (5) show concentration of phytic acid (mg/g), trypsin inhibitor activity [trypsin inhibitor unit (TIU)/mg] and total vicine (mg/g). Soybean seeds had the highest phytic acid and trypsin inhibitor activity, with an average of 10.23 mg/g and 41.09 TIU/mg compared to faba bean which has the lowest content 2.07 mg/g and 21.37 TIU/mg, respectively. These results are in accordance with those obtained by Fernandez et al. (1982). Faba bean seeds had the highest total vicine content with an average 14.16 mg/g compared to soybean which has an amount of 5.15 mg/g.

Phytic acid changed significantly ($P < 0.05$) from 10.23 and 2.07 mg/g in raw seeds of soybean and faba bean to

Table (5): Antinutritional components (phytic acid, trypsin inhibitor activity and total vicine) of raw seeds, cotyledons and hull of soybean and faba bean (on dry weight basis).

Materials	Soybean			Faba bean		
	Raw seeds	Cotyled- ons	Hull L.S.D.	Raw seeds	Cotyled- ons	Hull L.S.D.
Phytic acid (mg/g)	10.23 ^a	10.15 ^a	11.18	2.07 ^a	1.91 ^a	2.97
Trypsin inhibitor activity (TIU/mg)	41.09 ^a	41.92 ^a	41.03 ^a	21.37	22.32	16.16
Total vicine (mg/g)	5.15 ^a	5.17 ^a	4.91	14.16	16.03	3.94

a-b There is no significant difference between any two means have the same letter within certain components with in the same bean.

11.18 and 2.97 mg/g of soybean and faba bean hull, respectively, but it decreased insignificantly ($P > 0.05$) to 10.15 and 1.91 mg/g of soybean and faba bean cotyledons, respectively.

Trypsin inhibitor activity changed insignificantly ($P > 0.05$) from 41.09 TIU/mg in raw seeds to 41.92 TIU/mg of soybean cotyledons, but it decreased insignificantly ($P > 0.05$) to 41.03 TIU/mg of soybean hull. In faba bean, trypsin inhibitor activity increased significantly ($P < 0.05$) from 21.37 TIU/mg of raw seeds to 22.32 TIU/mg of cotyledons, but it decreased significantly ($P < 0.05$) to 16.16 TIU/mg in the hull.

Total vicine changed insignificantly ($P > 0.05$) from 5.15 mg/g in raw seeds to 5.17 mg/g of soybean cotyledons, but decreased significantly ($P < 0.05$) to 4.91 mg/g in soybean hull. In faba bean total vicine increased significantly ($P < 0.05$) from 14.16 mg/g in raw seeds to 16.03 mg/g of cotyledons, but it decreased significantly ($P < 0.05$) to 3.94 mg/g in the hull. These results confirmed the reports indicating the glucose-6-phosphate dehydrogenase deficient favism-sensitive human subjects respond to faba bean seeds (Mager et al., 1969; Liener, 1977 and Abul-Seoud, 1984).

5.2. Distribution of antinutritional factors in cotyledons and hull of soybean and faba bean:

Results obtained in Table (6) also summarized the distribution of phytic acid, trypsin inhibitor activity and total vicine concentration in cotyledons and hull of soybean and faba bean.

The ratio between cotyledons and hull was found to be 91.86 : 8.14 and 84.53 : 15.47 in soybean and faba bean, respectively. Phytic acid, trypsin inhibitor activity and total vicine were found to be distributed in higher ratio in cotyledons than in hull of soybean and faba bean. They distributed in the percentage % of 91.10, 91.87, 92.23 and 77.78, 88.30, 95.69 in cotyledons of soybean and faba bean, respectively, against 8.90, 8.13, 7.77 and 22.22, 11.70, 4.31 in hull of soybean and faba bean, respectively. These results obtained in Table (5 and 6) are in agreement with those obtained by Collier (1976), Jamalian (1978), Abul-Seoud (1984).

5.3. Effect of soaking period and germination on antinutritional factors of soybean and faba bean cotyledons:

Soaking of legume seeds in water is a method used for the purpose of eliminating toxic substances and anti-nutrient, as well for removing the seed coat.

Table (6): Distribution of antinutritional factors (phytic acid, trypsin inhibitor activity and total vicine) in cotyledons and hulls of soybean and faba bean.

Materials	Soybean 100%		Faba bean 100%	
	Cotyledons	Hull	Cotyledons	Hull
Components	%	%	%	%
Phytic acid (mg/g)	9.32	0.91	1.61	0.46
Trypsin inhibitor activity (TIU/mg)	37.75	3.34	18.87	2.50
Total vicine (mg/g)	4.75	0.40	13.55	0.61
			77.78	22.22
			84.53%	15.47%

Results obtained in Table (7) showed that soaking soybean and faba bean seeds in water for 12 and 24 hr caused losses of phytic acid, trypsin inhibitor activity and total vicine.

Phytic acid, trypsin inhibitor activity and total vicine decreased significantly ($P < 0.05$) from 10.15 mg/g, 41.92 TIU/mg 5.17 mg/g and 1.91 mg/g, 22.32 TIU/mg, 16.03 mg/g at zero time of soaking of soybean and faba bean cotyledons, respectively to 8.97, 8.71 mg/g; 37.90, 28.25 TIU/mg; 4.13, 3.08 mg/g and 1.68, 1.65 mg/g; 18.52, 15.53 TIU/mg 14.20, 11.39 mg/g after soaking for 12 and 24 hr of soybean and faba bean cotyledons, respectively.

Residual amount of phytic acid, trypsin inhibitor activity and total vicine in soybean cotyledons after soaking for 24 hours reached 85.81, 67.36 and 59.57%, respectively of its origins, before the soaking process. While the residual amount of phytic acid, trypsin inhibitor activity and total vicine in faba bean cotyledons after soaking for 24 hr reached 86.39, 69.58 and 71.05%, respectively of its origins, before the soaking process. These results agree with those obtained by Fernandez *et al.* (1982), Abul-Seoud (1984), Paredes-Lopez and Harry (1989).

High loss of total vicine in soybean might be due to low thickness of seed coat, high water permeability

Table (7): Effect of soaking period and germination on antinutritional factors (phytic acid, trypsin inhibitors activity and total vicine of soybean and faba bean cotyledons (on dry weight basis).

Treatments	Soybeans			Faba bean						
	Zero soaking time of soaking 12 hr	Soaking for 24 hr	Germi-nated L.S.D.	Zero soaking time of soaking 12 hr	Soaking for 24 hr	Germi-nated L.S.D.				
Phytic acid (mg/g)	10.15	8.97 ^a	8.71 ^a	8.64 ^a	0.38	1.91	1.68 ^a	1.65 ^a	1.61 ^a	0.22
Residual (%)	100.00	88.37	85.81	85.12	100.00	87.96	86.39	84.29		
Trypsin inhibitor activity (TIU/mg)	41.92	37.90	28.25	39.29	0.57	22.32	18.52	15.53	19.06	0.18
Residual (%)	100.00	90.37	67.36	93.68	100.00	82.97	69.58	85.39		
Total vicine (mg/g)	5.17	4.13	3.08	4.45	0.17	16.03	14.20	11.39	13.10	0.38
Residual (%)	100.00	79.88	59.57	86.07	100.00	88.58	71.05	81.72		

^a There is no significant difference between any two means have the same letter within certain components within the same bean.

through cells of seeds, high swelling capacity of seeds and relatively high solubility of vicine in water. These reasons might increased leaching of vicine out of soybean as compared with faba bean (Kakade and Evans, 1966).

The preparation of germinated soybean and faba bean were carried out by soaking soybean and faba bean seeds in water for 15 hr followed by germination for 24 hr. This experiment was carried out to study the effect of germination on phytic acid, trypsin inhibitor activity and total vicine of both two kinds of legume seeds.

Results in Table (7) also showed that germination decreased significantly ($P < 0.05$) phytic acid, trypsin inhibitor activity and total vicine to 8.64 mg/g, 39.29 TIU/mg; 4.45 mg/g and 1.61 mg/g, 19.06 TIU/mg, 13.10 mg/g of germinated soybean and faba bean cotyledons, respectively, compared to results before soaking.

Germination led to slight increase of residual trypsin inhibitor activity and total vicine from 67.36 and 59.57% after soaking for 24 hr to 93.68 and 86.07%, respectively in germinating soybean cotyledons for 24 hr. Also germination led to slight increase of residual trypsin inhibitor and total vicine from 69.58 and 71.05% after soaking for 24 hr to 85.39 and 81.72%, respectively in germinating faba bean cotyledons for 24 hours.

Germination led to slight decrease of residual phytic acid from 85.81 and 86.39% after soaking for 24 hr to 85.12 and 84.29% in germinating soybean and faba bean cotyledons, respectively.

These results are in agreement with those obtained by Collins and Sanders (1976), Liener and Kakade (1980), Abdullah et al. (1984), Abul-Seoud (1984).

5.4. Effect of cooking for 30 minutes on antinutritional factors of soybean and faba bean cotyledons:

Results in Table (8) indicated that cooking soybean and faba bean cotyledons in boiling water for 30 min. at 100°C decreased significantly ($P < 0.05$) phytic acid, trypsin inhibitor activity and total vicine contents. The concentration of these component decreased from 10.15 mg/g, 41.92 TIU/mg and 5.17 mg/g at zero time of soaking soybean cotyledons to 9.03, 33.25, 3.21; 8.64, 23.34, 2.81; 8.36, 19.28, 2.01 and 8.42 mg/g, 22.66 TIU/mg, 2.95 mg/g after cooking without soaking, cooking after soaking for 12, 24 hr and cooking after germination soybean cotyledons, respectively.

In the same time the concentration of these component decreased from 1.91 mg/g, 22.32 TIU/mg and 16.03 mg/g at zero time of soaking faba bean cotyledons to 1.72, 16.12,

Table (8): Effect of cooking for 30 minutes at 100°C on antinutritional factors (phytic acid, trypsin inhibitor activity and total vicine of soybean and faba bean cotyledons (on dry weight basis).

Treatments	Soybeans				Faba bean				
	Coty- ledons without soaking	Cooked without soaking	Cooked after 12 hr soaking	Cooked after 24 hr soaking	Coty- ledons without soaking	Cooked without soaking	Cooked after 12 hr soaking	Cooked after 24 hr soaking	Cooked after germination
Phytic acid (mg/g)	10.15	9.03	8.64	8.36	10.15	1.72	1.56	1.51	1.54
Residual (%)	100.00	88.97	85.12	82.36	100.00	90.05	81.68	79.06	80.63
Trypsin inhibitor activity (TIU/mg)	41.92	33.25	23.34	19.28	22.32	16.12	12.85	11.60	14.25
Residual (%)	100.00	79.28	55.65	45.97	100.00	72.22	57.57	51.97	63.84
Total vicine (mg/g)	5.17	3.21	2.81	2.01	16.03	8.64	8.24	6.39	7.56
Residual (%)	100.00	62.09	54.35	38.88	100.00	53.90	51.40	39.86	47.16

a-b There is no significant difference between any two means have the same letter within certain components within the same bean.

8.64; 1.56, 12.85, 8.24; 1.51, 11.60, 6.39 and 1.54 mg/g, 14.25 TIU/mg, 7.56 mg/g after cooking without soaking, cooking after soaking for 12, 24 hr and cooking after germination faba bean cotyledons, respectively.

Obviously, residual phytic acid, trypsin inhibitor activity and total vicine of soybean and faba bean decreased to 82.36, 45.97, 38.88% and 79.06, 51.97, 39.86% after cooking of soaked for 24 hr, of soybean and faba bean cotyledons, respectively.

The destruction of trypsin inhibitor activity in both soybean and faba bean cotyledons due to cooking may be attributed to destroying or inactivation, but not to leaching out of the beans. These result could be assured by determining trypsin inhibitor activity of the obtained soup.

These results were assured by those obtained by Sudarmadji and Markakis (1977), Delumen and Salamat (1980), Tan and Wong (1982), Abul-Seoud (1984), Paredes-Lopez and Harry (1989).

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Part II. Optimization of factors affecting fermentation in production of tempeh from soybean and faba bean cotyledons:

Stainless steel trays (0.35x0.30x0.05 m) with a holding capacity of 0.8 kg (7.62 kg/m²) were designed and fabricated for the production of soybean and faba bean tempehs. Rhizopus oligosporus CAIM 182 was used for fermentation process and factors affecting pilot plant fermentation i.e. pretreatments of soybean and faba bean cotyledons; soaking period, germination process, incubation temperature and incubation period (fermentation time); were studied. Changes occurring in chemical composition, chemical freshness parameters and antinutritional factors were studied to select the excellent treatment of tempeh produced from soybean or faba bean.

1. Chemical composition of soybean or faba bean tempehs:

The pretreatment soybean and faba bean cotyledons were inoculated with spores suspension of the mold Rhizopus oligosporus and incubated at 25°, 31° and 37°C for 0, 24, 36, 48, 60 and 72 hr to investigate the changes in chemical constituents (moisture, crude protein, non protein nitrogen, true protein, ether extract, ash, fiber and available carbohydrate contents) of tempeh product.

1.1. Changes in moisture content:

Data in Tables (9 and 10) shows the changes in moisture content of tempeh produced from soybean and faba bean cotyledons, respectively during fermentation.

Statistical analysis indicated that there are more or less significant differences in moisture content of soybean and faba bean tempehs between the different treatments. Also, comparing between incubation temperatures generally or within the different treatments and between incubation periods generally or within different treatments in either soybean or faba bean tempeh indicated that there is no finile correlation between either incubation temperatures or incubation periods in moisture content of produced soybean or faba bean tempehs. This could be reffered to fluctuate in relative humidity of the incubator which was ranged between 55 and 70%. Anyhow, moisture content ranged between 52.01 and 64.79% for tempeh produced from unsoaked soybean at 31°C incubation temperature for 60 hr and tempeh produced from germinated soybean at 37°C incubation temperature for 36 hr, respectively. Results of Paredes-Lopez and Harry (1989) also presented fluctuation in moisture content of faba bean tempeh during incubation periods. These results indicated that moisture content ranged between 49.70 to 63.3 for tempeh produced from faba bean at 37°C for 12 and 72 hr incubation periods,

Table (9): Changes in moisture content during tempeh fermentation produced from soybean (g/100 g).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	65.98	58.74	56.71	58.00	60.63	59.11	59.86
	31	65.98	55.52	53.73	56.23	52.01	63.23	57.78
	37	65.98	60.37	63.40	63.16	53.90	62.60	61.57
	Mean	65.98	58.21	57.95	59.13	55.51	61.65	59.74
Soaking for 12 hr, dehulled and cooked	25	55.22	55.75	57.26	55.23	54.12	59.58	56.19
	31	55.22	57.92	62.23	57.91	58.55	58.25	58.36
	37	55.22	62.31	59.65	63.48	63.53	56.20	60.07
	Mean	55.22	58.66	59.75	58.87	58.73	58.01	58.21
Soaking for 24 hr, dehulled and cooked	25	63.55	60.59	62.26	61.78	58.41	59.45	61.01
	31	63.55	58.11	57.25	56.74	57.70	56.21	58.26
	37	63.55	63.69	59.51	63.02	63.20	60.66	62.27
	Mean	63.55	60.80	59.67	60.51	59.77	58.77	60.51
Germinated, dehulled and cooked	25	62.42	59.72	62.85	63.12	59.45	61.57	61.52
	31	62.42	57.33	60.08	60.79	57.67	61.56	59.98
	37	62.42	63.46	64.79	64.00	56.52	63.18	62.40
	Mean	62.42	60.17	62.57	62.64	57.88	62.10	61.30
Mean of incubation period		61.79	59.46	59.99	60.29	57.97	60.13	59.94

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	59.65	58.59	61.58

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.95
- L.S.D. between means of any two incubation temperature = 1.08
- L.S.D. between means of any two incubation period = 0.60
- L.S.D. between means of any two incubation temperature/treatment = 0.99
- L.S.D. between means of any two incubation period/treatment = 2.17
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.66.

