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NUTRITIONAL POTENTIAL AND FUNCTIONAL PROPERTIES OF TEMPE PRODUCED FROM MIXTURES OF DIFFERENT LEGUMES

2: Antinutritional factors, functional properties and sensory evaluation

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ABSTRACT

Tempe (fermented food) was produced by *Rhizopus oligosporus* using a mixture of faba bean, lupine , chickpea and green peas. Changes in anti-nutritional factors (tannins, trypsin inhibitors, phytic acid and heamaglutinin) and *in-vitro* protein digestibility of the produced tempe were studied. Protein solubility index (PSI) water absorption, fat absorption, emulsification and foam capacities, as well as, foam stability were carried out. Generally, fermentation decreased significantly ($p \leq 0.05$) tannins, phytic acid and trypsin inhibitors while, heamaglutinin was completely inactivated. Despite of antinutritional compounds, *in-vitro* protein digestibility of all mixtures was improved. Except water absorption, fermentation decreased all functional properties of the legume mixtures. The mixtures 50% of each of peas, chickpea and lupine with 50% faba bean showed significantly higher acceptance compared with other mixtures.

Key words: *antinutritional compound, chickpea, faba bean, fermentation, functional properties, lupine, peas, tempe.*

1. INTRODUCTION

Legumes are used as a main source of proteins, especially in the developing countries, including Egypt, where animal proteins are expensive. The utilization of legumes has been limited due to the presence of certain antinutritional factors, including phytic acid, condensed tannins, trypsin inhibitors and haemaglutinin, which reduce the nutritional quality of proteins. Attempts to increase the utilization of legumes have been employed in a wide range of processing techniques such as cooking, autoclaving, roasting, frying, steaming, toasting and canning (Kingsly, 1995; Alonso *et al.*, 1998; El-Adawy *et al.* 2003; Egounlety and Aworh, 2003). Fermentation is one of the processes that decrease the level of anti-nutrients in the food grains and increase the protein availability, *in vitro* protein digestibility and nutritive value (Chavan and Kadam, 1989).

Tempe is a popular fermented food in Indonesia. It is produced by fungal fermentation of soybean or other legumes (Ashenafi and Busse, 1991). It could be served as an excellent substitute for animal protein products and therefore it holds promise to combat mal-nutrition in the countries where proteins and calories are in short supply (Mital and Grag, 1990). Tempe technology meet an increasing interest in the developing countries as a small scale method to derive nutritious foods from locally available legumes and cereals (Nout *et al.*, 1987). Different substrates have been used to elaborate tempe: common bean, rapeseeds, lupine horsbean, groundnut, wheat, mung bean (Hachmeister and Fung, 1993 and El-Bagoury *et al.*, 2001).

The present work was carried out to evaluate the changes in antinutritional factors (tannins, trypsin inhibitors, phytic acid and heamaglutinin), functional properties and organoleptic characteristics of the tempe produced by mixing different legumes.

2. MATERIALS AND METHODS

2.1. MATERIAL

Four different kinds of legumes, green peas (*Pisum sativum*) variety Lencolen, broad bean (*Vicia faba* L.) variety Giza 3 , Chickpeas (*Cicer* *aritinum*) and termis (*Lupinus termis*) were obtained from the Agricultural Research Center, Giza, Egypt.

2.2. METHODS

2.2.1. Tempe preparation:

Eight blends of fermented tempe were prepared according to (Nassar *et al.*, 2006) as described in Fig. (1).

Broad bean dehulled | Green peas dehulled | Chickpea | Lupine

↓

Soaking in tap water (1 : 20, w / v) for 16 h at ~ 25°C

↓

Manual dehulling

↓

Ground into grits

↓

Mixing

↓

Cooking for 25 min in acidified tap water

↓

Cooling to 37°C

↓

Inoculation with *Rhyzopus oligosporus* suspension

↓

Paking in Petri dishes

↓

Incubation for 48 h at 37°C ± 1

↓

Tempe

Fig. (1): Tempe preparation.

