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Supplementation and Cooking of Pearl Millet: Changes in Protein Fractions and Sensory Quality

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Abstract: Pearl millet and soybean flour were used in this study. Investigation showed that the major fraction of pearl millet protein was the prolamin followed by globulin and glutelin, while that of soybean was the globulin followed by glutelin and lesser amounts of albumin and prolamin. Cooking of pearl millet or soybean was found to decrease the globulin and true-prolamin fractions, while the prolamin-like, true-glutelin and insoluble protein were increased. The albumin fraction of cooked pearl millet flour increased, while that of soybean flour decreased. The glutelin-like fraction of cooked pearl millet flour decreased, while that of soybean flour was increased. Supplementation of pearl millet flour with soybean protein was found to increase significantly the globulin fraction and decreased the true-prolamin and true-glutelin, while cooking of pearl millet flour supplemented with soybean protein was found to decrease the globulin and true-prolamin fractions, but increased the true-glutelin fraction and insoluble protein. The globulin fraction of cooked pearl millet flour supplemented with soybean protein was higher than that of cooked flour. Sensory evaluation of locally processed pearl millet supplemented with 5, 10 and 15% soybean protein showed high value for colour and low value for flavor compared to the unsupplemented pearl millet. The taste of the supplement processed with 5 and 10% soybean protein showed the same value as that of the control, while the texture showed high value. Based on the judgement of the panelists, the processed supplement (15% soybean) protein showed low taste value and the same value as that of the control for its texture.

Key words: Millet · Cooking · Soybean · Supplementation · Protein fractions · Sensory quality

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is consumed as a staple food by large sections of the population in India and Africa and, recently, attempts have been made to combine high grain yield with good nutritional quality. The nutritional properties of pearl millet have received more attention than those of the other common millets, because it is the largest-seeded and most widely grown type [1]. Millet is usually ground for feeding to animals other than poultry and it is very important in human diets, particularly those of the poorest people of the semi-arid tropics. The protein quality of pearl millet is low in the levels of lysine and tryptophan; hence, there is growing emphasis on the improvement of protein quantity and quality in cereal crops. Therefore, attempts have been made to fortify these cereals with legumes or other cereals to make nutritionally superior and acceptable products [2]. To improve the nutritional quality of cereal-based traditional diets in Africa, the use of soybean (*Glycine max* L., Merrill) flour as a protein supplement has often been suggested. Soybean has recently become popular in the West African sub-region due to the high protein content and quality and it can be effectively used in traditional cereal-based weaning foods as an acceptable protein supplement [3]. Pearl millet proteins were separated into six fractions; globulin, albumin, true-prolamin, prolamin-like, glutelin-like and true-glutelin. Prolamins constitute the major protein fraction in pearl millet followed by glutelins. They were constituted about 75% of the total protein fractions [4]. The major portion of proteins in beans was the globulins followed by glutelins and lesser amounts of albumin and prolamins [5]. The albumin and globulin fraction contain contain higher levels of the amino acid lysine as was reported by Wu and Wall [6]; hence, soybean protein quality is attributable to

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the higher levels of the albumin plus globulin fractions, which are rich in lysine. Pulses role, as protein supplements in the diets based on cereals and millets, is well recognized [7]. This indicates that the nutritional value and the protein availability of pearl millet flour would be expected to increase by increasing the lysine level due to the increase in the globulin fractions as a result of supplementation with soybean protein. Therefore, the objective of the present investigation was to study the effect of supplementation with soybean protein and cooking on protein fractions and sensory quality of pearl millet flour.

MATERIALS AND METHODS

Materials: Soybean flour was obtained from USA market and pearl millet cultivar “Dempy“ seeds was obtained from El Obeid Research Station, Sudan. The grains were harvested during the season 2006/2007. The grains were cleaned from dust and foreign materials and broken grains. The clean grains were milled into fine powder to passed a 0.4 mm screen. The flour was kept into nylon bags and placed into small clean bottles at 4°C in a refrigerator for further analysis. Unless otherwise stated all chemicals and reagents used in this study are of analytical grade.