Table (10): Changes in moisture content during tempeh fermentation produced from faba bean (g/100 g).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	68.22	67.48	66.87	67.88	69.14	67.82	67.90
	31	68.22	64.98	67.34	70.67	64.33	72.11	67.94
	37	68.22	69.95	72.52	74.25	75.24	76.06	72.71
	Mean	68.22	67.47	68.91	70.93	69.37	72.00	69.52
Soaking for 12 hr, dehulled and cooked	25	64.57	66.20	66.41	63.09	66.27	63.74	65.05
	31	64.57	65.35	65.56	55.75	66.06	61.06	63.06
	37	64.57	68.36	70.87	70.32	73.87	71.95	69.99
	Mean	64.57	66.64	67.61	63.05	68.73	65.58	66.03
Soaking for 24 hr, dehulled and cooked	25	64.37	62.28	65.32	59.61	59.57	63.87	62.50
	31	64.37	65.92	64.70	62.15	64.48	67.43	64.89
	37	64.37	68.41	67.21	69.71	73.92	73.92	69.51
	Mean	64.37	65.54	65.74	63.82	65.99	68.24	65.63
Germinated, dehulled and cooked	25	67.72	64.26	62.60	60.66	63.10	62.47	63.47
	31	67.72	63.06	62.61	63.99	62.64	62.77	63.80
	37	67.72	66.53	68.53	69.37	67.75	69.86	68.29
	Mean	67.72	64.62	64.58	64.67	64.50	65.03	65.19
Mean of incubation period		66.22	66.07	66.71	65.62	67.20	67.71	66.59

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	64.73	64.92	70.13

L.S.D. ($P < 0.05$):

- L.S.D. between means of any two treatments = 0.32
- L.S.D. between means of any two incubation temperature = 0.28
- L.S.D. between means of any two incubation period = 0.17
- L.S.D. between means of any two incubation temperature/treatment = 0.42
- L.S.D. between means of any two incubation period/treatment = 0.59
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.29

respectively. In the same time results of Agosin et al. (1989) indicated that moisture content ranged between 67.8 to 69.4% for Lupine tempeh at 30°C for 12 and 45 hr incubation periods, respectively.

1.2. Changes in crude protein:

Changes in crude protein content during tempeh production from soybean or faba bean cotyledons are presented in Tables (11 and 12), respectively.

Statistical analysis showed that crude protein content of soybean tempeh increased significantly ($P < 0.05$) to 48.97, 49.45 and 47.95% due to soaking process for 12 and 24 hr and germination process, respectively compared to 46.22% of tempeh produced from soybean without soaking. In contrast, crude protein content of faba bean tempeh decreased significantly to 34.12, 34.08 and 30.90% due to soaking process for 12 and 24 hr and germination process, respectively, compared to 36.69% crude protein content of tempeh produced from faba bean without soaking.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) in crude protein content of either soybean or faba bean tempehs from 47.66 and 31.23 to 48.44 and 33.67, and 48.34 and 36.95%, respectively.

Table (11): Changes in crude protein content during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)					Mean	
		0	24	36	48	60		72
Dehulled without soaking and cooked	25	42.61	44.53	46.83	46.41	46.84	47.08	45.72
	31	42.61	43.16	49.73	47.28	49.35	49.80	46.99
	37	42.61	44.72	46.56	47.81	46.75	47.17	45.94
	Mean	42.61	44.14	47.72	47.17	47.65	48.02	46.22
Soaking for 12 hr, dehulled and cooked	25	44.20	46.97	46.21	47.49	49.47	55.32	48.28
	31	44.20	49.99	49.92	49.48	52.84	55.54	50.33
	37	44.20	48.60	48.56	48.77	50.61	49.10	48.31
	Mean	44.20	48.52	48.23	48.68	50.97	53.22	48.97
Soaking for 24 hr, dehulled and cooked	25	44.43	49.58	48.58	49.48	49.55	48.83	48.41
	31	44.43	47.67	49.04	48.85	50.73	53.21	48.99
	37	44.43	49.14	51.72	52.21	55.18	52.94	50.94
	Mean	44.43	48.80	49.78	50.18	51.82	51.66	49.45
Germinated, dehulled and cooked	25	44.59	46.25	50.58	49.87	47.62	50.55	48.24
	31	44.59	45.56	48.61	47.63	47.17	50.99	47.43
	37	44.59	47.50	51.52	49.71	46.50	49.17	48.17
	Mean	44.59	46.44	50.24	49.07	47.10	50.24	47.95
Mean of incubation period		43.96	46.98	48.99	48.78	49.39	50.79	48.15

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	47.66	48.44	48.34

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.94

L.S.D. between means of any two incubation temperature = 1.01

L.S.D. between means of any two incubation period = 0.89

L.S.D. between means of any two incubation temperature/treatment = 1.71

L.S.D. between means of any two incubation period/treatment = 2.07

L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.62

Table (12): Changes in crude protein content during tempeh fermentation produced from faba bean (g/100 g on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	32.13	32.83	33.49	31.23	34.01	35.90	33.27
	31	32.13	34.38	35.64	37.05	40.38	42.84	37.07
	37	32.13	32.17	34.78	42.87	47.82	48.67	39.74
	Mean	32.13	33.13	34.64	37.05	40.74	42.47	36.69
Soaking for 12 hr, dehulled and cooked	25	30.12	32.35	30.53	29.69	31.51	31.59	30.97
	31	30.12	35.12	33.92	28.52	32.29	36.14	32.69
	37	30.12	33.81	37.04	41.26	43.91	46.13	38.71
	Mean	30.12	33.76	33.83	33.16	35.90	37.95	34.12
Soaking for 24 hr, dehulled and cooked	25	29.43	33.09	30.14	31.27	28.66	31.18	30.63
	31	29.43	35.08	36.12	36.02	34.58	37.70	34.82
	37	29.43	32.94	32.59	39.41	40.40	46.00	36.78
	Mean	29.43	33.70	32.95	35.53	34.55	38.29	34.08
Germinated, dehulled and cooked	25	28.16	29.52	33.22	28.96	27.88	32.54	30.05
	31	28.16	30.25	31.08	28.50	30.34	32.30	30.11
	37	28.16	30.82	35.31	33.35	31.39	36.29	32.55
	Mean	28.16	30.20	33.20	30.27	29.87	33.71	30.90
Mean of incubation period		29.96	32.70	33.66	34.00	35.27	38.11	33.95

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	31.23	33.67	36.95

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 1.29
- L.S.D. between means of any two incubation temperature = 0.92
- L.S.D. between means of any two incubation period = 0.60
- L.S.D. between means of any two incubation temperature/treatment = 1.61
- L.S.D. between means of any two incubation period/treatment = 2.10
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.32

Data revealed that crude protein content in soybean tempeh increased significantly ($P < 0.05$) from 43.96 to 46.98, 48.99, 48.78, 49.39 and 50.79% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. The same trend was obtained in faba bean tempeh, whereas crude protein content increased significantly ($P < 0.05$) from 29.96 to 32.70, 33.66, 34.00, 35.27 and 38.11% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively.

Statistical analysis indicated that there are more or less differences between either incubation temperatures or incubation periods within the different treatments, in crude protein of soybean or faba bean tempehs. Anyhow crude protein ranged between 43.16 and 55.54% for tempeh produced from soybean without soaking incubated at 31°C for 24 hr and soybean soaked for 12 hr incubated at 31°C for 72 hr, respectively, compared to 42.61 and 44.19% for the same treatments before carrying out the fermentation process, respectively. With respect to faba bean tempeh, crude protein ranged between 27.88 to 48.67% for tempeh produced from germinated faba bean incubated at 25°C for 60 hr and faba bean without soaking incubated at 37°C for 72 hr, respectively, compared to 28.16 and 32.13% for the same treatments before carrying out the fermentation process, respectively. L.S.D. between any two values of

crude protein of soybean and faba bean tempehs at given incubation period within incubation temperature within treatment are 3.62 and 3.32, respectively.

It is important to decide here that crude protein was calculated as $N\% \times 6.25$. The 6.25 nitrogen factor led to an over estimation of the bean protein content. However, it was used since most of the workers in this area use this factor (Paredes-Lopez and Harry, 1989). On the other hand, results of Paredes-Lopez and Harry (1989) indicated that protein content ranged between 25.30 to 31.50 in tempeh produced from soaked faba bean for 15 hr before and after fermentation period of 72 hr at 37°C, respectively. With respect to soybean tempeh, results of Kuo et al. (1989) indicated that tempeh produced from soaked soybean 12-15 hr, incubated at 28-30°C for 24 hr, included 47.0% crude protein on the base of 6.25 nitrogen factor. This means that obtained results in the present investigation in good agreement with finding of Lin (1980) and previous mentioned results.

1.3. Changes in non protein nitrogen:

Data in Tables (13 and 14) indicate the changes in non protein nitrogen (NPN) of tempeh produced from soybean or faba bean cotyledons, respectively.

Statistical analysis indicated that germination process in soybean only led to significant increase ($P < 0.05$) in

NPN of soybean tempeh, while it has not significant effect ($P>0.05$) on NPN of faba bean tempeh. In the same time soaking process for either 12 or 24 hr has no significant effect ($P>0.05$) on NPN of both soybean and faba bean tempehs.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P<0.05$) in NPN of soybean and faba bean tempehs from 0.43 and 0.40% to 0.48 and 0.50% and 0.54 and 0.64%, respectively. Statistical analysis indicated the same trend for the effect of incubation temperature on NPN of faba bean tempeh within the different treatments that increasing incubation temperature led to significant increase ($P<0.05$) in NPN. On the other hand, there are more significant differences ($P<0.05$) or insignificant differences ($P>0.05$) in NPN of soybean tempeh between incubation temperatures within the different treatments.

Data revealed that NPN in soybean tempeh increased significantly ($P<0.05$) from 0.19% to 0.32, 0.41, 0.48, 0.66 and 0.83% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. The same trend was obtained in the case of faba bean tempeh. Comparing between incubation periods within any treatment of either soybean or faba bean tempehs indicated the same trend that

Table (13): Changes in non protein nitrogen during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.29	0.29	0.33	0.37	0.45	0.63	0.39
	31	0.29	0.35	0.41	0.44	0.66	0.79	0.49
	37	0.29	0.39	0.46	0.52	0.63	0.78	0.51
	Mean	0.29	0.34	0.40	0.44	0.58	0.73	0.46
Soaking for 12 hr, dehulled and cooked	25	0.17	0.29	0.29	0.35	0.57	0.85	0.42
	31	0.17	0.42	0.42	0.50	0.71	0.93	0.53
	37	0.17	0.46	0.47	0.53	0.68	0.82	0.52
	Mean	0.17	0.39	0.39	0.46	0.65	0.87	0.49
Soaking for 24 hr, dehulled and cooked	25	0.11	0.27	0.27	0.39	0.60	0.75	0.40
	31	0.11	0.19	0.26	0.37	0.64	0.82	0.40
	37	0.11	0.31	0.48	0.62	0.83	0.93	0.55
	Mean	0.11	0.26	0.34	0.46	0.69	0.83	0.45
Germinated, dehulled and cooked	25	0.18	0.27	0.48	0.52	0.69	0.85	0.50
	31	0.18	0.28	0.43	0.48	0.69	0.91	0.50
	37	0.18	0.36	0.57	0.62	0.76	0.93	0.57
	Mean	0.18	0.30	0.49	0.54	0.71	0.90	0.52
Mean of incubation period		0.19	0.32	0.41	0.48	0.66	0.83	0.48

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.43	0.48	0.54

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.04
- L.S.D. between means of any two incubation temperature = 0.03
- L.S.D. between means of any two incubation period = 0.03
- L.S.D. between means of any two incubation temperature/treatment = 0.07
- L.S.D. between means of any two incubation period/treatment = 0.06
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.11

Table (14): Changes in non protein nitrogen during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.20	0.23	0.34	0.42	0.53	0.62	0.39
	31	0.20	0.32	0.40	0.63	0.74	0.86	0.53
	37	0.20	0.23	0.52	0.81	0.95	1.02	0.64
	Mean	0.20	0.29	0.42	0.62	0.74	0.83	0.52
Soaking for 12 hr, dehulled and cooked	25	0.11	0.29	0.38	0.50	0.64	0.77	0.45
	31	0.11	0.30	0.40	0.35	0.65	0.88	0.45
	37	0.11	0.26	0.53	0.79	0.96	1.05	0.62
	Mean	0.11	0.28	0.44	0.55	0.75	0.90	0.51
Soaking for 24 hr, dehulled and cooked	25	0.09	0.24	0.28	0.38	0.44	0.62	0.34
	31	0.09	0.30	0.42	0.67	0.75	0.89	0.52
	37	0.09	0.35	0.48	0.87	0.97	1.12	0.65
	Mean	0.09	0.30	0.39	0.64	0.72	0.88	0.50
Germinated, dehulled and cooked	25	0.13	0.24	0.39	0.47	0.53	0.82	0.43
	31	0.13	0.30	0.41	0.47	0.72	0.92	0.49
	37	0.13	0.38	0.59	0.71	0.74	1.24	0.63
	Mean	0.13	0.31	0.46	0.55	0.66	0.99	0.52
Mean of incubation period		0.13	0.30	0.43	0.59	0.72	0.90	0.51

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.40	0.50	0.64

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.06

L.S.D. between means of any two incubation temperature = 0.03

L.S.D. between means of any two incubation period = 0.03

L.S.D. between means of any two incubation temperature/treatment = 0.08

L.S.D. between means of any two incubation period/treatment = 0.08

L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.13

NPN is significantly increased ($P < 0.05$) with increasing of incubation period.

Anyhow NPN in soybean tempeh ranged between 0.19 and 0.93%. The lower limit belongs to tempeh produced from soaked soybean for 24 hr, incubated at 31°C for 24 hr compared to 0.11 for the same treatment before carrying out fermentation process. The upper limit belongs to tempeh produced from soaked soybean for 24 hr and germinated soybean incubated at 37°C for 72 hr compared to 0.11 and 0.18% for the same treatments before carrying out fermentation process, respectively. This upper limit also belongs to tempeh produced from soaked soybean for 12 hr, incubated at 31°C for 72 hr compared to 0.17% for the same treatment before carrying out fermentation process. In the case of faba bean tempeh, NPN, ranged between 0.23 and 1.24% for tempeh produced from faba bean without soaking incubated at 25°C for 24 hr and germinated faba bean incubated at 37°C for 72 hr compared to 0.20 and 0.13% for the same treatments before carrying out fermentation process, respectively.

These results are in good agreement with finding of Kuo et al. (1989) and Paredes-Lopez and Harry (1989). NPN was 0.4% in tempeh produced from soaked soybean for 12-15 hr, incubated at 28-30°C for 24 hr (Kuo et al., 1989).

It was 1.17% in tempeh produced from soaked faba bean overnight, incubated at 37°C for 72 hr (Paredes-Lopez and Harry, 1989).

1.4. Changes in true protein content:

Changes in true protein content during tempeh production from soybean or faba bean cotyledons are presented in Tables (15 and 16), respectively.

Statistical analysis indicated that true protein in soybean tempeh increased significantly ($P < 0.05$) to 45.91, 46.60 and 44.70% due to soaking process for 12, 24 hr and germination process compared to 43.29% of tempeh produced from soybean without soaking. On the other hand, true protein in faba bean tempeh decreased significantly ($P < 0.05$) to 30.97, 30.92 and 27.60% in tempeh produced after soaking process for 12, 24 hr and germination process, respectively compared to 33.47% of tempeh produced from faba bean without soaking. The same trend was observed in crude protein.

It could be noticed that increasing incubation temperature from 25° to 37 led to significant increase ($P < 0.05$) in true protein of soybean or faba bean tempehs from 44.96 and 28.71% to 46.23 and 32.95%, respectively. Data indicated that increasing incubation temperature from 25°C to 37°C within different treatments of soybean or

Table (15): Changes in true protein during tempeh fermentation produced from soybean (g/100 g, on dry weight basis)*

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	40.80	42.72	44.77	44.07	44.01	42.79	43.19
	31	40.80	40.98	47.18	44.56	45.25	44.87	43.94
	37	40.80	42.26	43.71	44.58	42.84	42.28	42.75
	Mean	40.80	41.99	45.22	44.40	44.03	43.31	43.29
Soaking for 12 hr, dehulled and cooked	25	43.14	45.13	44.43	45.28	45.90	49.99	45.65
	31	43.14	47.39	47.28	46.66	48.40	49.33	47.03
	37	43.14	45.74	45.62	45.46	46.34	43.99	45.05
	Mean	43.14	46.09	45.78	45.80	46.88	47.77	45.91
Soaking for 24 hr, dehulled and cooked	25	43.72	47.89	46.87	46.50	45.80	44.12	45.82
	31	43.72	46.46	47.39	46.54	46.55	48.09	46.46
	37	43.72	47.21	48.70	48.34	49.99	47.11	47.51
	Mean	43.72	47.19	47.65	47.13	47.45	46.44	46.60
Germinated, dehulled and cooked	25	43.44	44.75	47.56	46.64	43.33	45.26	45.16
	31	43.44	43.81	45.95	44.65	42.85	45.32	44.34
	37	43.44	45.25	47.98	45.83	41.75	43.36	44.60
	Mean	43.44	44.60	47.16	45.71	42.64	44.65	44.70
Mean of incubation period		42.78	44.97	46.45	45.76	45.25	45.54	45.13

* Determined by difference between total nitrogen and non protein nitrogen.