2.2.2. Anti-nutritional factors determination

Total tannins were colorimetrically determined as described in AOAC (1990). Phytic acid was determined according to the method of Wheeler and Ferrel (1971). Procedure was followed for the analysis of phytic acid including determination of phosphorus by the method of Tausky and Shorr (1953). Trypsin inhibitor activity was determined according to the method of Kakade *et al.*, (1969) using Benzoyl-DL-Argenine-P-nitroanalide (PAPA) as a substrate. The method of Liener and Hill (1953) was used to determine the haemaglutinin activity. *In-vitro* protein digestibility was determined by the method of Salgó *et al.*, (1984) by measuring the change in the sample solution pH after incubation at 37°C for 10 min. with trypsin-pancreatin enzyme mixture.

2.2.3. Functional properties

Protein solubility indexes were determined according to Smith *et al.*, (1959). Water and fat absorption capacities were determined according to the procedure of Sosulski (1962) and Sosulski *et al.*, (1976), respectively. The procedure described by Beuchat *et al.*, (1975) was used to determine the emulsification capacity. The method of Lawhon *et al.*, (1972) was used to measure the foam capacity and stability.

2.2.4.Sensory evaluation

Fermented tempe was cut into pieces (6X6 cm) and fried in pre-heated (180°C) sunflower oil in deep fryer for 90 sec on each side, removed from the fryer and allowed to cool to room temperature ~ 25°C. Colour, flavour, appearance, texture and overall acceptability of produced tempe were evaluated by ten graduate student and staff members of Food Science and Technology Department, Menoufia University using a hedonic scale of ten points for each trait.

2.2.5. Statistical analysis

Results were expressed as the mean values of three separate determinations, except for foam stability. Data were subjected to analysis of variance using a completely randomized design (Steel and Torrie, 1980).

3. RESULTS AND DISCUSSION

3.1. Anti-nutritional content

Table (1) shows the anti-nutritional contents and *in-vitro* protein digestibility (IVPD) of Faba bean, Lupine, Chickpeas and green peas seed meal used for tempe preparation. Green peas had the highest content of tannin (2.07 mg/gm meal) and heamaglutinin (4600 Heamaglutinin Unit/gm meal), while faba bean meal had the highest content of phytic acid (8.72 mg/gm meal). On the other side, lupine seed meal had the lowest contents of tannin (0.75mg/gm meal), phytic acid (3.26 mg/gm meal), trypsin inhibitor (nil) and the heamaglutinin (nil). *In-vitro* protein digestibility can be arranged in the following decreasing order, peas (88.91%), lupine (83.15%), faba bean (76.60%) and chickpeas (71.82%).

Table (1): Anti-nutritional contents of raw legumes used in tempe preparation.

Legume Source	Tannin mg/g meal	Phytic acid mg/g meal	Trypsin inhibitor TUI/mg protein	Heamaglutinin H.U/gm meal	IVPD %
Fababean	1.62 ± 0.15	8.72 ± 0.5	8.5 ± 0.2	3400 ± 20	76.60 ± 0.7
Lupine	0.75 ± 0.13	3.26 ± 0.41	Nil	Nil	83.15 ± 0.83
Chickpea	1.34 ± 0.12	5.66 ± 0.38	31.26 ± 0.41	1620 ± 80	71.82 ± 0.66
Peas	2.07 ± 0.18	7.75 ± 0.51	9.96 ±0.36	4600 ± 40	88.91 ± 0.92
L.S.D.5%	0.20	0.56	0.45	80.00	1.08

IVPD : In-vitro protein digestibility

The effect of fermentation by *Rhizopus oligosporus* on the antinutritional contents of tempe produced from mixture of different legumes is shown in Table (2). Compared to the raw legume mixtures, significant ($p \leq 0.05$) decrease in the antinutritional contents was observed in all fermented mixtures. Fermented mixture contained equal part of different legumes (mixture) had the lowest content of tannin (0.45 mg/gm flour) followed by 75% faba bean +25% lupine. Generally, fermentation reduced the tannin content of all produced tempe by the range of 58% (50% faba bean + 50% lupine) to 68% (mixture). The highest reduction rate of phytic acid was noticed in the mixture of 50% faba bean + 50% lupine (70.23%) followed by 75% faba bean +25% lupine (62.07%). Generally, fermentation is known to cause a greater reduction in phytic acid than other antinutrients due to the low pH, which is considered to be optimum for phytase activity. This decrease could be due to the enzymatic hydrolysis of phytic acid by phytase to inositol and ortho phosphate (Sutardi and Bukle, 1985; El-Sayed and El-Bagoury, 2003). Similar trend was observed in trypsin inhibitor content in all fermented legume mixtures. The reduction rates ranged from 55.28% to 76.41%. The lowest trypsin inhibitor content was detected in tempe produced from 50% faba bean + 50% lupine (1.82 unit trypsin inhibited/mg protein). This reduction could be due to the heat treatment used in the cooking process. These results agreed with those reported by Egounlety and Aworh (2003) who reported that fermentation of soybean decreased trypsin inhibitor by 74.2%, while heat treatment decreased it by 82.1%. Generally, no heamaglutinin activity was detected in all fermented legume mixtures.