Processing of Supplemented and Unsupplemented Flour: Three levels of soybean flour were added to increase pearl millet protein by 5, 10 and 15 %. Each amount was curried and added to pearl millet according to Person’s square. The flour of the samples was suspended in water (1:10 W/V) and boiled in a boiling water bath for 20 min, the cooked gruel was then dried at 65°C and reground to pass a 0.4 mm screen. The samples were kept in small bottles at 5°C in a refrigerator for further analysis.

Protein Fractionation: The nitrogen from the defatted treated and untreated leaves was extracted stepwise by a series of solvents according to Landry and Moureaux [8] technique. About 3.5 g of each sample was kept in a suspension with 35 mL of extractant by magnetic stirring in 50 mL centrifuge tubes, the protein was fractionated step wise at 20°C using 0.5 M NaCl to obtain globulin, distilled water to obtain albumin, 60% ethanol to obtain prolamin, 60% ethanol with 0.6% 2-mercaptoethanol (2ME) to obtain the G_1-glutelin, borate buffer (pH 10) with 0.6% 2ME and 0.5M NaCl to obtain G_2-glutelin and borate buffer (pH 10) with 0.6% 2-ME and 0.5% sodium dodecyl sulphate (SDS) to obtain G_3-glutelin. The solid material was isolated from extractants by centrifugation at 3000 rpm for 15 min. For each solvent the supernatants were combined to give the total extract. Nitrogen content of each fraction was determined by the micro-kjeldahl method [9]. The residue left after extraction was analyzed for nitrogen content [9].

Sensory Evaluation: A trained panel of ten members, composed of adult males and females, was assigned to determine preference of processed pearl millet flour as a control and when supplemented with 5, 10 and 15% soybean protein for colour, flavor, taste and texture. They were scored on a scale of 1-4 (1 = poor, 2 = good, 3 = very good and 4 = excellent). The order of presentation of the samples was randomized. To determine if the observed differences in judges’ responses were statistically significant, the mean scores were analyzed by Duncan’s multiple range test.

Statistical Analysis: Each determination consisted of three separate samples, which were analyzed and the figures were then averaged. Data were assessed by analysis of variance (ANOVA) [10] and by the Duncan’s multiple range test with a probability $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Cooking on Protein Solubility Fractions of Pearl Millet and Soybean Flour: The percentages of protein fractions of uncooked and cooked pearl millet cultivar are shown in Table 1. The globulin fraction of uncooked pearl millet cultivar was found to be 31.3% and decreased significantly ($P \leq 0.05$) to 15.7% after cooking. The albumin of uncooked pearl millet was found to be 1.0% and increased to 1.8% after cooking. The true-prolamin fraction was 37.7% for uncooked pearl millet and decreased significantly ($P \leq 0.05$) to 29.5% after cooking. The prolamin-like was increased from 5.6 to 7.3% after cooking. The glutelin-like was 4.4% of uncooked pearl millet and decreased to 4.0% after cooking. The true-glutelin was 20.4% of uncooked pearl millet and increased significantly ($P \leq 0.05$) to 38.4% after cooking. The insoluble protein increased significantly ($P \leq 0.05$) from 2.1 to 5.0% after cooking. The results obtained indicated that there were significant differences among the values of the protein fractions of pearl millet after cooking. Prolamins constituted the major protein fraction in pearl millet and this was considered nutritionally undesirable because it was shown to be low in lysine and tryptophan content. Neucere and Sumrell [11] reported that the low

Table 1: Effect of cooking on protein content and fractions (%) of pearl millet and soybean flour