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	44.96	45.44	46.23

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.88
- L.S.D. between means of any two incubation temperature = 0.82
- L.S.D. between means of any two incubation period = 0.90
- L.S.D. between means of any two incubation temperature/treatment = 1.60
- L.S.D. between means of any two incubation period/treatment = 1.86
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 3.26

Table (16): Changes in true protein during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis)*.

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	30.86	31.52	31.37	28.59	30.70	32.01	30.84
	31	30.86	32.39	33.17	33.03	35.76	37.49	33.78
	37	30.86	30.11	31.67	37.87	41.91	42.30	35.79
	Mean	30.86	31.34	32.07	33.16	36.12	37.27	33.47
Soaking for 12 hr, dehulled and cooked	25	29.41	30.56	28.16	26.57	27.51	26.78	28.17
	31	29.41	33.27	31.47	26.35	28.20	30.66	29.89
	37	29.41	32.16	33.73	36.34	37.84	39.55	34.84
	Mean	29.41	32.00	31.12	29.75	31.18	32.33	30.97
Soaking for 24 hr, dehulled and cooked	25	28.86	31.59	28.37	28.88	25.89	27.30	28.48
	31	28.86	33.18	33.47	31.86	29.88	32.12	31.56
	37	28.86	30.73	29.57	33.87	34.34	39.01	32.73
	Mean	28.86	31.83	30.47	31.54	30.04	32.81	30.92
Germinated, dehulled and cooked	25	27.33	28.00	30.81	26.00	24.57	27.29	27.33
	31	27.33	28.38	28.54	25.56	25.82	26.58	27.04
	37	27.33	28.43	31.31	28.94	26.76	27.79	28.43
	Mean	27.33	28.24	30.22	26.83	25.72	27.22	27.60
Mean of incubation period		29.12	30.86	30.94	30.32	30.77	32.41	30.74

* Determined by difference between total nitrogen and non protein nitrogen.

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	28.71	30.57	32.95

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 1.27
- L.S.D. between means of any two incubation temperature = 0.55
- L.S.D. between means of any two incubation period = 0.84
- L.S.D. between means of any two incubation temperature/treatment = 1.55
- L.S.D. between means of any two incubation period/treatment = 1.99
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.09

faba bean was almost accompanied with significant increase ($P < 0.05$) in true protein.

True protein in soybean and faba bean tempehs increased significantly ($P < 0.05$) from 42.78 and 29.12% to 45.54 and 32.41%, respectively by increasing incubation period from 0 to 72 hr. Comparing between incubation periods within any treatment of either soybean or faba bean tempehs indicated the same trend that true protein is significantly increased ($P < 0.05$) with increasing incubation period, except for tempeh produced from germinated faba bean which true protein decreased insignificantly ($P > 0.05$) with increasing incubation period after 36 hr.

Statistical analysis indicated that there are more or less differences between either incubation temperatures or incubation periods within the different treatments, in true protein of soybean or faba bean tempehs. Anyhow true protein ranged between 40.98 and 49.99%. The lower limit belongs to tempeh produced from soybean without soaking incubated at 31°C for 24 hr compared to 40.80% for the same treatment before carrying out fermentation process. The upper limit belongs to tempeh produced from soaked soybean for 12 hr incubated at 25°C for 72 hr compared to 43.14% for the same treatment before carrying out fermentation process. This upper limit also belongs

to tempeh produced from soaked soybean for 24 hr incubated at 37°C for 60 hr compared to 43.72% for the same treatment before carrying out fermentation process. In the case of faba bean tempeh, true protein ranged between 24.57 and 42.30% for tempeh produced from germinated faba bean incubated at 25°C for 60 hr and faba bean without soaking incubated at 37°C for 72 hr.

These results are in good agreement with finding of Wang et al. (1968); Neumann et al. (1984), Kuo et al. (1989) and Paredes-Lopez and Harry (1989). True protein was 43.75% in tempeh produced from soaked soybean for 12-15 hr, incubated at 28-30°C for 24 hr (kuo et al., 1989). It was 22.50% in tempeh produced from soaked faba bean for overnight, and incubated at 37°C for 72 hr (Paredes-Lopez and Harry, 1989).

1.5. Changes in ether extract:

Changes in ether extract content during tempeh production from soybean or faba bean cotyledons using Rhizopus oligosporus are shown in Table (17 and 18), respectively.

Statistical analysis indicated that ether extract of soybean tempeh decreased significantly ($P < 0.05$) to 23.52 and 24.69% due to soaking process for 12 and 24 hr, respectively compared to 24.97% of tempeh produced from

soybean without soaking. In contrast, germination process led to significant increase ($P < 0.05$) to 25.46% in ether extract of soybean tempeh. Ether extract in faba bean tempeh was decreased significantly ($P < 0.05$) to 1.78 and 1.68% due to soaking process for 12 and 24 hr, respectively compared to 1.92% of tempeh produced from faba bean without soaking. Germination process led to insignificant decrease ($P > 0.05$) to 1.91% in ether extract of faba bean tempeh.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant decrease ($P < 0.05$) in ether extract from 25.68 and 2.02% to 23.32 and 1.65% and 24.99 and 1.80% of soybean and faba bean tempehs, respectively. The same trend is noticed between incubation temperatures within different treatments of either soybean or faba bean tempehs.

Data revealed that ether extract of soybean tempeh decreased significantly ($P < 0.05$) from 27.68 to 27.12, 25.46, 24.14, 22.44 and 21.12% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. The same trend was observed in the case of faba bean tempeh. In the same time differences in ether extract between different incubation periods within different treatments of either soybean or faba bean tempehs were mostly decreased significantly ($P < 0.05$) by increasing incubation periods.

Table (17): Changes in ether extract content during tempeh fermentation produced from soybean (g/100 g on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	27.87	27.38	26.23	25.57	24.10	22.97	25.69
	31	27.87	26.70	25.01	23.62	22.28	21.43	24.49
	37	27.87	27.01	25.63	24.23	22.60	20.97	24.72
	Mean	27.87	27.03	25.62	24.47	22.99	21.79	24.97
Soaking for 12 hr, dehulled and cooked	25	28.64	26.15	24.64	24.10	23.28	21.75	24.76
	31	28.64	24.39	22.79	21.13	20.41	19.39	22.79
	37	28.64	25.46	24.87	24.01	23.11	22.17	24.71
	Mean	28.64	25.33	24.10	23.08	22.27	21.10	24.09
Soaking for 24 hr, dehulled and cooked	25	28.99	29.58	29.02	27.09	24.02	21.22	26.65
	31	28.99	26.37	24.00	21.21	16.22	15.14	21.99
	37	28.99	28.89	25.32	24.37	23.04	22.02	25.44
	Mean	28.99	28.28	26.11	24.22	21.09	19.46	24.69
Germinated, dehulled and cooked	25	28.62	28.20	26.95	25.72	24.18	23.37	26.17
	31	28.62	27.16	24.82	23.65	22.37	20.75	24.56
	37	28.62	28.15	26.19	24.96	23.72	22.28	25.65
	Mean	28.62	27.84	25.99	24.78	23.42	22.13	25.46
Mean of incubation period		28.53	27.12	25.46	24.14	22.44	21.12	24.80

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	25.68	23.32	24.99

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.20
- L.S.D. between means of any two incubation temperature = 0.07
- L.S.D. between means of any two incubation period = 0.07
- L.S.D. between means of any two incubation temperature/treatment = 0.23
- L.S.D. between means of any two incubation period/treatment = 0.24
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.32

Table (18): Changes in ether extract content during tempeh fermentation produced from faba bean (g/100 g on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	2.28	2.41	2.26	1.97	1.85	1.79	2.09
	31	2.28	2.10	1.78	1.64	1.50	1.42	1.79
	37	2.28	2.16	1.90	1.75	1.64	1.59	1.89
	Mean	2.28	2.22	1.98	1.79	1.66	1.60	1.92
Soaking for 12 hr, dehulled and cooked	25	2.14	2.36	2.19	1.88	1.72	1.64	1.99
	31	2.14	1.94	1.62	1.46	1.30	1.25	1.62
	37	2.14	2.06	1.77	1.60	1.44	1.39	1.73
	Mean	2.14	2.12	1.86	1.65	1.49	1.43	1.78
Soaking for 24 hr, dehulled and cooked	25	2.09	2.29	2.14	1.82	1.70	1.53	1.93
	31	2.09	1.64	1.39	1.20	1.13	1.02	1.41
	37	2.09	1.87	1.70	1.58	1.49	1.40	1.69
	Mean	2.09	1.93	1.74	1.53	1.44	1.32	1.68
Germinated, dehulled and cooked	25	2.47	2.34	2.20	1.92	1.78	1.66	2.06
	31	2.47	2.13	1.81	1.59	1.42	1.30	1.79
	37	2.47	2.25	1.93	1.70	1.54	1.46	1.89
	Mean	2.47	2.24	1.98	1.74	1.58	1.47	1.91
Mean of incubation period		2.25	2.13	1.89	1.68	1.54	1.46	1.82

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	2.02	1.65	1.80

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.13
- L.S.D. between means of any two incubation temperature = 0.02
- L.S.D. between means of any two incubation period = 0.02
- L.S.D. between means of any two incubation temperature/treatment = 0.14
- L.S.D. between means of any two incubation period/treatment = 0.14
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.15

Anyhow ether extract in soybean tempeh ranged between 15.14 and 29.58% for tempeh produced from soybean soaked for 24 hr incubated at 31°C for 72 hr and the same treatment incubated at 25°C for 24 hr, respectively compared to 28.99% for the same treatments before carrying out the fermentation process. With respect to faba bean tempeh, ether extract ranged between 1.02 and 2.41% for tempeh produced from faba bean soaked for 24 hr incubated at 31°C for 72 hr and faba bean without soaking incubated at 25°C for 24 hr, respectively compared to 2.09 and 2.28% for the same treatments before carrying out the fermentation process, respectively. L.S.D. between any two values of ether extract of soybean and faba bean tempehs at given incubation period within incubation temperature within treatment are 0.32 and 0.15, respectively.

These results are in good agreement with findings of Van Buren et al. (1972), Kuo et al. (1989) and Paredes-Lopez and Harry (1989). Ether extract was 27.50 and 23.2% in tempeh produced from soaked soybean for 12-15 hr incubated at 31°C for 12 and 72 hr, respectively (Van Buren et al., 1972). Ether extract contained 17.20% of tempeh produced from soaked soybean for 12-15 hr, incubated at 28-30°C for 24 hr (Kuo et al., 1989). It was 1.3% in tempeh produced from soaked faba bean overnight, incubated at 37°C for 72 hr (Paredes-Lopez and Harry, 1989).

1.6. Changes in ash content:

Data in Tables (19 and 20) show the changes in ash content during tempeh production from soybean or faba bean cotyledons, respectively.

Statistical analysis showed that ash content of soybean tempeh decreased significantly ($P < 0.05$) to 4.48, 4.31 and 4.07% due to soaking process for 12 and 24 hr and germination process, respectively compared to 4.84% of tempeh produced from soybean without soaking. The same trend was obtained in faba bean tempeh, whereas ash content decreased significantly ($P < 0.05$) to 2.97, 2.95 and 3.18% due to soaking process for 12 and 24 hr and germination process, respectively compared to 3.47% of tempeh produced from faba bean without soaking.

It could be noticed that increasing incubation temperature from 25° to 31°C led to insignificant increase ($P > 0.05$) from 4.34 to 4.42% in ash content of soybean tempeh, respectively, while increasing incubation temperature to 37°C led to significant increase ($P < 0.05$) to 4.52% in ash content of soybean tempeh. In faba bean tempeh, increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) from 2.87% to 3.11 and 3.45% in ash content of faba bean tempeh, respectively. Statistical analysis indicated that there

Table (19): Changes in ash content during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	4.32	4.16	4.62	4.84	4.99	5.22	4.69
	31	4.32	4.67	4.61	5.36	4.97	5.74	4.95
	37	4.32	4.64	5.02	4.72	4.87	5.65	4.87
	Mean	4.32	4.49	4.75	4.97	4.94	5.24	4.84
Soaking for 12 hr, dehulled and cooked	25	4.34	4.84	3.95	4.17	3.44	4.70	4.24
	31	4.34	4.24	4.53	4.05	3.73	4.33	4.20
	37	4.34	4.82	4.94	4.34	4.37	4.72	4.59
	Mean	4.34	4.63	4.47	4.19	3.85	4.58	4.34
Soaking for 24 hr, dehulled and cooked	25	4.39	4.52	3.84	4.05	5.03	4.04	4.31
	31	4.39	4.81	3.99	3.93	4.30	4.19	4.22
	37	4.39	4.68	4.22	4.18	4.51	4.42	4.40
	Mean	4.39	4.67	3.92	4.05	4.61	4.22	4.31
Germinated, dehulled and cooked	25	3.76	3.71	3.71	4.09	3.76	3.93	3.99
	31	3.76	4.07	4.10	4.13	4.10	4.76	4.15
	37	3.76	4.09	3.93	4.32	4.15	4.18	4.07
	Mean	3.76	3.96	3.91	4.18	4.00	4.62	4.07
Mean of incubation period		4.20	4.44	4.26	4.34	4.35	4.74	4.39

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	4.34	4.42	4.52

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.15
- L.S.D. between means of any two incubation temperature = 0.12
- L.S.D. between means of any two incubation period = 0.17
- L.S.D. between means of any two incubation temperature/treatment = 0.24
- L.S.D. between means of any two incubation period/treatment = 0.34
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.58

Table (20): Changes in ash content during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	3.05	3.58	2.84	3.09	2.60	2.80	2.99
	31	3.05	3.08	3.17	3.73	3.64	4.16	3.47
	37	3.05	3.60	3.91	4.19	4.90	4.22	3.96
	Mean	3.05	3.39	3.31	3.67	3.71	3.73	3.47
Soaking for 12 hr, dehulled and cooked	25	2.94	2.25	2.66	2.71	2.77	2.45	2.63
	31	2.94	3.12	3.09	2.60	3.31	2.46	2.92
	37	2.94	2.73	3.72	3.16	4.05	3.49	3.35
	Mean	2.94	2.70	3.16	2.82	3.38	2.80	2.97
Soaking for 24 hr, dehulled and cooked	25	3.18	2.71	2.60	2.26	2.89	2.80	2.74
	31	3.18	2.92	2.39	2.78	2.89	3.37	2.92
	37	3.18	2.07	2.67	3.39	3.71	4.18	3.20
	Mean	3.18	2.57	2.55	2.81	3.16	3.45	2.95
Germinated, dehulled and cooked	25	2.80	3.31	3.35	3.12	3.42	2.57	3.10
	31	2.80	3.01	2.88	3.54	3.27	3.31	3.14
	37	2.80	3.48	3.32	3.75	3.10	3.42	3.31
	Mean	2.80	3.27	3.18	3.47	3.26	3.10	3.18
Mean of incubation period		2.99	2.98	3.05	3.19	3.38	3.27	3.14

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	2.87	3.11	3.45

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.21
- L.S.D. between means of any two incubation temperature = 0.12
- L.S.D. between means of any two incubation period = 0.15
- L.S.D. between means of any two incubation temperature/treatment = 0.29
- L.S.D. between means of any two incubation period/treatment = 0.22
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.55

are more or less significant differences between incubation temperature within the different treatments in ash content of soybean or faba bean tempehs.

Statistical analysis showed that there are more or less significant differences between incubation periods generally or within the different treatments in ash content of soybean or faba bean tempehs. Anyhow ash content ranged between 3.44 and 5.74% for tempeh produced from soybean soaked for 12 hr, incubated at 25°C for 60 hr and soybean without soaking incubated at 31°C for 72 hr, respectively compared to 4.34 and 4.32% for the same treatments before carrying out the fermentation process, respectively. With respect to faba bean tempeh, ash content ranged between 2.25 and 4.90% for tempeh produced from faba bean soaked for 12 hr, incubated at 25°C for 24 hr and faba bean without soaking, incubated at 37°C for 60 hr, respectively compared to 2.94 and 3.05% for the same treatments before carrying out the fermentation process, respectively.