Fermentation process significantly ($p \leq 0.05$) increased the *in-vitro* protein digestibility (IVPD) of all fermented legume mixtures, the highest IVPD was observed in the mixture of 50% faba bean +50% lupine (97.43%) while, the lowest IVPD was noticed in fermented 100% faba bean (92.61%). This increase could have been due to either reduction of tannin and trypsin inhibitor contents during pretreatment and fermentation processes and / or partial hydrolysis of the native protein during fermentation which led to an increase in the proteolytic enzyme efficiency.

3.2. Functional properties

Protein solubility indexes (PSI) of raw material and tempe produced from mixtures of different legumes are presented in Tables (3 and 4). Generally, protein was more soluble in alkali than salt. Lupine seed flour had the highest protein solubility index (66.76% in distilled water, 71.10% in salt and 79.12% in alkali , while peas flour had the lowest protein solubility indexes in all solvents. The highest protein solubility index was noticed in the mixture of 50% lupin + 50% faba bean (64.48% in distilled water, 70.47% in salt and 76.11% in alkali). Fermentation by *Rhizopus oligosporus* significantly ($p \leq 0.05$) decreased the protein solubility indexes in all solvents. Tempe produced from 100% faba bean had the highest PSI (42.12% in distilled water, 46.34% in salt and 52.91% in alkali) followed by that produced from the mixture of 50% lupine + 50% faba bean (39.08% in distilled water, 43.75% in salt and 49.81% in alkali). The higher PSI in alkali than the other solvents may have been due to the fact that water extract only albumin, sodium chloride extracts albumin and globulin, globulin and other solubilized types of protein (El-Adawy *et al.*, 2003).The decrease in PSI *via* fermentation may be due to denaturation of protein during cooking process prior to fermentation.

Table (2): Antinutritional contents of legume mixtures and produced Tempe.

Legume	Tannin flour mg/g	Phytic acid flour mg/g	Trypsin inhibitor (TUI/mg protein)	Heamaglutinin (H.U/g flour)	IVPD %
100% FB	1.62 ± 0.15	8.72 ± 0.5	8.05 ± 0.20	3400 ± 20	76.60 ± 0.7
75% FB +25% L	1.46 ± 0.14	7.35 ± 0.28	6.00 ± 0.25	2550 ± 20	78.23 ± 0.86
75% FB +25% C	1.55 ± 0.13	7.95 ± 0.26	13.82 ± 0.31	2950 ± 30	75.40 ± 0.92
75% FB +25% P	1.72 ± 0.15	8.47 ± 0.32	8.49 ± 0.27	3700 ± 40	79.67 ± 0.91
50% FB +50% L	1.18 ± 0.15	5.98 ± 0.25	4.07 ± 0.21	1700 ± 10	79.87 ± 0.81
50% FB +50% C	1.48 ± 0.12	7.19 ± 0.27	19.63 ± 0.33	2500 ± 10	74.21 ± 0.79
50% FB +50% P	1.81 ± 0.10	8.23 ± 0.32	8.98 ± 0.28	4000 ± 30	82.75 ± 0.87
Mixture	1.44 ± 0.13	6.36 ± 0.29	12.30 ± 0.30	2400 ± 20	80.10 ± 0.77
Fermented products					
100% FB	0.66 ± 0.10	3.31 ± 0.22	2.12 ± 0.20	Nil	92.61 ± 0.75
75% FB +25% L	0.50 ± 0.08	2.42 ± 0.18	1.89 ± 0.18	Nil	94.76 ± 0.82
75% FB +25% C	0.61 ± 0.12	3.17 ± 0.21	3.70 ± 0.21	Nil	93.87 ± 0.76
75% FB +25% P	0.64 ± 0.11	3.15 ± 0.22	3.06 ± 0.22	Nil	96.93 ± 0.95
50% FB +50% L	0.49 ± 0.07	1.78 ± 0.16	1.82 ± 0.17	Nil	97.43 ± 0.98
50% FB +50% C	0.56 ± 0.13	2.82 ± 0.20	4.63 ± 0.26	Nil	93.25 ± 0.82
50% FB +50% P	0.60 ± 0.12	3.35 ± 0.21	3.00 ± 0.28	Nil	96.62 ± 0.86
Mixture	0.45 ± 0.08	2.96 ± 0.18	3.27 ± 0.31	Nil	95.00 ± 0.9
L.S.D. 5%	0.17	0.33	0.32	80.00	1.04

