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NUTRITIONAL AND BIOLOGICAL VALUES FOR TEMPEH PRODUCED FROM COTYLEDONS OF BEAN, COWPEA AND CHICKPEA SEEDS

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ABSTRACT

Tempehs produced from cotyledons of bean, cowpea and chickpea seeds were biologically and chemically evaluated. Results of biological assays, using male albino rats, indicated that tempeh produced from cotyledons of chickpea gave the highest percentage of weight gain after 10 days (75.07%), net protein utilization (72.31%), net protein ratio (5.31%) and digestibility coefficient (92.12%). Also tempeh produced from chickpea gave the highest biological value (78.50%), while the lowest value was noted in tempeh produced from bean (73.65%). Total essential amino acid content of tempeh produced from bean (2.917 g/g nitrogen) was higher than that produced from each of cowpea (2.641 g/g nitrogen) and chickpea (2.446 g/g nitrogen). Furthermore, total essential amino acid content of tempeh produced from bean and cowpea were higher compared with raw cotyledons, while was lower in chickpea.

INTRODUCTION

Tempeh, also known as tempeh kedele, is a popular Indonesian soybean food made from yellow soybeans by fermentation with a mold, *Rhizopus oligosporus.* Tempeh serves not only as a protein-rich meat substitute but also as a source of vitamin B_{12} (Steinkraus *et al.* 1983). An important function of the mold in such food fermentation is the synthesis of enzymes which hydrolyze soybean constituents and contribute to the development of a desirable texture, aroma and flavor (Sutardi and Buckle, 1988). Such enzymatic hydrolysis may also reduce or eliminate antinutritional components and consequently improve the nutritional quality of the fermented product (Sutardi and Buckle, 1985 and Paredes-Lopez and Harry, 1989).

Mugula (1992) estimated the improvement of the nutritive quality of a mixture of sorghum-commonbean (40:60) manufactured tempeh by a mixture of *Rhizopus oligosporus : Rhizopus oryzae* (1:1) in mixed culture fermentation. Total protein, crude fat and ash content increased slightly, while carbohydrates decreased. The dietary fiber of the tempeh increased by 10%. Mould fermentation increased the content of reducing sugars, total acid and aminonitrogen to 15.3, 6.7 and 4.6-fold, respectively. Phytate content decreased by 44% and while tannic acid content increased by 52%. In vitro iron absorption increased from 2.8 to 12.5%.

Joseph and Swanson (1994) conducted growth and nitrogen balance feeding trials with rats to estimate the protein quality of idli, a fermented steamed cake prepared from beans (*Phaseolus vulgaris*) and rice. Feed efficiency ratio (FER), protein efficiency ratio (PER), relative protein efficiency ratio (rPER), true digestibility coefficient (DC) and net protein utilization (NPU) of fermented idli diets were significantly lower than those of unfermented idli diets. Biological value (BV) of fermented and unfermented idli diets were similar to the BV of casein control diet. In conclusion, fermentation does not improve the protein quality of idli prepared from beans and rice.

Tchango (1995) studied the nutritional quality of maize-soybean (70:30) tempeh flour manufactured by fermentation with *Rhizopus oligosporus : Rhizopus oryzae* (1:1) was estimated using albino weanling rats. Mould fermentation of maize-soybean mixture did not significantly affect its proximate composition. It increased the content of reducing sugars, total acids and aminonitrogen by about 43, 195 and 482%, respectively, and decreased phytate content by 46%. In vitro iron absorption for maize flour and maize-soybean tempeh flour was 2.46 and 5.51%, respectively. Protein efficiency ratio (PER) and net protein ratio (NPR) for maize-soybean tempeh flour and skim-milk diets were 2.71 and 2.96, and 3.31 and 3.51, respectively. In vivo protein digestibility of the 2 products was 95.0 and 98.0%, respectively.

The objective of this work is to evaluate the nutritive value of tempeh-type using bean, cowpea and chickpea cotyledons as substrates which were produced as described by Bahlol *et al.* (1999).

MATERIALS & METHODS

Raw materials:

Tempeh products were produced according to Bahlol *et al.* (1999) from bean (*Phaseolus vulgaris*) (moisture, 54.99%; protein, 14.42%; ether extract, 0.50%; and ash, 1.08%) cowpea (*Vigna sinesis*) (moisture, 58.86%; protein, 11.63%; ether extract, 0.43%; and ash, 0.74%) and chickpea seeds (*Cicer arietinum*) (moisture, 59.03%; protein, 11.22%; ether extract, 1.60%; and ash, 0.52%).

Methods:

A) Analytical methods:

Moisture, crude protein, ether extract and ash contents were determined in cotyledons and tempeh according to the methods described in A.O.A.C. (1990).

Minerals content were determined according to the methods of A.O.A.C. (1990) using Perkin-Elmer, 2380, Atomic Absorption Spectroscopy (AAS) apparatus at Central Laboratory of Moshtohor Faculty of Agric.

Samples were prepared for the determination of amino acids according to the method of Moore *et al.* (1958) as follows: Amino acids were determined in the prepared hydrolysed samples using gas liquid chromatography equipped with a flame ionization detector at Ismailia Faculty of Agric., Suiz Chanal Univ.

B) Biological assays for tempeh products:

Biological assays were carried out to determine the feed efficiency (FE), protein efficiency ratio (PER), net protein ratio (NPR), digestability coefficient (DC), net protein utilization (NPU) and biological value (BV) as described in the standard A.O.A.C. (1990).

Diet composition:

Salt mixture:

The salt and vitamins mixture used in this investigation was as recommended by A.O.A.C. (1990).