These results are in good agreement with those obtained by Kuo et al. (1989), Paredes-Lopez and Harry (1989), Paredes-Lopez et al. (1990). Tempeh produced from soaked soybean for 12-15 hr, incubated at 28-30°C for 24 hr, included 3.30% ash content (Kuo et al., 1989). Ash content ranged between 2.30 and 2.70% in tempeh produced from soaked

faba bean for 15 hr before and after fermentation period of 72 hr at 37°C, respectively (Paredes-Lopez and Harry, 1989). Paredes-Lopez et al. (1990) reported that ash content of tempeh produced from faba bean soaked overnight decreased from 2.50 to 2.40 and 2.40 by increasing incubation period from 0 to 24 and 48 hr at 37°C, respectively.

1.7. Changes in fiber content:

Data in Tables (21 and 22) indicate changes in the fiber content of tempeh produced from soybean and faba bean cotyledons using the mold Rhizopus oligosporus.

Statistical analysis indicated that fiber content in soybean tempeh increased significantly ($P < 0.05$) to 4.94, 5.42 and 5.64% due to soaking process for 12 and 24 hr and germination process compared to 4.52% of soybean tempeh produced from soybean without soaking, respectively. The same trend was observed in the case of faba bean tempeh.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) in fiber content of soybean and faba bean tempehs from 4.66 and 3.80 to 5.35 and 4.25% and 5.39 and 4.26%, respectively. Statistical analysis indicated the same trend for the effect of incubation

Table (21): Changes in fiber content during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	3.78	3.85	3.96	4.15	4.32	4.67	4.12
	31	3.78	4.05	4.34	4.96	5.18	5.72	4.68
	37	3.78	4.13	4.53	4.99	5.29	5.79	4.75
	Mean	3.78	4.01	4.29	4.70	4.93	5.39	4.52
Soaking for 12 hr, dehulled and cooked	25	4.09	4.18	4.29	4.51	4.72	4.94	4.46
	31	4.09	4.45	4.97	5.32	5.89	6.23	5.16
	37	4.09	4.51	4.88	5.39	6.07	6.34	5.21
	Mean	4.09	4.38	4.71	5.07	5.56	5.84	4.94
Soaking for 24 hr, dehulled and cooked	25	4.43	4.56	4.72	4.97	5.18	5.43	4.88
	31	4.43	4.89	5.86	5.94	6.42	7.01	5.68
	37	4.43	4.76	5.42	6.04	6.49	6.98	5.69
	Mean	4.43	4.74	5.17	5.65	6.03	6.47	5.42
Germinated, dehulled and cooked	25	4.62	4.78	4.96	5.26	5.52	5.84	5.16
	31	4.62	4.91	5.45	6.28	6.75	7.23	5.87
	37	4.62	4.97	5.49	6.32	6.83	7.15	5.90
	Mean	4.62	4.89	5.30	5.95	6.37	6.74	5.64
Mean of incubation period		4.23	4.51	4.87	5.34	5.72	6.11	5.13

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	4.66	5.35	5.39

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.16
- L.S.D. between means of any two incubation temperature = 0.05
- L.S.D. between means of any two incubation period = 0.04
- L.S.D. between means of any two incubation temperature/treatment = 0.18
- L.S.D. between means of any two incubation period/treatment = 0.18
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.22

Table (22): Changes in fiber content during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	2.98	3.09	3.24	3.38	3.67	4.05	3.40
	31	2.98	3.25	3.58	3.96	4.37	4.63	3.80
	37	2.98	3.19	3.62	3.88	4.45	4.71	3.81
	Mean	2.98	3.18	3.48	3.74	4.16	4.46	3.67
Soaking for 12 hr, dehulled and cooked	25	3.24	3.36	3.48	3.75	3.94	4.39	3.69
	31	3.24	3.59	3.87	4.22	4.46	4.85	4.04
	37	3.24	3.48	3.93	4.35	4.71	5.03	4.12
	Mean	3.24	3.48	3.76	4.11	4.37	4.76	3.95
Soaking for 24 hr, dehulled and cooked	25	3.51	3.64	3.78	3.94	4.17	4.36	3.90
	31	3.51	3.92	4.34	4.89	5.05	5.41	4.53
	37	3.51	3.94	4.46	4.86	5.11	5.54	4.57
	Mean	3.51	3.83	4.20	4.56	4.78	5.10	4.33
Germinated, dehulled and cooked	25	3.76	3.84	4.05	4.27	4.53	4.71	4.19
	31	3.76	3.98	4.56	4.88	5.12	5.34	4.61
	37	3.76	3.92	4.32	4.76	5.03	5.41	4.53
	Mean	3.76	3.91	4.31	4.64	4.89	5.15	4.44
Mean of incubation period		3.37	3.60	3.94	4.26	4.55	4.87	4.10

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	3.80	4.25	4.26

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.17
- L.S.D. between means of any two incubation temperature = 0.08
- L.S.D. between means of any two incubation period = 0.08
- L.S.D. between means of any two incubation temperature/treatment = 0.22
- L.S.D. between means of any two incubation period/treatment = 0.22
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.33

temperature within the different treatments on fiber content of either soybean or faba bean tempehs were mostly increased significantly ($P < 0.05$) by increasing incubation temperature from 25° to 31° and 37°C, respectively.

Data revealed that fiber content in soybean and faba bean tempehs increased significantly ($P < 0.05$) from 4.23 and 3.37% to 4.51 and 3.60%, 4.87 and 3.94%, 5.34 and 4.26%, 5.72 and 4.55% and 6.11 and 4.87% by increasing incubation period from 0 to 24, 36, 48, 60, and 72 hr, respectively. In the same time differences in fiber content between different incubation periods within the different treatments of either soybean or faba bean tempehs were mostly increased significantly ($P < 0.05$) by increasing incubation periods.

Anyhow fiber content in soybean tempeh ranged between 3.85 and 7.23% for tempeh produced from soybean without soaking, incubated at 25°C for 24 hr and germinated soybean, incubated at 31°C for 72 hr, respectively compared to 3.78 and 4.62% for the same treatments before carrying out the fermentation process. With respect to faba bean tempeh, fiber content ranged between 3.09 and 5.41%. The lower limit belongs to tempeh produced from faba bean without soaking, incubated at 25°C for 24 hr compared to 2.98% for the same treatment before carrying out the fermentation process. The upper limit belongs to tempeh produced from

faba bean soaked for 12 hr, incubated at 31°C for 72 hr compared to 3.51% for the same treatment before carrying out the fermentation process. This upper limit also belongs to tempeh produced from germinated faba bean incubated at 37°C for 72 hr compared to 3.76% for the same treatment before carrying out the fermentation process.

These results are in good agreement with finding of Van Buren et al. (1972) and Agosin et al. (1989). Fiber content increased from 2.77 to 3.07, 3.89 and 4.81% by increasing incubation period from 0 to 12, 24 and 36 hr, respectively, of tempeh produced from soybean (Van Buren et al., 1972). It increased from 2.20 and 2.20% to 2.40 and 2.50% by increasing incubation period from 0 to 24 hr of tempeh produced from sweet and bitter lupine soaked overnight incubated at 30°C, respectively (Agosin et al., 1989).

1.8. Changes in available carbohydrates:

Data in Tables (23 and 24) show changes in available carbohydrates during tempeh production from soybean or faba bean cotyledons, respectively.

Statistical analysis indicated that available carbohydrates of soybean tempeh decreased significantly ($P < 0.05$) to 17.68 16.17 and 16.87% due to soaking process

for 12 and 24 hr and germination process compared to 19.50% of tempeh produced from soybean without soaking, respectively. On the other hand, in faba bean tempeh, available carbohydrates increased significantly ($P < 0.05$) to 57.20, 56.96 and 59.57% due to soaking process for 12 and 24 hr and germination process compared to 54.31% of tempeh produced from faba bean without soaking, respectively.

Statistical analysis showed that there are more or less significant differences in available carbohydrates of soybean or faba bean tempehs between the different incubation temperatures. Also comparing between incubation temperature within the different treatments and between incubation periods generally or within the different treatments in either soybean or faba bean tempehs indicated that there are more or less significant differences in available carbohydrates.

Anyhow available carbohydrates in soybean tempeh ranged between 11.75 and 22.33% for tempeh produced from soybean soaked for 24 hr, incubated at 25°C for 24 hr and the same treatment, incubated at 31°C for 60 hr, respectively compared to 17.76% for the same treatment before carrying out fermentation process. With respect to faba bean tempeh, available carbohydrates ranged between 40.82 and 63.20% for tempeh produced from faba bean without soaking, incubated at 37°C for 72 hr and faba bean soaked for 12 hr, incubated at 31°C for 48 hr respectively compared to

Table (23): Changes in available carbohydrates during tempeh fermentation produced from soybean (g/100 g, on dry weight basis)*.

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	21.43	20.06	18.59	19.03	19.74	20.06	19.82
	31	21.43	21.41	16.24	18.78	17.89	17.98	18.96
	37	21.43	19.49	18.26	18.24	20.49	20.45	19.73
	Mean	21.43	20.32	17.70	18.68	19.37	19.50	19.50
Soaking for 12 hr, dehulled and cooked	25	18.74	17.87	20.90	19.73	19.09	13.30	18.27
	31	18.74	16.92	17.79	19.71	17.13	14.81	17.52
	37	18.74	16.61	16.73	17.48	15.83	18.02	17.24
	Mean	18.74	17.13	18.47	18.97	17.35	15.37	17.68
Soaking for 24 hr, dehulled and cooked	25	17.76	11.75	13.84	14.41	16.22	20.55	15.76
	31	17.76	16.26	17.11	20.06	22.33	20.45	19.00
	37	17.76	12.51	13.32	13.20	12.12	13.65	13.76
	Mean	17.76	13.51	14.76	15.89	16.89	18.22	16.17
Germinated, dehulled and cooked	25	18.41	17.06	13.79	15.16	18.93	15.31	16.44
	31	18.41	18.30	17.02	18.31	19.58	16.17	17.97
	37	18.41	15.29	12.86	14.69	18.80	17.22	16.21
	Mean	18.41	16.88	14.56	16.05	19.10	16.23	16.87
Mean of incubation period		19.08	16.37	16.44	17.40	18.18	17.33	17.56

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	17.69	18.52	16.86

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.81
- L.S.D. between means of any two incubation temperature = 0.90
- L.S.D. between means of any two incubation period = 1.07
- L.S.D. between means of any two incubation temperature/treatment = 1.68
- L.S.D. between means of any two incubation period/treatment = 2.12
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.78

Table (24): Changes in available carbohydrates during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis)*.

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	59.56	58.09	58.17	60.33	57.87	55.45	58.25
	31	59.56	57.18	55.82	53.98	50.27	46.95	53.96
	37	59.56	59.72	55.79	47.27	41.19	40.82	50.73
	Mean	59.56	58.33	56.59	53.86	49.78	47.74	54.31
Soaking for 12 hr, dehulled and cooked	25	61.56	59.68	60.80	61.97	60.06	59.93	60.67
	31	61.56	56.24	57.45	63.20	58.65	55.15	58.71
	37	61.56	57.92	53.53	50.30	45.99	43.96	52.21
	Mean	61.56	57.95	57.26	58.49	54.90	53.01	57.20
Soaking for 24 hr, dehulled and cooked	25	61.79	58.30	61.33	60.71	62.57	60.13	60.81
	31	61.79	56.43	55.76	55.10	56.34	52.50	56.31
	37	61.79	59.19	58.58	50.87	49.29	42.88	53.77
	Mean	61.79	57.97	58.54	55.56	56.07	51.84	56.96
Germinated, dehulled and cooked	25	62.81	60.98	57.22	61.73	62.39	58.52	60.61
	31	62.81	60.61	59.67	61.49	59.85	57.72	60.39
	37	62.81	59.53	55.10	56.44	58.92	53.42	57.70
	Mean	62.81	60.37	57.33	59.89	60.39	56.55	59.57
Mean of incubation period		61.43	58.66	57.43	56.95	55.29	52.29	57.01

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	60.08	57.34	53.60

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 1.39
- L.S.D. between means of any two incubation temperature = 0.59
- L.S.D. between means of any two incubation period = 0.96
- L.S.D. between means of any two incubation temperature/treatment = 1.68
- L.S.D. between means of any two incubation period/treatment = 2.24
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 3.46

59.56 and 61.56% for the same treatments before carrying out fermentation process, respectively.

1.9. changes in pH value:

The changes in pH value during tempeh production from soybean or faba bean cotyledons using Rhizopus oligosporus are presented in Tables (25 and 26), respectively.

Statistical analysis show that pH values in soybean and faba bean tempehs was significantly increased ($P < 0.05$) to 6.45, 6.48 and 6.52 due to soaking process for 12 and 24 hr and germination process, respectively compared to 6.18 of tempeh produced from soybean without soaking. The same trend was observed in the case of faba bean tempeh.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) in pH value of soybean or faba bean tempehs from 6.20 and 6.17 to 6.49 and 6.47 and 6.53 and 6.55, respectively. These results indicated that incubation temperature 31°C led to less significant increase in pH value than those of 37°C incubation temperature of soybean or faba bean tempehs. Statistical analysis indicated the same trend for the effect of incubation temperature within the different treatments on pH value of either soybean or faba bean tempehs were mostly increased significantly ($P < 0.05$) by increasing incubation temperature from 25° to 31° and 37°, respectively.

Table (25): Changes in pH value during tempeh fermentation produced from soybean.

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	5.40	5.65	5.80	5.97	6.19	6.38	5.88
	31	5.40	5.95	6.28	6.48	6.72	7.20	6.34
	37	5.40	6.01	6.26	6.42	6.65	7.13	6.31
	Mean	5.40	5.87	6.11	6.29	6.52	6.90	6.18
Soaking for 12 hr, dehulled and cooked	25	5.91	5.96	6.08	6.40	6.54	6.72	6.27
	31	5.91	5.99	6.24	6.60	7.03	7.28	6.51
	37	5.91	6.07	6.19	6.78	7.09	7.40	6.57
	Mean	5.91	6.01	6.17	6.59	6.87	7.13	6.45
Soaking for 24 hr, dehulled and cooked	25	6.01	6.09	6.17	6.30	6.46	6.67	6.28
	31	6.01	6.11	6.25	6.47	6.85	7.20	6.48
	37	6.01	6.23	6.45	6.86	7.15	7.33	6.67
	Mean	6.01	6.14	6.29	6.54	6.82	7.07	6.48
Germinated, dehulled and cooked	25	5.95	6.15	6.33	6.47	6.55	6.63	6.35
	31	5.95	6.36	6.53	6.84	7.00	7.18	6.64
	37	5.95	6.22	6.39	6.55	6.98	7.32	6.57
	Mean	5.95	6.24	6.42	6.62	6.84	7.04	6.52
Mean of incubation period		5.82	6.06	6.25	6.51	6.76	7.04	6.41

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	6.20	6.49	6.53

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.02
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.01
- L.S.D. between means of any two incubation temperature/treatment = 0.03
- L.S.D. between means of any two incubation period/treatment = 0.03
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.04

Table (26): Changes in pH value during tempeh fermentation produced from faba bean.

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	5.51	5.89	6.02	6.15	6.31	6.46	6.06
	31	5.51	6.07	6.32	6.53	6.90	7.16	6.42
	37	5.51	6.18	6.33	6.68	6.99	7.29	6.50
	Mean	5.51	6.05	6.22	6.45	6.73	6.97	6.33
Soaking for 12 hr, dehulled and cooked	25	5.67	5.90	6.10	6.28	6.41	6.61	6.16
	31	5.67	6.12	6.40	6.59	6.82	7.31	6.49
	37	5.67	6.20	6.37	6.71	6.85	7.06	6.48
	Mean	5.67	6.07	6.29	6.53	6.69	6.99	6.37
Soaking for 24 hr, dehulled and cooked	25	5.95	6.02	6.18	6.32	6.50	6.68	6.28
	31	5.95	6.21	6.36	6.59	6.88	7.11	6.52
	37	5.95	6.32	6.53	6.91	7.13	7.46	6.72
	Mean	5.95	6.18	6.36	6.61	6.84	7.08	6.51
Germinated, dehulled and cooked	25	5.81	5.93	6.16	6.30	6.41	6.53	6.19
	31	5.81	6.19	6.36	6.48	6.79	7.01	6.44
	37	5.81	6.20	6.40	6.65	6.82	7.09	6.50
	Mean	5.81	6.11	6.31	6.48	6.67	6.88	6.38
Mean of incubation period		5.74	6.10	6.30	6.52	6.73	6.98	6.40

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	6.17	6.47	6.55

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.02
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.01
- L.S.D. between means of any two incubation temperature/treatment = 0.03
- L.S.D. between means of any two incubation period/treatment = 0.03
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.04

Data revealed that pH value in soybean and faba bean tempehs increased significantly ($P < 0.05$) from 5.82 and 5.74 to 6.06 and 6.10, 6.25 and 6.30, 6.51 and 6.52, 6.76 and 6.73, and 7.04 and 6.98 by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. In the same time differences in pH values between different incubation periods within the different treatments of either soybean or faba bean tempehs were mostly increased significantly ($P < 0.05$) by increasing incubation periods.