* Mixture = 25% bean + 25% green peas + 25% chickpea + 25% lupine
IVPD : *In-vitro* protein digestibility FB (Faba bean), L (Lupine) , C (Chickpea), P (Peas).

Table (3): Protein solubility index (PSI) of raw materials used in tempe preparation.

Legume	% solubility		
	Distilled water	5% NaCl	0.02 M NaOH
Faba bean	62.21 ± 0.85	69.85 ± 0.78	73.11 ± 0.95
Lupine	66.76 ± 0.72	71.10 ± 0.783	79.12 ± 1.2
Chickpea	60.42 ± 0.50	68.22 ± 0.71	77.63 ± 1.11
Peas	53.65 ± 0.64	66.52 ± 0.793	69.87 ± 1.6
L.S.D.5%	0.85	0.93	1.60

Table (4): Protein solubility index (PSI) of legume mixtures and produced tempe.

Legume	% solubility		
	Distilled water	5% NaCl	0.02 M NaOH
100% FB	62.21 ± 0.85	69.85 ± 0.78	73.11 ± 0.95
75% FB +25% L	63.35 ± 0.63	70.16 ± 0.71	74.61 ± 1.25
75% FB +25% C	61.76 ± 0.66	69.44 ± 0.62	74.24 ± 1.16
75% FB +25% P	60.07 ± 0.42	69.00 ± 0.32	72.31 ± 0.95
50% FB +50% L	64.48 ± 0.70	70.47 ± 0.57	76.11 ± 0.93
50% FB +50% C	61.31 ± 0.32	69.05 ± 0.50	75.37 ± 0.86
50% FB +50% P	57.93 ± 0.51	68.18 ± 0.63	71.49 ± 0.82
Mixture	60.75 ± 0.67	67.91 ± 0.78	74.90 ± 01.3
Fermented products			
100% FB	42.12 ± 0.35	46.34 ± 0.44	52.91 ± 0.67
75% FB +25% L	38.95 ± 0.47	42.82 ± 0.35	48.11 ± 0.46
75% FB +25% C	33.51 ± 0.25	36.22 ± 0.58	42.06 ± 0.35
75% FB +25% P	32.93 ± 0.38	33.88 ± 0.73	38.56 ± 0.27
50% FB +50% L	39.08 ± 0.46	43.75 ± 0.75	49.81 ± 0.57
50% FB +50% C	33.16 ± 0.56	36.12 ± 0.26	42.20 ± 0.43
50% FB +50% P	31.41 ± 0.62	34.28 ± 0.37	39.100 ± 0.82
Mixture	35.16 ± 0.39	38.87 ± 0.46	41.95 ± 0.75
L.S.D. 5%	0.70	0.78	1.30

Mixture = 25% bean + 25% green peas + 25% chickpea + 25% lupine
FB (Faba bean), L (Lupine) , C (Chickpea), P (Peas).

Water and fat absorption as well as emulsification and foam capacity of faba bean, lupine, chickpea, green peas and their mixtures, as well as, produced tempe are shown in Tables (5 and 6). Generally, green peas had a significantly higher ($p \leq 0.05$) water absorption and emulsification capacity, while lupine seed flour showed the lowest functional properties. Faba bean had the lowest fat absorption and foam capacity. Mixing of 50% faba bean + 50% green peas increased the water absorption and emulsification capacity to 208.12% and 25.5%, respectively.

Table (5): Functional properties of raw legume used in tempe preparation.

Legume	Water absorption %	Fat absorption %	Emulsification %	Foam capacity
Faba bean	202 ± 1.0	105 ± 0.55	23 ± 0.7	23 ± 0.50
Lupine	175.5 ± 0.9	82 ± 0.41	18 ± 0.40	10.9 ± 0.3
Chickpea	195 ± 0.80	93 ± 0.38	21 ± 0.5	8.33 ± 0.40
Peas	260 ± 1.0	98 ± 0.51	28 ± 0.30	6.5 ± 0.20
L.S.D.5%	1.00	0.80	0.7	0.50

Table (6): Functional properties of legume mixtures and produced tempe.