Test animals:

Weanling male albino rats with average of 30-47 grams were divided into two main divisions. The first included 4 groups each of 5 rats for each diet of bean tempeh, cowpea tempeh, chickpea tempeh and casein diet and fed for 4 weeks to determine FE and PER. The second included 5 groups each of 5 rats for each diet bean tempeh, cowpea tempeh, chickpea tempea, casein diet and protein free diet and fed for 10 days to determine NPR, NPU, DC and BV.

RESULTS AND DISCUSSION

Biological value:

1- Weight gain, total food and protein consumption, feed efficiency (FE) and protein efficiency ratio (PER):

Results in Table (1) indicated that after 10 days feeding, chickpea tempeh diet showed the highest weight gain (25.38 g) which is similar somewhat to the casein diet (25.32 g). while the cowpea and bean tempehs diets gave 16.73 and 16.18 g. With regard to the total food and protein intake it could be noticed that the highest quantity of food and protein supply was consumed by rats fed on chickpea diet.

The feed efficiency (FE) and the protein efficiency ratio (PER) of rats fed on 10% protein in tempeh diets for 4 weeks together with the control diet (Casein diet) are indicated in Table (2). It is clear that the highest value for (FE) was obtained for chickpea tempeh diet (0.150). Next to this value was for cowpea tempeh diet, the lowest value was for bean tempeh diet.

It is also noted that the PER of all experimental diets were 10 times magnified image of the FE values for all experimental diets. This might be true because in the FE equations the total food intake was in the denumerator part of it, while in the PER equations only the consumed protein which was only 10% of all tested diet was at the lower part of the equation denumerator (Protein Advisory Group 1970 and Hussein, 1987).

2- Body nitrogen, nitrogen intake, fecal nitrogen, net protein utilization (NPU), net protein ratio (NPR), diestibility coefficient (DC) and biological value (BV):

Table (3) indicates the body nitrogen, nitrogen intake, fecal nitrogen, (NPU) and (NPR) of rats fed on tempeh diets, casien diet and free protein diet for 10 days. The best results for (NPU) values were obtained with chickpea tempeh diet, then cowpea tempeh diet, while the lowest value was of the bean tempeh diet as were 72.31, 66.90 and 62.56%, respectively.

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NPR value for the three diets in Table (3) indicated that chickpea tempeh had the best value (5.31%), followed by cowpea tempeh (4.86%), while the lowest value was found in bean tempeh (4.07%).

The digestibility coefficient of the three tempeh diets and the control casein diet as showen in (Table, 3) indicated that the highest value was obtained with chickpea tempeh of (92.12%), followed by cowpea tempeh of (86.15%) and least value was obtained from bean tempeh of (84.94%).

The chickpea tempeh gave the highest value of BV (78.50%), while cowpea tempeh and bean tempeh gave 77.66 and 73.65%, respectively, however Brandizog *et al.* (1981) reported 57 to 61%, 86 to 88% and 65 to 71% for DC, NPU and BV, respectively, for weaning fed mixtures made of 70:30 of ragi sorghum and green gram flour as a product from malted and unmalted grams.

3- Amino acids content:

Table (4) shows that the amino acid composition of cotyledons and tempeh of bean, cowpea and chickpea. It is clear that certain difference existed in the amino acids pattern or their distribution as well as the proportion of each amino acid to total.

Although arginine constituted high portion in cotyledons of bean its propotion decreased in tempeh produced from it, while the opposite situation cowpea. However, arginine was lower in chickpea compared to bean and cowpea.

The acidic amino acids asparatic and glutamic constituted the major portion in all the cotyledons and tempeh produced from the tested samples. The essential amino acids in cotyledons of bean increased in the produced tempeh , while therionine, valine and isoleucine decreased. In cowpea, lysine and hestidine were lower in tempeh product compared to cotyledons. In chickpea, the essential amino acid decreased in tempeh while isoleucine, phenylalanine and lysine increased over those levels originally present in chickpea (floure cotyledon).

The nutritional value of the tempeh produced from bean, cowpea and chickpea cotyledons were evaluated by comparing the quantity of an essential amino acid in tempeh to the quantity of the respective amino acid of egg protein. Amino acid values for raw egg were obtained from

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FAO (1970). These egg ratio values are given in Table (5). The egg ratios for all tempeh produced are very similar. Histidine and lysine have egg ratio values of 100% or above in tempeh produced from been and cowpea. While isoleucine was 100% in tempeh produced from chickpea. The smallest egg ratio, the limiting amino acid, was the sulfur amino acid methionine in tempeh produced from bean and cowpea, while it was leucine in tempeh produced from chickpea. Meredith and Dull (1979) mentioned that egg ratios for snap beans ranged from 44-76 and for sweet potatoes from 51-84 .

4- Minerals content:

Table (6) represents seven of minerals content (mg/100 g on dry basis) of the bean, cowpea, chickpea and their tempeh product. These minerals are sodium, potassium, magnesium and iron, beside some trace elements (zinc, copper and manganes).

The results indicated that processing of used legumes (soaking for 24 hr, cooking after 24 hr soaking and fermentation) led to decrease in Na, and K compared with raw material. On the other hand, tempeh products had higher content from Fe, Zn and Mn compared with raw material (before soaking) while they had the lowest content from Cu in all tested samples.

Tempeh produced had the lowest content from Na, K, Mg and Cu comparing with raw material. While it was higher content from Fe, Zn and Mn compared with raw material.

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قسم علوم الأغذية – كلية الزراعة بمشتهر – جامعة الزقازيق/فرع بنها

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