Anyhow pH value in soybean tempeh ranged between 5.65 and 7.40 for tempeh produced from soybean without soaking incubated at 25°C for 24 hr and soybean soaked for 12 hr, incubated at 37°C for 72 hr, respectively compared to 5.40 and 5.91 for the same treatments before carrying out the fermentation process, respectively. With respect to faba bean tempeh, pH value ranged between 5.89 and 7.46 for tempeh produced from faba bean without soaking and incubated at 25°C for 24 hr and faba bean soaked for 24 hr, incubated at 37°C for 72 hr, respectively compared to 5.51 and 5.95 for the same treatments before carrying out the fermentation process, respectively. This increasing of pH value was accompanied by increasing of ammonia.

These results are in good agreement with the findings of Murata et al. (1967), Van Buren et al. (1972),

Paredes-Lopez et al. (1990) Agosin et al. (1989). pH value increased from 5.40 to 5.90, 6.20, 6.50 and 7.2 by increasing incubation period from 0 to 12, 24, 36 and 72 hr, respectively of tempeh produced from soybean (Van-Buren et al., 1972). It increased from 6.00 to 6.61 and 6.96 by increasing incubation period from 0 to 24 and 48 hr, respectively of tempeh produced from faba bean soaked overnight and incubated at 37°C (Paredes-Lopez et al., 1990). Agosin et al. (1989) reported that pH value increased from 5.93 to 5.97, 6.42, 7.18 and 7.38 by increasing incubation period from 0 to 17, 24, 32 and 45 hr, respectively of tempeh produced from sweet lupine soaked overnight and incubated at 30°C.

2. Changes in quality index:

Changes in chemical freshness parameters of soybean or faba bean tempehs, including total volatile nitrogen (TVN), ammonia and thiobarbituric acid (TBA) are presented in Tables (27, 28, 29, 30, 31, and 32), respectively.

2.1. Changes in total volatile nitrogen (TVN):

Data in Tables (27 and 28) showed different changes in total volatile nitrogen during tempeh production from soybean or faba bean cotyledons, respectively using the mold of Rhizopus oligosporus.

Statistical analysis indicated that total volatile nitrogen in soybean tempeh was significantly decreased ($P < 0.05$) to 0.50 and 0.41% due to soaking process for 12 and 24 hr, respectively compared to 0.70% of tempeh produced from soybean without soaking. On the other hand,

Table (27): Changes in total volatile nitrogen during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.04	0.21	0.41	0.45	1.09	1.16	0.56
	31	0.04	0.63	0.87	0.93	0.96	1.21	0.77
	37	0.04	0.76	0.80	0.98	1.03	1.09	0.78
	Mean	0.04	0.53	0.69	0.82	1.03	1.15	0.70
Soaking for 12 hr, dehulled and cooked	25	0.05	0.07	0.32	0.44	0.47	0.83	0.36
	31	0.05	0.17	0.38	0.68	1.00	1.00	0.55
	37	0.05	0.21	0.42	0.78	0.97	1.10	0.59
	Mean	0.05	0.15	0.37	0.63	0.81	0.98	0.50
Soaking for 24 hr, dehulled and cooked	25	0.07	0.09	0.12	0.15	0.23	0.47	0.19
	31	0.07	0.16	0.29	0.39	0.50	0.95	0.39
	37	0.07	0.49	0.54	0.75	1.00	1.06	0.65
	Mean	0.07	0.25	0.32	0.43	0.58	0.83	0.41
Germinated, dehulled and cooked	25	0.06	0.15	0.64	0.92	1.00	1.10	0.65
	31	0.06	0.22	0.87	1.05	1.07	1.16	0.78
	37	0.06	0.48	0.98	1.04	1.08	1.46	0.81
	Mean	0.06	0.28	0.83	1.00	1.05	1.24	0.75
Mean of incubation period		0.06	0.30	0.55	0.72	0.87	1.05	0.59

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.44	0.64	0.69

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.03

L.S.D. between means of any two incubation temperature = 0.02

L.S.D. between means of any two incubation period = 0.01

L.S.D. between means of any two incubation temperature/treatment = 0.05

L.S.D. between means of any two incubation period/treatment = 0.03

L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.05

Table (28): Changes in total volatile nitrogen during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.06	0.28	0.45	0.60	0.85	0.87	0.52
	31	0.06	0.44	0.69	0.85	0.90	1.25	0.70
	37	0.06	0.69	0.80	1.25	1.39	1.47	0.94
	Mean	0.06	0.47	0.65	0.90	1.05	1.20	0.72
Soaking for 12 hr, dehulled and cooked	25	0.07	0.09	0.54	0.67	0.68	0.95	0.50
	31	0.07	0.51	0.71	0.73	0.87	0.89	0.63
	37	0.07	0.62	0.94	1.09	1.16	1.22	0.85
	Mean	0.07	0.41	0.73	0.83	0.90	1.02	0.66
Soaking for 24 hr, dehulled and cooked	25	0.09	0.11	0.65	0.69	0.84	0.98	0.56
	31	0.09	0.31	0.36	0.91	0.97	1.11	0.66
	37	0.09	0.62	0.83	1.06	1.32	1.35	0.88
	Mean	0.09	0.35	0.68	0.89	1.04	1.15	0.70
Germinated, dehulled and cooked	25	0.05	0.12	0.45	0.57	0.97	1.01	0.53
	31	0.05	0.44	0.71	0.90	0.97	1.05	0.69
	37	0.05	0.50	0.79	0.91	1.04	1.18	0.75
	Mean	0.05	0.35	0.65	0.79	0.99	1.08	0.66
Mean of incubation period		0.07	0.40	0.68	0.85	1.00	1.11	0.69

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.53	0.67	0.86

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.03
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.01
- L.S.D. between means of any two incubation temperature/treatment = 0.04
- L.S.D. between means of any two incubation period/treatment = 0.03
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.04

germination process led to significant increase ($P < 0.05$) to 0.75 in TVN of soybean tempeh. This may be due to some physiological changes during the germination process. In faba bean tempeh TVN did not appear the same trend as in soybean tempeh that it was decreased significantly ($P < 0.05$) to 0.66 and 0.66% due to soaking process for 12 hr and germination process, respectively, compared to 0.72% of tempeh produced from faba bean without soaking. In the same time soaking process for 24 hr has no significant effect on the value of TVN which was 0.70%.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) in TVN of either soybean and faba bean tempehs from 0.44 and 0.53% to 0.64 and 0.67% and 0.69 and 0.86%, respectively. This could be attributed to more activity for fungus growth with increasing incubation temperature to 37°C. The same trend was noticed when comparison between these incubation temperature within the different treatments of soybean or faba bean tempehs.

1.00% and 1.05 and 1.11% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. The same effect of increasing incubation period was noticed within the different treatments of soybean or faba bean tempehs that TVN increased significantly ($P < 0.05$) with increasing incubation period.

Anyhow, it could be considered that the excellent tempeh is that produce from soybean or faba bean tempehs after soaking for 24 hr, incubated at 31°C for 36 hr incubation period. Under these conditions TVN was 0.29 and 0.36% in soybean and faba bean tempehs, respectively. These values are lesser than 0.40% which is the higher accepted value by the panelists who were asked to evaluate the products organoleptically in this research. It is clear that there are other conditions have lower TVN than 0.29 and 0.36% in soybean and faba bean tempehs, respectively but it can not be considered as excellent conditions that their products will includes higher amounts of

2.2. Changes in ammonia:

Using the mold of Rhizopus oligosporus in tempeh production from soybean or faba bean cotyledons led to increase in ammonia as it is indicated in Tables (29 and 30), respectively.

Statistical analysis indicated that there are more or less significant differences in ammonia of soybean or faba bean tempehs between the different treatments. Anyhow, general means of different treatments could be, ignored that they are greater than the accepted limit (0.30%) as increased by different treatments of soybean or faba tempehs.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant increase ($P < 0.05$) in ammonia of soybean and faba bean tempehs from 0.34 and 0.41% to 0.53 and 0.52% and 0.56 and 0.68%, respectively. This could be attributed to more activity for fungus growth with increasing incubation temperature to 37°C. The same trend is noticed when making a comparison between these temperatures within the different treatments of soybean or faba bean tempehs.

Table (29): Changes in ammonia during tempeh fermentation produced from soybean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.03	0.15	0.31	0.44	0.72	0.84	0.42
	31	0.03	0.57	0.70	0.75	0.85	0.97	0.65
	37	0.03	0.67	0.68	0.78	0.83	1.10	0.68
	Mean	0.03	0.46	0.56	0.66	0.80	0.97	0.58
Soaking for 12 hr, dehulled and cooked	25	0.04	0.04	0.27	0.39	0.42	0.72	0.31
	31	0.04	0.05	0.30	0.61	0.80	0.84	0.44
	37	0.04	0.07	0.35	0.72	0.84	0.97	0.50
	Mean	0.04	0.05	0.31	0.57	0.69	0.84	0.42
Soaking for 24 hr, dehulled and cooked	25	0.05	0.05	0.06	0.07	0.08	0.34	0.11
	31	0.05	0.06	0.25	0.31	0.42	0.83	0.32
	37	0.05	0.30	0.43	0.63	0.83	0.93	0.53
	Mean	0.05	0.14	0.25	0.33	0.44	0.70	0.32
Germinated, dehulled and cooked	25	0.04	0.07	0.53	0.78	0.82	0.94	0.53
	31	0.04	0.16	0.65	0.75	0.93	0.99	0.59
	37	0.04	0.43	0.58	0.80	0.81	1.12	0.63
	Mean	0.04	0.22	0.59	0.78	0.85	1.02	0.58
Mean of incubation period		0.04	0.22	0.43	0.59	0.70	0.88	0.48

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.34	0.53	0.56

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.03
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.02
- L.S.D. between means of any two incubation temperature/treatment = 0.03
- L.S.D. between means of any two incubation period/treatment = 0.04
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.06

Table (30): Changes in ammonia during tempeh fermentation produced from faba bean (g/100 g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.02	0.14	0.29	0.43	0.69	0.77	0.39
	31	0.02	0.27	0.49	0.63	0.71	0.96	0.51
	37	0.02	0.43	0.63	0.90	1.09	1.26	0.72
	Mean	0.02	0.28	0.47	0.65	0.83	1.00	0.54
Soaking for 12 hr, dehulled and cooked	25	0.03	0.05	0.45	0.57	0.57	0.68	0.39
	31	0.03	0.39	0.61	0.64	0.71	0.79	0.53
	37	0.03	0.46	0.81	0.84	0.90	1.07	0.69
	Mean	0.03	0.30	0.62	0.68	0.73	0.85	0.54
Soaking for 24 hr, dehulled and cooked	25	0.03	0.09	0.44	0.59	0.74	0.83	0.45
	31	0.03	0.22	0.29	0.52	0.84	0.97	0.48
	37	0.03	0.51	0.72	0.87	1.09	1.19	0.74
	Mean	0.03	0.27	0.48	0.66	0.89	1.00	0.56
Germinated, dehulled and cooked	25	0.02	0.04	0.28	0.44	0.72	0.88	0.40
	31	0.02	0.31	0.46	0.49	0.81	0.94	0.51
	37	0.02	0.37	0.58	0.67	0.79	1.03	0.58
	Mean	0.02	0.24	0.44	0.53	0.77	0.95	0.50
Mean of incubation period		0.03	0.27	0.50	0.63	0.81	0.95	0.54

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.41	0.52	0.68

L.S.D. ($P < 0.05$):

L.S.D. between means of any two treatments = 0.02

L.S.D. between means of any two incubation temperature = 0.02

L.S.D. between means of any two incubation period = 0.01

L.S.D. between means of any two incubation temperature/treatment = 0.03

L.S.D. between means of any two incubation period/treatment = 0.02

L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.04

Data revealed that ammonia increased significantly ($P < 0.05$) from 0.04 and 0.03% to 0.22 and 0.27%, 0.43 and 0.50%, 0.59 and 0.63%, 0.70 and 0.81% and 0.88 and 0.95% by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr of soybean and faba bean tempehs, respectively. The same effect of increasing incubation period was noticed within the different treatments of soybean or faba bean tempehs that ammonia increased significantly ($P < 0.05$) with increasing the incubation period.

Anyhow, it could be considered that the excellent tempeh is that produce from soybean or faba bean after soaking for 24 hr, incubated at 31°C and for 36 hr incubation period. Under these conditions ammonia was 0.25 and 0.29% in soybean and faba bean tempehs, respectively. These values are less than 0.30% which is the higher accepted value by the panelists who were asked to evaluate the products organoleptically in this research. It is clear that there are other conditions have lower ammonia than 0.25 and 0.29% in soybean and faba bean tempehs, respectively but it can not be considered as excellent conditions that their products will included higher amounts of antinutritional components such as phytic acid, trypsin inhibitor activity and total vicine as will be clear later.

These results are in good agreement with finding of Van Buren et al. (1972) and Agosin et al. (1989). Ammonia increased from 0.05 to 0.22, 0.40, 0.47 and 0.59% by increasing incubation period from 0 to 12, 24, 36 and 72 hr, respectively of tempeh produced from soybean (Van Buren et al., 1972). It increased from 0.04 to 0.07, 0.08, 0.10, 0.21 and 0.60% with increasing incubation period from 0 to 12, 17, 24, 32 and 45 hr, respectively of tempeh produced from sweet lupine soaked overnight and incubated at 30°C (Agosin et al., 1989). These results also, are in comparable with obtained by Smith et al. (1964) and Steinkraus et al. (1960).

2.3. Changes in thiobarbituric acid (TBA):

Changes occurring in thiobarbituric acid during tempeh production from soybean or faba bean cotyledons using Rhizopus oligosporus are shown in Tables (31 and 32), respectively.

Statistical analysis indicated that there are more or less significant differences in TBA of soybean or faba bean tempehs between the different treatments. Anyhow, general means of the different treatments indicated that they are under the maximum accepted limit (7.71 mg malonaldehyde/kg) mentioned before of buffalo meat by Bahlol (1989).

Table (31): Changes in thiobarbituric acid during tempeh fermentation produced from soybean (mg mlanoaldehyde/kg, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.42	0.89	0.91	0.92	0.94	1.01	0.85
	31	0.42	0.90	0.92	0.93	0.94	0.95	0.84
	37	0.42	0.89	0.92	0.93	0.94	0.95	0.84
	Mean	0.42	0.89	0.92	0.93	0.94	0.97	0.84
Soaking for 12 hr, dehulled and cooked	25	0.38	0.35	0.38	0.47	0.60	0.75	0.49
	31	0.38	0.32	0.33	0.37	0.54	0.82	0.46
	37	0.38	0.42	0.51	0.53	0.86	0.90	0.60
	Mean	0.38	0.36	0.41	0.46	0.67	0.82	0.52
Soaking for 24 hr, dehulled and cooked	25	0.35	0.32	0.48	0.52	0.77	0.97	0.57
	31	0.35	0.30	0.34	0.41	0.53	0.85	0.46
	37	0.35	0.44	0.48	0.51	0.86	0.93	0.60
	Mean	0.35	0.35	0.43	0.48	0.72	0.92	0.54
Germinated, dehulled and cooked	25	0.41	0.86	0.87	0.90	0.91	0.93	0.81
	31	0.41	0.91	0.95	0.96	0.97	0.98	0.86
	37	0.41	0.91	0.93	0.93	0.95	0.95	0.85
	Mean	0.41	0.89	0.92	0.93	0.94	0.95	0.84
Mean of incubation period		0.39	0.62	0.67	0.70	0.82	0.92	0.69

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.68	0.66	0.72

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.03
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.01
- L.S.D. between means of any two incubation temperature/treatment = 0.03
- L.S.D. between means of any two incubation period/treatment = 0.04
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.04

Table (32): Changes in thiobarbituric acid during tempeh fermentation produced from faba bean (mg mlanoaldhyde/kg, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	0.45	0.35	0.37	0.39	0.49	0.51	0.43
	31	0.45	0.32	0.34	0.35	0.38	0.41	0.38
	37	0.45	0.37	0.41	0.46	0.48	0.53	0.45
	Mean	0.45	0.35	0.37	0.40	0.45	0.48	0.42
Soaking for 12 hr, dehulled and cooked	25	0.40	0.28	0.29	0.31	0.44	0.45	0.36
	31	0.40	0.24	0.26	0.27	0.31	0.33	0.30
	37	0.40	0.28	0.29	0.31	0.34	0.38	0.33
	Mean	0.40	0.27	0.28	0.30	0.36	0.39	0.33
Soaking for 24 hr, dehulled and cooked	25	0.37	0.29	0.33	0.35	0.36	0.48	0.36
	31	0.37	0.26	0.27	0.29	0.31	0.34	0.31
	37	0.37	0.29	0.30	0.33	0.40	0.45	0.36
	Mean	0.37	0.28	0.30	0.32	0.36	0.42	0.34
Germinated, dehulled and cooked	25	0.43	0.34	0.35	0.36	0.47	0.48	0.41
	31	0.43	0.31	0.32	0.33	0.35	0.37	0.35
	37	0.43	0.34	0.38	0.44	0.49	0.50	0.43
	Mean	0.43	0.33	0.35	0.38	0.44	0.45	0.40
Mean of incubation period		0.41	0.31	0.33	0.35	0.40	0.44	0.37

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	0.39	0.34	0.39

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.02
- L.S.D. between means of any two incubation temperature = 0.01
- L.S.D. between means of any two incubation period = 0.01
- L.S.D. between means of any two incubation temperature/treatment = 0.02
- L.S.D. between means of any two incubation period/treatment = 0.02
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.03

There are more or less significant differences in TBA of soybean or faba bean tempehs due to increasing incubation temperature from 25° to 31° and 37°C. Anyhow, general means, indicated that they are under the maximum accepted limit (7.71 mg malonaldehyde/kg) mentioned before of buffalo meat by Bahlol (1989). Comparison between different incubation temperatures within the different treatments indicated that 31°C incubation temperature is mostly with lowest TBA content.