Legume	Water absorption %	Fat absorption %	Emulsification %	Foam capacity
100% FB	202.00 ± 1.0	105.00 ± 0.55	23.00 ± 0.7	23.00 ± 0.5
75% FB +25% L	195.37 ± 0.90	99.25 ± 0.51	21.75 ± 0.6	24.40 ± 0.5
75% FB +25% C	200.25 ± 0.95	102.00 ± 0.53	22.50 ± 0.4	25.20 ± 0.4
75% FB +25% P	216.50 ± 1.1	103.25 ± 0.46	24.25 ± 0.3	22.10 ± 0.3
50% FB +50% L	188.75 ± 0.85	93.50 ± 0.42	20.50 ± 0.5	25.00 ± 0.2
50% FB +50% C	198.50 ± 0.95	99.00 ± 0.41	22.00 ± 0.3	28.10 ± 0.3
50% FB +50% P	231.00 ± 1.1	101.50 ± 0.47	25.50 ± 0.2	21.80 ± 0.3
Mixture	208.12 ± 0.95	94.51 ± 0.53	22.50 ± 0.4	25.15 ± 0.5
Fermented products				
100% FB	296.78 ± 1.0	95.50 ± 0.56	14.00 ± 0.5	15.40 ± 0.5
75% FB +25% L	302.52 ± 0.9	75.30 ± 0.47	13.00 ± 0.3	13.21 ± 0.2
75% FB +25% C	306.56 ± 1.1	80.60 ± 0.36	14.00 ± 0.2	12.24 ± 0.3
75% FB +25% P	320.33 ± 1.2	93.91 ± 0.53	11.50 ± 0.4	11.11 ± 0.4
50% FB +50% L	330.11 ± 1.1	79.90 ± 0.28	12.00 ± 0.3	4.00 ± 0.4
50% FB +50% C	325.67 ± 0.98	82.90 ± 0.38	14.50 ± 0.4	8.30 ± 0.3
50% FB +50% P	343.00 ± 0.96	92.75 ± 0.45	16.50 ± 0.8	6.60 ± 0.2
Mixture	296.72 ± 0.92	83.60 ± 0.35	15.00 ± 0.25	8.71 ± 0.7
L.S.D. 5%	1.11	0.56	0.80	0.5

Mixture = 25% bean + 25% green peas + 25% chickpea + 25% lupine
FB (Faba bean), L (Lupine) , C (Chickpea), P (Peas).

Fermentation significantly ($p \leq 0.05$) increased water absorption in all produced tempe. Tempe produced from 100% faba bean had the highest fat absorption and foam capacity, while the highest water absorption and emulsification capacity was observed in tempe produced from the mixture of 50% faba bean and 50% green peas. Despite of water absorption, all studied functional properties were significantly ($p \leq 0.05$) decreased. These changes in the functional properties may be due to the changes in the protein structure *via* cooking and fermentation process. Also, the differences in protein functionality among the studied legume mixtures could be attributed to the differences in its contents from non-polar side chains which may bind with the hydrocarbon units of oil (Kandil, 2004).

Figures (2, 3 and 4) illustrate foam stability of legume mixtures as well as produced tempe. Generally, foam stability tended to be decreased with the time of standing at room temperature due to collapsing and bursting of the formed air bubbles. Raw chickpea seed flour had the highest foam capacity (31.6) and stability (22.0, 18.0, 13.3 and 10.7 after 15, 30, 45 and 60 min) followed by lupine seed flour. The mixture of 50% chickpea and 50% faba bean had the highest foam capacity and stability. Fermentation process highly decrease the foam capacity in all legume mixtures. Foam stability of all fermented legume mixtures was completely destroyed after 30 min; this could be due to heat processing of legumes during the tempe production.

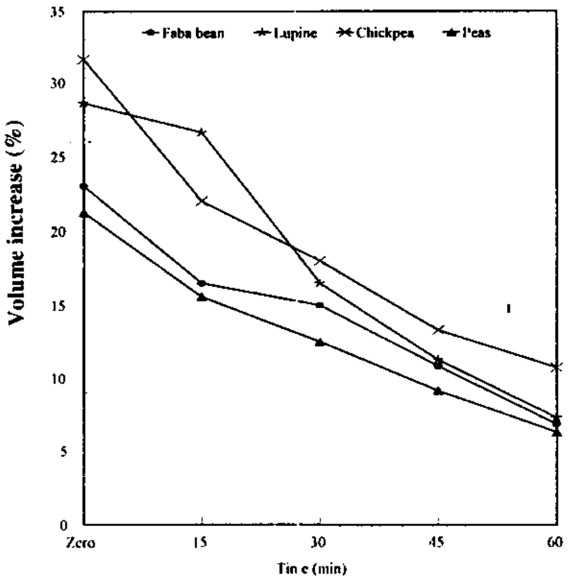

Fig. (2): Foam stability of raw materials used in Tempe preparation.

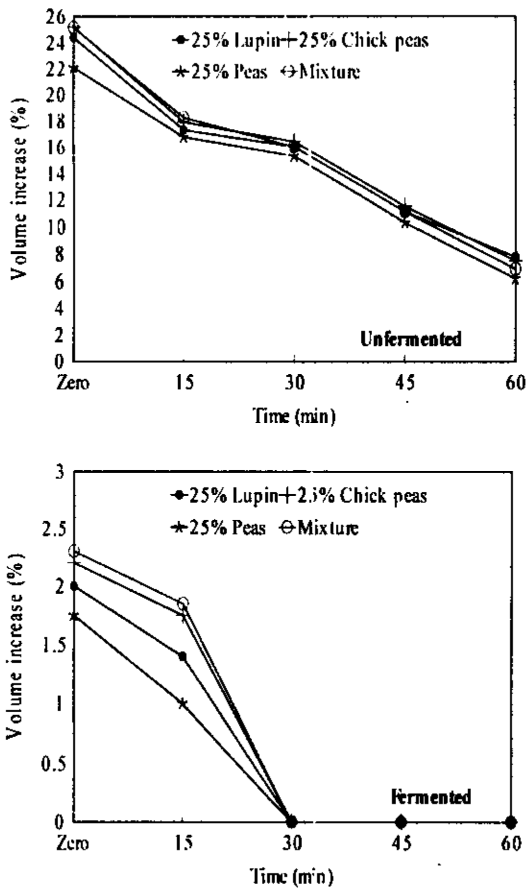

Fig. (3): Foam stability of unfermented and fermented legume mixture (75% faba bean + 50%of each legumes).

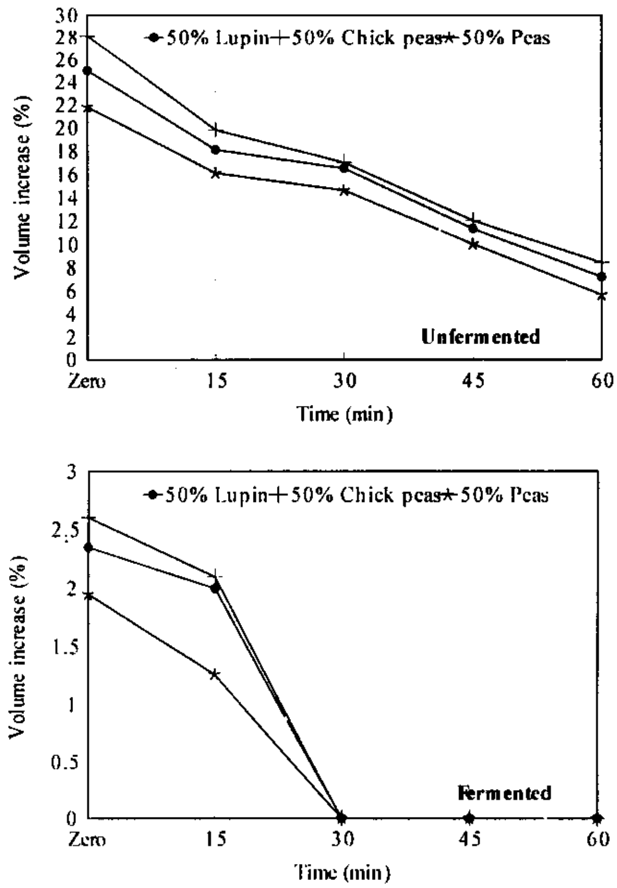

Fig. (4): Foam stability of unfermented and fermented legume mixture (50% faba bean + 50%of each legumes).