Data revealed that TBA in soybean tempeh increased significantly ($P < 0.05$) from 0.39 mg malonaldehyde/kg to 0.62, 0.67, 0.70, 0.82 and 0.92 mg malonaldehyde/kg by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively. Thiobarbituric acid in faba bean tempeh decreased significantly ($P < 0.05$) from 0.41 mg malonaldehyde/kg to 0.31, 0.33, 0.35 and 0.40 mg malonaldehyde/kg by increasing incubation period from 0 to 24, 36, 48 and 60 hr, respectively, while it increased significantly ($P < 0.05$) to 0.44 mg malonaldehyde/kg by increasing incubation period to 72 hr, of faba bean tempeh. Anyhow these mentioned means below the maximum accepted level. In the same time, comparing between different incubation period within the different treatments indicated that there are more or less significant differences in TBA of soybean or faba bean tempehs by increasing incubation period within the different treatments.

Anyhow TBA ranged between 0.30 and 0.98 mg malonaldehyde/kg for tempeh produced from soybean soaked for 24 hr, incubated at 31°C for 24 hr and germinated soybean, incubated at 31°C for 72 hr, respectively compared to 0.35 and 0.41 mg/malonaldehyde/kg for the same treatments before carrying out the fermentation process, respectively. With respect to faba bean tempeh, TBA ranged between 0.24 and 0.53 mg malonaldehyde/kg for tempeh produced from faba bean soaked for 12 hr, incubated at 31°C for 24 hr and faba bean without soaking, incubated at 37°C for 72 hr, respectively compared to 0.40 and 0.45 mg/malonaldehyde/kg for the same treatments before carrying out the fermentation process, respectively.

3. Changes in antinutritional factors:

Changes in antinutritional factors of tempeh produced from soybean or faba bean including phytic acid content, trypsin inhibitor activity and total vicine content are presented in Tables (33, 34, 35, 36, 37 and 38), respectively.

3.1. Changes in phytic acid contents:

The changes occurring in phytic acid during tempeh production from soybean or faba bean cotyledons using Rhizopus oligosporus are shown in Tables (33 and 34), respectively.

Statistical analysis indicated that phytic acid content in soybean and faba bean tempehs was significantly decreased ($P < 0.05$) to 6.79 and 1.05 mg/g, respectively due to soaking process for 12 hr compared to tempeh produced from soybean or faba bean without soaking which have 7.25 and 1.24 mg/g, respectively. More significant decrease ($P < 0.05$) to 5.99 and 0.95 mg/g in soybean and faba bean tempehs, respectively was noticed due to increasing soaking process for 24 hr. On the other hand, germination process led to significant increase ($P < 0.05$) in phytic acid content to 6.83 and 1.04 mg/g in soybean and faba bean tempehs, respectively compared to tempeh produced after soaking process for 24 hr.

It could be noticed that increasing incubation temperature from 25° to 31° and 37° was accompanied by significant decrease ($P < 0.05$) in phytic acid of soybean and faba bean tempehs from 7.44 and 1.20 mg/g to 6.12 and 0.96 mg/g and 6.59 and 1.05 mg/g, respectively. These results indicated that incubation temperature 31°C led to more significant decrease ($P < 0.05$) in phytic acid than those of 37°C incubation temperature of soybean and faba bean tempehs.

Data revealed that phytic acid content in soybean or faba bean tempehs decreased significantly ($P < 0.05$) from 8.61 and 1.58 mg/g to 7.73 and 1.36, 6.63 and 1.08, 6.17

Table (33): Changes in phytic acid content during tempeh fermentation produced from soybean (mg/g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	9.03	8.42	7.69	7.35	7.01	6.73	7.71
	31	9.03	7.65	6.41	6.09	5.82	5.44	6.74
	37	9.03	8.16	7.34	6.88	6.45	5.91	7.30
	Mean	9.03	8.08	7.15	6.77	6.43	6.03	7.25
Soaking for 12 hr, dehulled and cooked	25	8.64	8.16	7.46	7.09	6.85	6.56	7.46
	31	8.64	7.55	6.13	5.82	5.29	4.91	6.39
	37	8.64	7.72	6.29	5.86	5.44	5.08	6.51
	Mean	8.64	7.81	6.63	6.26	5.86	5.52	6.79
Soaking for 24 hr, dehulled and cooked	25	8.36	8.01	7.21	6.79	6.48	6.07	7.15
	31	8.36	6.41	4.05	3.78	3.56	3.48	4.94
	37	8.36	7.63	5.78	4.91	4.54	4.08	5.88
	Mean	8.36	7.35	5.68	5.16	4.86	4.54	5.99
Germinated, dehulled and cooked	25	8.42	8.19	7.63	7.25	6.81	6.23	7.42
	31	8.42	7.28	6.57	6.04	5.32	4.84	6.41
	37	8.42	7.53	6.94	6.22	5.68	5.17	6.66
	Mean	8.42	7.67	7.05	6.50	5.94	5.41	6.83
Mean of incubation period		8.61	7.73	6.63	6.17	5.77	5.38	6.72

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	7.44	6.12	6.59

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.06

L.S.D. between means of any two incubation temperature = 0.02

L.S.D. between means of any two incubation period = 0.02

L.S.D. between means of any two incubation temperature/treatment = 0.07

L.S.D. between means of any two incubation period/treatment = 0.07

L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.08

Table (34): Changes in phytic acid content during tempeh fermentation produced from faba bean (mg/g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	1.72	1.61	1.38	1.28	1.09	1.00	1.35
	31	1.72	1.45	1.18	0.97	0.84	0.70	1.14
	37	1.72	1.53	1.29	1.10	0.92	0.83	1.23
	Mean	1.72	1.53	1.28	1.12	0.95	0.84	1.24
Soaking for 12 hr, dehulled and cooked	25	1.56	1.42	1.24	1.07	0.94	0.86	1.18
	31	1.56	1.28	0.85	0.69	0.62	0.53	0.92
	37	1.56	1.33	1.04	0.85	0.74	0.69	1.04
	Mean	1.56	1.34	1.04	0.87	0.77	0.69	1.05
Soaking for 24 hr, dehulled and cooked	25	1.51	1.33	1.16	0.94	0.81	0.75	1.08
	31	1.51	1.19	0.74	0.58	0.49	0.41	0.82
	37	1.51	1.28	0.91	0.76	0.63	0.55	0.94
	Mean	1.51	1.27	0.94	0.76	0.64	0.57	0.95
Germinated, dehulled and cooked	25	1.54	1.38	1.25	1.08	1.00	0.90	1.19
	31	1.54	1.26	0.91	0.74	0.62	0.55	0.94
	37	1.54	1.21	0.99	0.83	0.72	0.64	0.99
	Mean	1.54	1.28	1.05	0.88	0.78	0.70	1.04
Mean of incubation period		1.58	1.36	1.08	0.91	0.79	0.70	1.07

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	1.20	0.96	1.05

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.04

L.S.D. between means of any two incubation temperature = 0.02

L.S.D. between means of any two incubation period = 0.01

L.S.D. between means of any two incubation temperature/treatment = 0.05

L.S.D. between means of any two incubation period/treatment = 0.05

L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.06

and 0.91, 5.77 and 0.79 and 5.38 and 0.70 mg/g by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively.

Comparing between incubation temperatures within the different treatments showed that phytic acid content of soybean or faba bean tempehs decreased significantly ($P < 0.05$) with increasing incubation temperature from 25° to 31° and 37°C. As the same general trend mentioned before, also incubation temperature 31°C led to more significant decrease ($P < 0.05$) in phytic acid content than those of 37°C incubation temperature of soybean or faba bean tempehs.

Increasing of incubation period from 0 to 24, 36, 48, 60 and 72 hr within different treatments led to significant decreases ($P < 0.05$) in phytic acid content of tempeh produced from any one of the four treatments of soybean tempeh. The same trend was obtained in the case of faba bean tempeh.

Comparing between incubation temperatures within the different incubation periods within the different treatments showed that phytic acid content decreased significantly ($P < 0.05$) from 7.21 and 8.36 mg/g to 4.05 mg/g by increasing incubation temperature from 25° to 31°C and increasing

incubation period from 0 to 36 hr of soybean tempeh produced from soaking process for 24 hr, respectively. In the case of faba bean tempeh, phytic acid content was also decreased significantly ($P < 0.05$) from 1.16 and 1.51 mg/g to 0.74 mg/g by increasing incubation temperature from 25° to 31°C and increasing incubation period from 0 to 36 hr of faba bean tempeh produced from soaking process for 24 hr, respectively.

These results indicated that this treatment was an optimum one to produce the excellent tempeh from soybean or faba bean, whereas it contained the lowest content of phytic acid comparing with the other different treatments at the same incubation period and temperature. Although increasing incubation period for this treatment was accompanied by more significant decrease ($P < 0.05$) in phytic acid content, it was considered the optimum one because of increasing chemical freshness parameters as discussed before. Anyhow this treatment led to remove 60.10 and 61.26% of phytic acid content of soybean and faba bean cotyledons, respectively.

The reduction of phytic acid content during tempeh production can be accounted for the activity of phytase enzyme elaborated by the mold Rhizopus oligosporus responsible for the fermentation. Production of phytase

by the fungus used is well documented (Sudarmadji and Markakis, 1978; Lolas and Markakis, 1977; Wang et al., 1980; Fardiaz and Markakis, 1981; Sutardi and Buckle, 1985a).

3.2. Changes in trypsin inhibitor activity:

Using of Rhizopus oligosporus in tempeh production from soybean or faba bean led to decrease in trypsin inhibitor activity as it was indicated in Tables (35 and 36), respectively.

Statistical analysis showed that trypsin inhibitor activity in soybean or faba bean tempehs was significantly decreased ($P < 0.05$) to 11.03 and 6.76 TIU/mg, respectively due to soaking process for 12 hr compared to 18.54 and 8.44 TIU/mg of tempeh produced from soybean or faba bean without soaking, respectively. More significant decrease ($P < 0.05$) to 8.92 and 5.40 TIU/mg in soybean and faba bean tempehs, respectively was noticed due to increasing soaking process for 24 hr. On the other hand, germination process led to significant increase ($P < 0.05$) in trypsin inhibitor activity to 14.28 and 7.51 TIU/mg in soybean and faba bean tempehs, respectively compared to tempeh produced from soaking process for 12 and 24 hr.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by

Table (35): Changes in trypsin inhibitor activity during tempeh fermentation produced from soybean (Trypsin inhibitor unit (TIU)/mg, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)					Mean	
		0	24	36	48	60		72
Dehulled without soaking and cooked	25	33.25	28.19	25.34	21.67	19.85	18.05	24.39
	31	33.25	17.08	9.61	8.93	8.47	8.26	14.27
	37	33.25	22.15	12.83	11.76	11.08	10.62	16.95
	Mean	33.25	22.47	15.93	14.12	13.13	12.31	18.54
Soaking for 12 hr, dehulled and cooked	25	23.34	17.86	13.71	10.09	9.65	9.23	13.98
	31	23.34	10.93	5.02	4.67	4.39	4.18	8.76
	37	23.34	12.08	7.24	6.85	6.44	6.07	10.34
	Mean	23.34	13.62	8.66	7.20	6.83	6.49	11.03
Soaking for 24 hr, dehulled and cooked	25	19.28	13.65	10.03	9.74	9.38	8.49	11.76
	31	19.28	8.14	3.21	2.85	2.63	2.55	6.44
	37	19.28	9.85	6.18	5.93	5.27	4.89	8.57
	Mean	19.28	10.55	6.47	6.17	5.76	5.31	8.92
Germinated, dehulled and cooked	25	26.66	21.34	17.96	16.51	16.08	15.73	19.05
	31	26.66	12.09	6.85	6.32	5.76	5.14	10.47
	37	26.66	15.43	10.07	9.67	9.21	8.82	13.31
	Mean	26.66	16.29	11.63	10.83	10.35	9.90	14.28
Mean of incubation period		25.63	15.73	10.67	9.58	9.02	8.50	13.19

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	17.30	9.99	12.29

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.82
- L.S.D. between means of any two incubation temperature = 0.18
- L.S.D. between means of any two incubation period = 0.09
- L.S.D. between means of any two incubation temperature/treatment = 0.87
- L.S.D. between means of any two incubation period/treatment = 0.84
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.52

Table (36): Changes in trypsin inhibitor activity during tempeh fermentation produced from faba bean (trypsin inhibitor unit (TIU)/mg, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	16.12	12.45	9.37	7.28	6.53	6.04	9.63
	31	16.12	9.63	5.11	4.67	4.22	3.85	7.27
	37	16.12	10.52	7.29	5.98	5.46	5.13	8.42
	Mean	16.12	10.87	7.26	5.98	5.40	5.01	8.44
Soaking for 12 hr, dehulled and cooked	25	12.85	10.16	8.07	6.87	6.44	5.83	8.37
	31	12.85	7.04	3.54	3.26	2.95	2.59	5.37
	37	12.85	8.27	5.13	4.71	4.23	4.05	6.54
	Mean	12.85	8.49	5.58	4.95	4.54	4.16	6.76
Soaking for 24 hr, dehulled and cooked	25	11.60	8.75	6.34	5.28	4.62	4.18	6.80
	31	11.60	5.38	2.16	1.84	1.47	1.25	3.95
	37	11.60	7.05	4.29	3.86	3.28	2.79	5.45
	Mean	11.60	7.06	4.26	3.66	3.06	2.74	5.40
Germinated, dehulled and cooked	25	14.25	11.32	8.61	7.46	6.83	6.20	9.11
	31	14.25	8.56	4.05	3.69	3.37	3.04	6.16
	37	14.25	9.27	5.73	5.22	4.69	4.41	7.26
	Mean	14.25	9.72	6.13	5.46	4.96	4.55	7.51
Mean of incubation period		13.71	9.04	5.81	5.01	4.49	4.12	7.03

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	8.48	5.69	6.92

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.44
- L.S.D. between means of any two incubation temperature = 0.12
- L.S.D. between means of any two incubation period = 0.19
- L.S.D. between means of any two incubation temperature/treatment = 0.48
- L.S.D. between means of any two incubation period/treatment = 0.45
- L.S.D. between means of any two incubation temperature/incubation period / treatment = 0.52

significant decrease ($P < 0.05$) in trypsin inhibitor activity of soybean and faba bean tempehs from 17.30 and 8.48 TIU/mg to 9.99 and 5.69 TIU/mg and 12.29 and 6.92 TIU/mg, respectively. These results indicated that incubation temperature 31°C led to more significant decrease ($P < 0.05$) in trypsin inhibitor activity than those of 37°C incubation temperature of soybean or faba bean tempehs.