Sensory evaluation of fried tempe is shown in Table (7). Fermented mixture of 50% green peas, lupine and chickpea with 50% faba bean had significantly ($p \leq 0.05$) higher overall acceptability (9.8, 9.4 and 9.2, respectively). The same mixtures also, had a higher texture, crump color and appearance.

Conclusion

Fermentation of legume mixtures by *Rhizopus oligosporus* increased *in-vitro* protein digestibility and significantly ($p \leq 0.05$) reduced the antinutritional contents (tannin, phytic acid, trypsin inhibitors and heamaglutinin). Tempe produced had a higher water absorption, while the other functional properties were significantly ($p \leq 0.05$) reduced.

Table (7): Sensory evaluation of fried Tempe produced from mixture of different legumes.

Sample	Colour	Flavour	Appearance	Texture	Over all acceptability
Control (100% bean)	7.9^{b}	7.5^{c}	8.6^{b}	7.8^{c}	7.4^{cd}
50% bean + 50% green peas	9.6^{a}	9.6^{a}	9.4^{a}	9.5^{a}	9.8^{a}
50% bean + 50% lupine	9.3^{a}	9.2^{a}	9.3^{a}	9.2^{a}	9.4^{ab}
50% bean + 50% chickpea	9.2^{a}	8.8^{ab}	9.3^{a}	9.1^{ab}	9.2^{ab}
75% bean + 25% green peas	8.6^{ab}	8.5^{ab}	9.0^{ab}	8.5^{b}	8.5^{b}
75% bean + 25% lupine	8.3^{b}	8.2^{b}	8.8^{ab}	8.2^{b}	8.1^{bc}
75% bean + 25% chickpea	8.0^{b}	7.9^{bc}	8.7^{b}	8.0^{bc}	7.7^{c}
Mixture	8.0^{b}	7.7^{bc}	8.8^{ab}	8.2^{b}	7.6^{c}

Means in the same column with different letters are significantly ($p \leq 0.05$) different.
Mixture = 25% bean + 25% green peas + 25% chickpea + 25% lupine.

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الخصائص التغذوية والوظيفية للتمبى المصنعة من بعض البقوليات

٢- مضادات التغذية و الصفات الوظيفية و التقييم الحسي للتمبى

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ملخص

يعتبر التمبى أحد الأغذية المتخمرة التي يتم استهلاكها على نطاق واسع في دول جنوب شرق أسيا. وعلى الرغم من ارتفاع القيمة الغذائية لهذا المنتج إلا أنه غير شائع الاستهلاك في مصر لذلك يهدف هذا البحث إلى استخدام بعض الخلطات من البقوليات الشائعة الاستخدام في السوق المصري مثل الفول البلدي ، الحمص ، الترمس الحلو والبسلة في تصنيع التيمبى باستخدام الفطر *Rhizopus oligosporus* وكذلك دراسة تأثير عملية التخمر على محتوى مخلوط هذه البقوليات من المواد المضادة للتغذية (التانين - مثبطات إنزيم التربسين - حامض الفيتك - الهيم اجلوتينين) بالإضافة إلى تقدير القيمة الهضمية للبروتين معمليا. وإلى جانب ذلك تم دراسة الخصائص الوظيفية للتمبى المنتجة مثل ذائبية البروتين - امتصاص الماء - امتصاص الزيت وخصائص الاستحلاب والرغوة مع تقدير الصفات الحسية للتمبى المنتج وقد بينت النتائج ما يلي:-

- أدت عملية إنتاج التمبى إلى حدوث خفض معنوي في كل من التانين و حامض الفيتك ومثبط إنزيم التربسين كما أدت إلى حدوث تثبيط تام للهيم اجلوتينين .
- حدث ارتفاع في القيمة الهضمية للبروتين كنتيجة لعملية التخمر
- أدت عملية التخمر إلى ارتفاع قدرة المنتج على امتصاص الماء بينما حدث انخفاض في كل من السعة الاستحلابية وخواص الرغوة وكذلك القدرة على امتصاص الزيت .
- بينت نتائج التقييم الحسي قبول المستهلك لنسب الخلط ٥٠٪ من كل من الترمس الحلو و البسلة مع ٥٠٪ من الفول البلدي.

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