Data revealed that trypsin inhibitor activity in soybean or faba bean tempehs decreased significantly ($P < 0.05$) from 25.63 and 13.71 TIU/mg to 15.73 and 9.04, 10.67 and 5.81, 9.58 and 5.01, 9.02 and 4.49 and 8.50 and 4.12 TIU/mg by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively.

Comparing between incubation temperature within the different treatments showed that trypsin inhibitor activity of soybean or faba bean tempehs decreased significantly ($P < 0.05$) with increasing incubation temperature from 25° to 31° and 37°C . As the same general trend mentioned before, also incubation temperature 31°C led to more significant decrease ($P < 0.05$) in trypsin inhibitor activity than those of 37°C incubation temperature of soybean or faba bean tempehs.

Increasing of incubation period from 0 to 24, 36, 48, 60 and 72 hr within different treatments led to

significant decrease ($P < 0.05$) in trypsin inhibitor activity of tempeh produced from any one of the four treatments of soybean tempeh. The same trend was obtained in the case of faba bean tempeh.

Comparing between incubation temperatures within the different incubation periods within the different treatments showed that trypsin inhibitor activity decreased significantly ($P < 0.05$) from 10.03 and 19.28 TIU/mg to 3.21 TIU/mg by increasing incubation temperature from 25°C to 31°C and increasing incubation period from 0 to 36 hr of soybean tempeh produced from soaking process for 24 hr, respectively. In the case of faba bean tempeh, trypsin inhibitor activity was also decreased significantly ($P < 0.05$) from 6.34 and 11.60 TIU/mg to 2.16 TIU/mg by increasing incubation temperature from 25°C to 31°C and increasing incubation period from 0 to 36 hr of faba bean tempeh produced from soaking process for 24 hr, respectively.

These results indicated that this treatment was an optimum one to produce the excellent tempeh from soybean or faba bean, whereas the tempeh produced from this treatment contained the lower amount of trypsin inhibitor activity comparing with the other different treatments at the same incubation period and temperature. Although increasing incubation period for this treatment was

accompanied by more significant decrease ($P < 0.05$) in trypsin inhibitor activity, it was considered that this treatment is the optimum one because of increasing chemical freshness parameters as discussed before. Anyhow this treatment led to remove 92.34 and 90.32% of trypsin inhibitor activity in soybean and faba bean cotyledons, respectively.

Results concerning the reduction of trypsin inhibitor activity during tempeh production is agreement with results obtained by Wang et al. (1972 & 1975), Kao and Robinson (1978) and Paredes-Lopez and Harry (1989) which they reported that Rhizopus oligosporus is capable of hydrolyzing the trypsin inhibitor of soybean or faba bean.

4.3. Changes in total vicine contents:

Production of tempeh using the mold Rhizopus oligosporus from soybean and faba bean led to decrease in total vicine as it was indicated in Tables (37 and 38), respectively.

Statistical analysis showed that total vicine content in soybean or faba bean tempehs was significantly decreased ($P < 0.05$) to 2.14 and 6.59 mg/g, respectively due to soaking process for 12 hr compared to 2.64 and 7.06 mg/g of tempeh produced from soybean or faba bean without soaking,

respectively. More significant decrease ($P < 0.05$) to 1.51 and 4.69 mg/g in soybean and faba bean tempehs, respectively was noticed due to increasing soaking process for 24 hr. On the other hand, germination process led to significant increase ($P < 0.05$) in total vicine content to 2.32 and 5.92 mg/g in soybean and faba bean tempehs, respectively compared to tempeh produced from soaking process for 12 and 24 hr in soybean tempeh and 24 hr in faba bean tempeh.

It could be noticed that increasing incubation temperature from 25° to 31° and 37°C was accompanied by significant decrease ($P < 0.05$) in total vicine content of soybean and faba bean tempehs from 2.30 and 6.60 mg/g to 2.03 and 5.60 mg/g and 2.13 and 6.00 mg/g, respectively. These results showed that incubation temperature 31°C led to more significant decrease ($P < 0.05$) in total vicine content than those of 37°C incubation temperature of soybean or faba bean tempehs.

Data revealed that total vicine content in soybean or faba bean tempehs decreased significantly ($P < 0.05$) from 2.75 and 7.71 mg/g to 2.46 and 6.78, 2.22 and 6.15, 2.01 and 5.61, 1.82 and 5.18 and 1.67 and 4.96 mg/g by increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr, respectively.

Table (37): Changes in total vicine content during tempeh fermentation produced from soybean (mg/g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)						Mean
		0	24	36	48	60	72	
Dehulled without soaking and cooked	25	3.21	3.06	2.89	2.72	2.59	2.43	2.82
	31	3.21	2.88	2.63	2.35	2.12	1.92	2.52
	37	3.21	2.93	2.71	2.45	2.21	2.01	2.59
	Mean	3.21	2.96	2.74	2.51	2.31	2.12	2.64
Soaking for 12 hr, dehulled and cooked	25	2.81	2.54	2.28	2.08	1.89	1.74	2.22
	31	2.81	2.45	2.14	1.84	1.57	1.41	2.04
	37	2.81	2.47	2.24	2.04	1.75	1.60	2.16
	Mean	2.81	2.49	2.22	1.99	1.74	1.58	2.14
Soaking for 24 hr, dehulled and cooked	25	2.01	1.85	1.73	1.59	1.47	1.35	1.67
	31	2.01	1.64	1.34	1.20	1.08	1.00	1.38
	37	2.01	1.74	1.46	1.32	1.20	1.11	1.47
	Mean	2.01	1.74	1.51	1.37	1.25	1.15	1.51
Germinated, dehulled and cooked	25	2.95	2.72	2.56	2.39	2.25	2.14	2.50
	31	2.95	2.56	2.26	1.97	1.75	1.60	2.18
	37	2.95	2.64	2.37	2.09	1.88	1.72	2.28
	Mean	2.95	2.64	2.40	2.15	1.96	1.82	2.32
Mean of incubation period		2.75	2.46	2.22	2.01	1.82	1.67	2.15

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	2.30	2.03	2.13

L.S.D. (P < 0.05):

- L.S.D. between means of any two treatments = 0.18
- L.S.D. between means of any two incubation temperature = 0.03
- L.S.D. between means of any two incubation period = 0.03
- L.S.D. between means of any two incubation temperature/treatment = 0.19
- L.S.D. between means of any two incubation period/treatment = 0.19
- L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.22

Table (38): Changes in total vicine content during tempeh fermentation produced from faba bean (mg/g, on dry weight basis).

Treatments	Incubation temperature (°C)	Incubation period (hours)					Mean	
		0	24	36	48	60		72
Dehulled without soaking and cooked	25	8.64	8.14	7.74	7.29	6.83	6.61	7.54
	31	8.64	7.02	6.76	6.29	5.84	5.53	6.68
	37	8.64	7.77	7.14	6.56	5.96	5.72	6.97
	Mean	8.64	7.64	7.21	6.71	6.21	5.95	7.06
Soaking for 12 hr, dehulled and cooked	25	8.24	7.62	7.10	6.66	6.32	6.15	7.02
	31	8.24	7.20	6.32	5.60	4.94	4.59	6.15
	37	8.24	7.47	6.72	6.24	5.55	5.36	6.60
	Mean	8.24	7.43	6.71	6.17	5.60	5.37	6.59
Soaking for 24 hr, dehulled and cooked	25	6.39	5.94	5.49	5.14	4.77	4.66	5.40
	31	6.39	4.88	3.70	3.46	3.27	2.96	4.11
	37	6.39	5.21	4.37	4.04	3.79	3.56	4.56
	Mean	6.39	5.34	4.52	4.21	3.94	3.73	4.69
Germinated, dehulled and cooked	25	7.56	6.90	6.64	6.21	5.77	5.61	6.45
	31	7.56	6.51	5.80	4.41	4.29	4.11	5.45
	37	7.56	6.68	6.02	5.42	4.80	4.62	5.85
	Mean	7.56	6.70	6.15	5.35	4.95	4.78	5.92
Mean of incubation period		7.71	6.78	6.15	5.61	5.18	4.96	6.07

Mean of incubation temperature.

Temperature	25°C	31°C	37°C
Mean	6.60	5.60	6.00

L.S.D. (P < 0.05):

L.S.D. between means of any two treatments = 0.25

L.S.D. between means of any two incubation temperature = 0.04

L.S.D. between means of any two incubation period = 0.05

L.S.D. between means of any two incubation temperature/treatment = 0.26

L.S.D. between means of any two incubation period/treatment = 0.27

L.S.D. between means of any two incubation temperature/incubation period/treatment = 0.31

Comparing between incubation temperature within the different treatment indicated that total vicine content of soybean and faba bean tempehs decreased significantly ($P < 0.05$) with increasing incubation temperature from 25° to 31° and 37°C . As the same general trend mentioned before also incubation temperature 31°C led to more significant decrease ($P < 0.05$) in total vicine content of soybean and faba bean tempehs than those of tempehs produced using 37°C incubation temperature.

In spite of increasing incubation period from 0 to 24, 36, 48, 60 and 72 hr was always accompanied by significant decrease ($P < 0.05$) in total vicine content, there was slight deviation in this comparison within most of different treatments. The occurred decreases were not always significant. In the case of soybean tempeh, increasing the incubation period to 72, 60, 36 and 60 hr, within tempeh produced from without soaking, soaking process for 12 hr, soaking process for 24 hr and germination process, respectively, was accompanied by a significant decrease ($P < 0.05$) in the total vicine content. In the same time increasing the incubation period from 36 to 60 hr or from 48 to 60 hr was accompanied by a significant decrease ($P < 0.05$) in total vicine content in the soybean tempeh produced from soaking process for 24 hr. In the case of faba bean tempeh increasing the incubation period

to 60 hr always accompanied by a significant decrease ($P < 0.05$) in total vicine content of faba bean tempeh produced by any of the different treatments. This means that the reduction in total vicine was insignificant ($P > 0.05$) after 60 hr incubation.

Comparing between incubation temperature within the different incubation periods within the different treatments showed that total vicine content decreased significantly ($P < 0.05$) from 1.73 and 2.01 mg/g to 1.34 mg/g by increasing incubation temperature from 25° to 31°C and increasing incubation period from 0 to 36 hr of soybean tempeh produced from soaking process for 24 hr, respectively. In the case of faba bean tempeh, total vicine content was also decreased significantly ($P < 0.05$) from 5.49 and 6.39 to 3.70 mg/g by increasing incubation temperature from 25° to 31°C and increasing incubation period from 0 to 36 hr of faba bean tempeh produced from soaking process for 24 hr, respectively.

These results revealed that this treatment was an optimum one to produce the excellent tempeh from soybean or faba bean, whereas the tempeh produced from this treatment contained the lower amount of total vicine content comparing with tempeh produced from the other different

treatments at the same incubation period and temperature. In spite of increasing incubation period for this treatment was accompanied by more significant decrease ($P < 0.05$) in total vicine content, this treatment was considered the optimum one because of increasing chemical freshness parameters as discussed before. Anyhow this treatment led to remove 74.08 and 76.92% of total vicine content of soybean and faba bean cotyledons, respectively.

P A R T I I I :

**Properties of Tempeh Produced from Soybean and Faba Bean
Cotyledons as Affected by Mixing with Green Spices and
Frying Compared with "Taameia".**

Part III: Properties of tempeh produced from soybean and faba bean cotyledons as affected by mixing with green spices and frying compared with "Taameia":

Results of the previous part indicated that excellent tempeh was prepared from soybean or faba bean seeds after soaking for 24 hr, dehulled by hand, cooked at 100°C for 30 minutes and inoculated with spores suspension of the mold Rhizopus oligosporus CAIM 182. The inoculated bean cotyledons were incubated at 31°C for 36 hr to produce fresh tempeh. Fermentation introduced desirable changes i.e. increased in the protein quality, decreased anti-nutritional factors and contribute to the development of a desirable texture, aroma and flavor substantially the biological value will increased. The aim of this part is to prepare tempeh products to be consumed in the form of fried tempeh which will be compared to "Taameia".

1. Changes in chemical composition:

Data in Table (39) show the chemical constituents of tempeh products compared with "Taameia". Fermentation process using Rhizopus oligosporus CAIM 182 decreased significantly ($P < 0.05$) moisture content from 63.55% at zero time of fermentation to 57.25% of soybean tempeh, while moisture content did not change of faba bean tempeh which contained 64.70%. Addition of green spices mixture to tempeh produced from soybean and faba bean cotyledons

increased significantly ($P < 0.05$) moisture content to 63.48 and 70.94% of soybean and faba bean tempehs mixed with green spices, respectively. Frying process in oil for 5 minutes decreased significantly ($P < 0.05$) moisture content to 26.07, 28.34, 23.67 and 25.56% of soybean tempeh without and with green species and faba bean tempeh without and with green spices, respectively.

As mentioned in the last part, fermentation process led to increase protein content of either soybean tempeh or faba bean tempeh, this increasing was significantly ($P < 0.05$) from 44.43 and 29.43% at zero time of fermentation of soybean and faba bean cotyledons, respectively to 49.04 and 36.12% of soybean and faba bean tempehs, respectively. Data in Table (39) indicated that this increasing was affected by adding green spices mixture which are known to be poor in protein content. So protein content was 40.56 and 30.28% in soybean and faba bean tempehs mixed with green spices, respectively. Any how protein content in the mentioned tempeh products, except faba bean tempeh mixed with green species, was significantly ($P < 0.05$) higher than protein content in "Taameia" paste (28.14%). Frying process decreased significantly ($P < 0.05$) crude protein to 40.20, 28.47, 23.84 and 16.96% of fried soybean tempeh without or mixed with green spices, faba bean tempeh without and mixed with green species, respectively. In "Taameia"

Table (39): Major chemical components of "Taameia" and tempeh products produced from soybean and faba bean (g/100 g, on dry weight basis).

Components	" Taameia "		Soybean tempeh		Faba bean cotyledons at zero time of fermentation		Faba bean tempeh		L.S.D.			
	Before frying	After frying	Without green spices	With green spices	Before frying	After frying	Without green spices	With green spices				
Moisture	64.84	41.70	57.25	26.07 ^a	63.48 ^b	28.34	64.37 ^b	23.67	70.94	25.56 ^a	1.30	
Crude protein	28.14 ^a	20.60	49.04	40.20 ^b	40.56 ^b	28.47 ^a	29.43 ^a	23.84	30.28 ^a	16.96	2.73	
Ether extract	1.62	26.67	24.00	37.78	20.13	37.15	2.09	33.71	1.20 ^a	38.61	0.21	
Ash	5.95	4.56 ^b	3.99	3.09 ^a	8.75	7.21	3.18 ^a	1.96	6.73	4.55 ^b	0.39	
Crude fiber	3.79 ^a	3.25	5.86 ^c	4.86	6.46	5.88 ^c	3.51	4.34 ^b	3.87 ^a	5.04	0.18	
Available carbohydrate *	60.50 ^d	44.92	17.76 ^a	14.07	24.10	24.29	61.79 ^d	55.76 ^c	36.62 ^b	56.20 ^c	34.84 ^b	2.97

* Calculated by difference.

a-d: There is no significant difference between any two means have the same letter within certain component.

also frying process decreased significantly ($P < 0.05$) protein content to 20.60% of fried "Taameia".

Ether extract decreased significantly ($P < 0.05$) from 28.99 and 2.09% at zero time of fermentation of soybean and faba bean cotyledons, respectively, to 24.00 and 1.39% of soybean and faba bean tempehs, respectively. The ability of the mold Rhizopus oligosporus to hydrolyze fat is well documented (Wagenkecht et al., 1961 and Agosin et al., 1989). Addition of green spices mixture decreased significantly ($P < 0.05$) ether extract to 20.13 and 1.20% of soybean and faba bean tempehs mixed with green spices, respectively. This decreasing is due to deficiency of green spices in ether extract. Frying process increased significantly ($P < 0.05$) ether extract of fried soybean tempeh without and mixed with green spices and faba bean tempeh without and mixed with green spices to 37.78, 36.15, 33.71 and 38.61%, respectively. Fried "Taameia" also contained 26.67% ether extract which is significant higher ($P < 0.05$) than "Taameia" paste 1.62%. Increasing ether extract in the fried products is expected due to the absorbed oil during the frying process.

Ash content decreased significantly ($P < 0.05$) from 4.39 and 3.18% at zero time of fermentation of soybean and faba bean cotyledons, respectively, to 3.99 and 2.39

of soybean and faba bean tempehs, respectively. Addition of green spices mixture increased significantly ($P < 0.05$) ash content of soybean and faba bean tempehs to 8.75 and 6.73%, respectively. Frying process decreased significantly ($P < 0.05$) ash content to 3.09, 7.21, 1.96 and 4.55% of fried soybean tempeh without and with mixed green spices and faba bean tempeh without and mixed with green species, respectively. Also frying process decreased significantly ($P < 0.05$) ash content from 5.95% of "Taameia" paste to 4.56% in fried "Taameia", respectively.

Crude fiber content increased significantly ($P < 0.05$) from 4.43 and 3.51% at zero time of fermentation of soybean and faba bean cotyledons, respectively to 5.86 and 4.34% of soybean and faba bean tempehs, respectively. These results are in agreement with those obtained by Steinkraus et al. (1960) and Van Buren et al. (1972). Addition of green spices mixture increased significantly ($P < 0.05$) fiber content of soybean and faba bean tempehs to 6.46 and 5.59%, respectively. Frying process decreased significantly ($P < 0.05$) fiber content of soybean tempeh without and mixed with green spices, faba bean tempeh without and mixed with green spices and "Taameia" to 4.86, 5.88, 3.87, 5.04 and 3.25%, respectively.

Available carbohydrates decreased insignificantly ($P > 0.05$) from 17.76% at zero time of fermentation of soybean

to 17.11% of soybean tempeh, respectively. On the other hand available carbohydrates decreased significantly ($P < 0.05$) from 61.79% at zero time of fermentation of faba bean to 55.73% of faba bean tempeh, respectively. These results is well documented by Quinn et al. (1975) and Paredes-Lopez et al. (1990) who refferred decreasing of available carbohydrates to hydrolysis of starch. Addition of green spices mixture increased significantly ($P < 0.05$) available carbohydrates to 24.10% of soybean tempeh, but they increased insignificantly ($P > 0.05$) in the case of faba bean tempeh to 56.20%. Frying process decreased significantly ($P < 0.05$) available carbohydrates to 14.07, 21.29, 36.62 and 34.84% of fried soybean tempeh without and mixed with green spices, faba bean tempeh without and mixed with green spices, respectively. Comparing with "Taameia", available carbohydrates also decreased significantly ($P < 0.05$) from 60.50 to 44.92% for "Taameia" paste and fried "Taameia", respectively.

2. Changes in quality index:

Total volatile nitroge, ammonia nitrogen, thiobarbituric acid and pH value were determined as chemical freshness parameters. Obtained data are tabulated in Table (40) which indicated that total volatile nitrogen (TVN) increased significantly ($P < 0.05$) from 0.07 and 0.09% at zero time of fermentation of soybean and faba bean

cotyledons, respectively, to 0.29 and 0.36% of soybean and faba bean tempeh, respectively. Addition of green spices increased significantly ($P < 0.05$) total volatile nitrogen to 0.56 and 0.53% of soybean tempeh mixed with green spices and faba bean tempeh mixed with green spices, respectively. Data in Table (40) indicated that frying process decreased significantly ($P < 0.05$) total volatile nitrogen of soybean tempeh without and mixed with green spices, faba bean tempeh without and mixed with green spices and "Taameia" to 0.12, 0.17, 0.29, 0.24 and 0.03%, respectively.

with respect to ammonia data in Table (40) showed that it increased significantly ($P < 0.05$) from 0.05 and 0.03 to 0.25 and 0.29% at zero time of fermentation of soybean and faba bean, respectively. This increase of ammonia could be largely attributed to deamination of amino acids (Van Buren et al., 1972 and Agosin et al., 1989). Addition of green spices mixture increased significantly ($P < 0.05$) ammonia to 0.42 and 0.40% of soybean and faba bean tempehs, respectively. Frying process decreased significantly ($P < 0.05$) ammonia to 0.09, 0.14, 0.16, 0.12 and 0.02 % of fried soybean tempeh without and mixed with green spices and faba bean tempeh without and mixed with green spices and "Taameia", respectively. Any how, it could be noticed that fried tempeh products contained higher amount of

Table (40): Freshness tests (total volatile nitrogen, ammonia and thiobarbituric acid) and pH of "Taameia" and tempeh products produced from soybean and faba bean cotyledons as affected by frying (on dry weight basis).

Components	Soybean		Soybean tempeh		Faba bean		Faba bean tempeh		L.S.D.			
	"Taameia" Before frying	After frying	Without green spices	With green spices	ons at zero time of fermentation	ons at zero time of fermentation	Without green spices	With green spices				
Total volatile nitrogen (%)	0.16 ^a	0.03	0.07	0.12	0.56	0.17 ^a	0.29 ^b	0.36	0.29 ^b	0.53	0.24	0.02
Ammonia (%)	0.11 ^b	0.02 ^a	0.05	0.09	0.42	0.14	0.25	0.29	0.16	0.40	0.12	0.02
Thiobarbituric acid	0.23 ^a	0.31	0.35 ^{cd}	0.43	0.26 ^b	0.40 ^e	0.34 ^c	0.27 ^b	0.34 ^c	0.22 ^a	0.40 ^a	0.03
pH	5.39	4.99	6.01 ^a	6.09 ^b	6.43 ^d	6.14 ^c	6.25	6.36	6.17 ^c	6.42 ^d	6.05 ^{ab}	0.05

a-e - There is no significant difference between any two means have the same letter within certain component.

* = (mg malonaldehyde/kg).

ammonia compared to "Taameia" but still in the accepted range.

Thiobarbituric acid (TBA) decreased insignificantly ($P < 0.05$) from 0.35 mg malonaldehyde/kg at zero time of fermentation of soybean to 0.34 mg malonaldehyde/kg in soybean tempeh, respectively, while it decreased significantly ($P < 0.05$) from 0.37 mg malonaldehyde/kg at zero time of fermentation in faba bean to 0.27 mg malonaldehyde/kg in faba bean tempeh, respectively. The difference between soybean and faba bean may be due to the high ether extract content in soybean. Adding green spices led to significant decrease ($P < 0.05$) in thiobarbituric acid of soybean and faba bean tempehs that it was 0.26 and 0.22 mg malonaldehyde/kg, respectively. Frying process increased significantly ($P < 0.05$) thiobarbituric acid to 0.43, 0.40, 0.34, 0.40 and 0.31 mg malonaldehyde/kg of fried soybean tempeh without and mixed with green spices, faba bean tempeh without and mixed with green spices and "Taameia", respectively. This significant increase could be refer to thiobarbituric acid of the used oil in frying process. Anyhow, in spite of thiobarbituric acid in fried tempeh products is significant higher than thiobarbituric acid in "Taameia", it is still in the accepted range.

pH values increased significantly ($P < 0.05$) from 6.01 and 5.95 at zero time of fermentation of soybean and faba

bean, respectively to 6.25 and 6.36 of soybean and faba bean tempehs, respectively. This increase could be largely attributed to the liberation of ammonia (Van Buren et al., 1972 and Agosin et al., 1989). Addition of green spices mixture increased significantly ($P < 0.05$) pH value to 6.43 and 6.42 of soybean and faba bean tempehs, respectively. Frying process decreased significantly ($P < 0.05$) pH value to 6.09, 6.14, 6.17, 6.05 and 4.99 in soybean tempeh without and mixed with green spices, faba bean tempeh without and mixed with green spices and "Taameia", respectively.

3. Changes in antinutritional factors:

Data presented in Table (41) show changes in antinutritional factors including phytic acid, trypsin inhibitor activity and total vicine during tempeh production from soybean and faba bean, addition of green spices and frying of this products in oil.

Phytic acid content decreased significantly ($P < 0.05$) from 8.36 and 1.51 mg/g in soybean and faba bean at zero time of fermentation to 4.05 and 0.74 mg/g of soybean and faba bean tempehs, respectively. The reduction of phytic acid content can be accounted for by the activity of phytase elaborated by the mold Rhizopus oligosporus, responsible for the fermentation. Production of phytase by the fungus used is well documented (Lolas and Markakis, 1977; Wang et al., 1980; Fardiaz and Markakis, 1981 and Sutardi and

Table (41): Antinutritional components (phytic acid, trypsin inhibitor activity and total vicine of "Taameia" and tempeh products produced from soybean and faba bean cotyledons (on dry weight basis).

Components	Soybean cotyledons at zero time of fermentation		Soybean tempeh		Faba bean cotyledons at zero time of fermentation		Faba bean tempeh		L.S.D.			
	Before frying	After frying	Without green spices	With green spices	Without green spices	With green spices	Before frying	After frying				
Phytic acid (mg/g)	1.63 ^e	0.80 ^{bc}	4.05 ^f	1.45 ^{de}	3.65 ^f	1.08 ^{cd}	1.51 ^e	0.74 ^{bc}	0.36 ^{ab}	0.64 ^{ab}	0.29 ^a	0.42
Trypsin inhibitor activity (TIU/mg)	16.74	5.67	3.21 ^c	1.16 ^a	3.32 ^c	1.14 ^a	11.60	2.16 ^b	0.79 ^a	2.01 ^b	0.75 ^a	0.44
Total vicine (mg/g)	13.19	4.40	1.34 ^c	0.40 ^a	1.24 ^c	0.32 ^a	6.39	3.70	0.92 ^b	3.48	0.87 ^b	0.15

a-f= There is no significant difference between any two means have the same letter within certain component.

Buckle, 1985 a). Addition of green spices mixture decreased significantly ($P < 0.05$) phytic acid content to 3.65 and 0.64 mg/g of soybean and faba bean tempehs. Frying process decreased significantly ($P < 0.05$) phytic acid content to 1.45 and 1.08 mg/g of soybean tempeh without and mixed with green spices, respectively, while the frying process decreased insignificantly ($P > 0.05$) phytic acid to 0.36 and 0.29 mg/g of faba bean tempeh without and mixed with green spices, respectively. In the same time frying process decreased significantly ($P < 0.05$) phytic acid from 1.63 in "Taameia" paste to 0.80 mg/g in fried "Taameia", respectively.

Trypsin inhibitor activity decreased significantly ($P < 0.05$) from 19.28 and 11.60 TIU/mg of soybean and faba bean at zero time of fermentation, respectively to 3.21 and 2.16 TIU/mg of soybean and faba bean tempehs, respectively. These results are in agreement with those obtained by Wang et al. (1972 & 1975) and Paredes-Lopez and Harry (1989) which they reported that Rhizopus oligosporus is capable of hydrolyzing the trypsin inhibitor of soybean and faba bean. Addition of green spices mixture to soybean and faba bean tempehs has no significant effect ($P > 0.05$) on trypsin inhibitor activity. On the other hand, frying process has significant effect ($P < 0.05$) on trypsin inhibitor activity that it was decreased to 1.16, 1.14, 0.79 and

0.75 TIU/mg in case of fried soybean tempeh without and mixed with green spices and faba bean tempeh without and mixed with green spices, respectively. In the same time frying process decreased significantly ($P < 0.05$) trypsin inhibitor activity from 16.74 TIU/mg in "Taameia" paste to 5.67 TIU/mg in fried "Taameia", respectively.

With respect to total vicine content, statistical analysis indicated that there are significant differences ($P < 0.05$) between "Taameia" (13.19 mg/g) and soybean and faba bean at zero time of fermentation (2.01 and 6.39 mg/g, respectively). Fermentation process caused significantly ($P < 0.05$) reduction in total vicine content of soybean and faba bean tempehs to 1.34 and 3.70 mg/g, respectively. Vicine was also decreased significantly ($P < 0.05$) to 1.24 and 3.48 mg/g in soybean and faba bean tempehs mixed with green spices, respectively. Frying process resulted in more significantly decrease ($P < 0.05$) in total vicine of "Taameia", soybean tempeh without and mixed with green spices and faba bean tempeh without and mixed with green spices to 4.40, 0.40, 0.32, 0.92 and 0.87 mg/g, respectively.

Fig. (1) shows a clear difference between "Taameia" and fried faba bean tempeh without or mixed with green spices from the stand point view of antinutritional components. Faba bean tempeh products minimized phytic

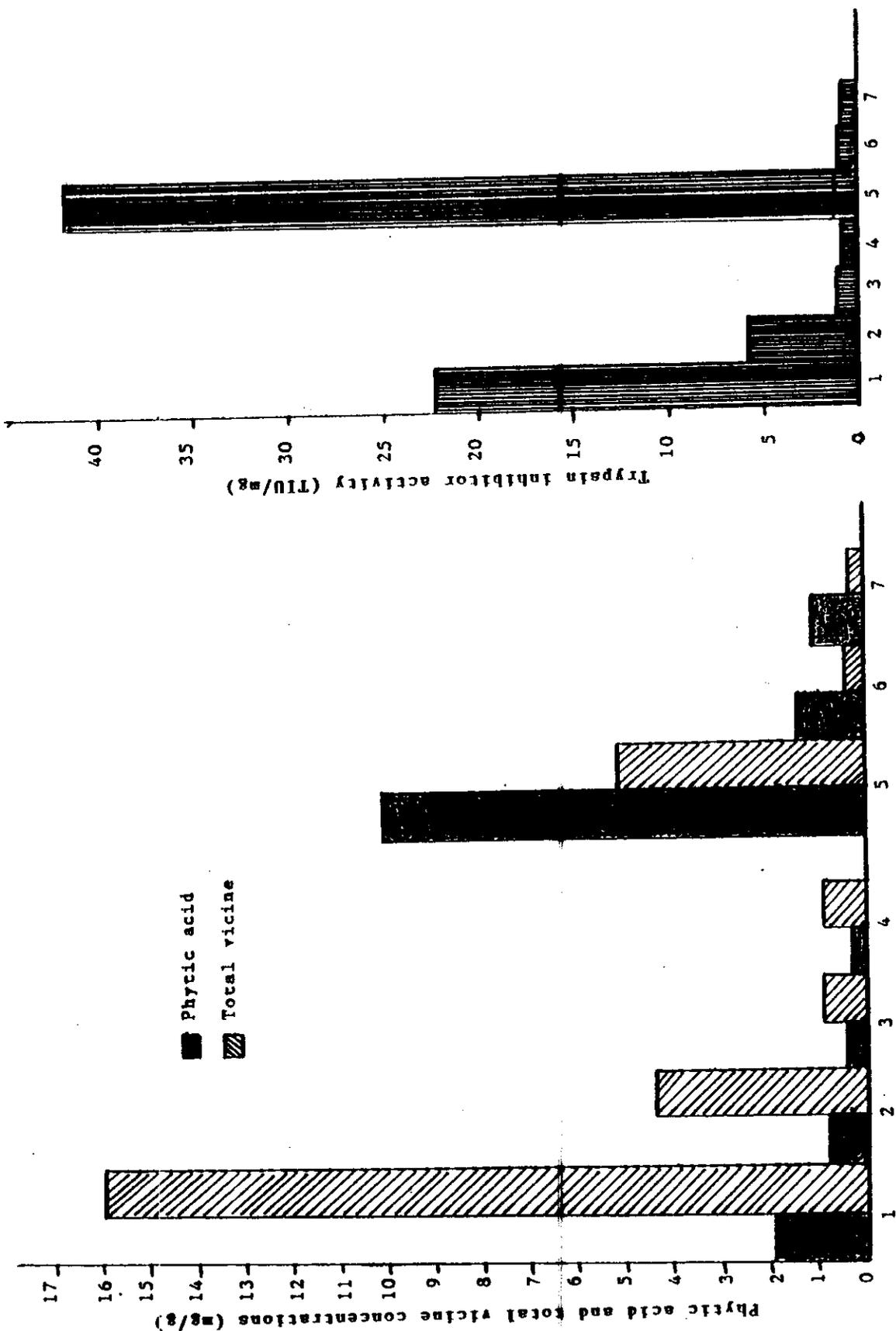


Fig. (1): Concentration of phytic acid, total vicine and trypsin inhibitor activity of: 1- Faba bean cotyledons, 2- "Taameia", 3- Fried faba bean tempeh without green spices, 4- Fried faba bean tempeh with green spices, 5- Soybean cotyledons, 6- Fried soybean tempeh without green spices, 7- Fried soybean tempeh with green spices.

acid, trypsin inhibitor activity and total vicine compared with "Taameia". Soybean tempeh products also minimized trypsin inhibitor activity and total vicine content compared to "Taameia", but their phytic acid contents were not less than that of "Taameia". This is due to the largest amount of phytic acid in soybean at zero time of fermentation. Anyhow processing of soybean, fried tempeh products minimized phytic acid to about 13-17% compared to its value at zero time of fermentation. These data indicated that production of tempeh is a good method in which microorganism (Rhizopus oligosporus) is used to produce a food with high nutritional value.