Samples	Treatment	Protein content	Globulin	Albumin	True prolamin	Prolamin like	Glutelin like	True glutelin	Insoluble protein	Total protein recovered
Pearl millet	Uncooked	13.67 (±0.06)^{b}	31.28 (±0.42)^{a}	1.03 (±0.16)^{b}	37.68 (±0.48)^{a}	5.60 (±0.56)^{b}	4.38 (±0.24)^{a}	20.35 (±0.42)^{b}	2.14 (±0.09)^{b}	102.45 (±0.28)^{a}
	Cooked	14.15 (±0.05)^{a}	15.73 (±0.34)^{b}	1.82 (±0.26)^{a}	29.45 (±0.46)^{b}	7.29 (±0.52)^{a}	4.00 (±0.37)^{a}	38.37 (±0.38)^{a}	5.04 (±0.09)^{a}	101.71 (±0.14)^{b}
Soybean	Uncooked	48.12 (±0.09)^{a}	82.83 (±0.12)^{a}	1.27 (±0.08)^{a}	3.59 (±0.24)^{a}	0.69 (±0.09)^{b}	1.32 (±0.12)^{b}	9.70 (±0.08)^{b}	3.03 (±0.05)^{b}	102.43 (±0.06)^{a}
	Cooked	48.13 (±0.05)^{a}	32.68 (±0.11)^{b}	0.74 (±0.05)^{b}	3.32 (±0.24)^{a}	2.13 (±0.16)^{a}	4.42 (±0.11)^{a}	54.13 (±0.12)^{a}	4.07 (±0.05)^{a}	101.49 (±0.05)^{b}

Each value is an average of three independent samples expressed on dry weight basis. Values are means (± SD). Means not sharing a common superscript letter in a column are significantly different at $P \leq 0.05$ as assessed by Duncan's multiple range test.

Table 2. Effect of supplementation of pearl millet with soybean protein at different levels (5%, 10% and 15%) on protein fractions (%)

Supplementation level (%)	Protein content	Globulin	Albumin	True prolamin	Prolamin like	Glutelin like	True glutelin	Insoluble protein	Total protein recovered
0	13.67 (±0.06)^{b}	31.28 (±0.42)^{a}	1.03 (±0.16)^{b}	37.68 (±0.48)^{a}	5.60 (±0.56)^{b}	4.38 (±0.24)^{a}	20.35 (±0.42)^{b}	2.14 (±0.09)^{b}	102.45 (±0.28)^{a}
5	19.51 (±0.05)^{c}	53.17 (±0.28)^{c}	1.20 (±0.12)^{b}	19.15 (±0.59)^{a}	2.93 (±0.22)^{a}	3.15 (±0.00)^{a}	21.28 (±0.17)^{a}	1.89 (±0.05)^{c}	102.77 (±0.11)^{a}
10	24.58 (±0.06)^{b}	63.14 (±0.21)^{b}	1.12 (±0.09)^{b}	12.46 (±0.46)^{b}	1.51 (±0.32)^{b}	2.63 (±0.17)^{b}	19.61 (±0.16)^{b}	2.22 (±0.10)^{b}	102.69 (±0.13)^{a}
15	30.92 (±0.09)^{a}	69.78 (±0.17)^{a}	1.47 (±0.06)^{a}	9.06 (±0.63)^{c}	2.01 (±0.14)^{b}	2.64 (±0.10)^{b}	15.00 (±0.19)^{c}	2.50 (±0.09)^{a}	102.45 (±0.13)^{a}

Each value is an average of three independent samples expressed on dry weight basis. Values are means (± SD). Means not sharing a common superscript letter in a column are significantly different at $P \leq 0.05$ as assessed by Duncan's multiple range test.

content of lysine is attributed to the high content of prolamin in most varieties. Cooking decreased the globulin and true-prolamin fractions while true-glutelin fraction increased. The increment in glutelin after cooking was reported in cereals by Arbab and El Tinay [12], Yousif and El Tinay [13] and Fageer and El Tinay [14]. The percentages of protein fractions of soybean flour before and after cooking are shown in Table 1. The globulin and albumin fractions of uncooked soybean flour were 82.8 and 1.3% and decreased significantly ($P \leq 0.05$) to 32.7 and 0.7%, respectively after cooking. The true-prolamin fraction was 3.6% for uncooked soybean and decreased to 3.3% after cooking. The prolamin-like, glutelin-like, true-glutelin and insoluble protein were increased significantly ($P \leq 0.05$) from 0.7, 1.3, 9.7 and 3.0%, respectively to 2.1, 4.4, 54.1 and 4.1%, respectively after cooking. The data obtained indicated that the major protein fraction of soybean flour was the globulin, followed by glutelins and lessor amounts of albumins and prolamins. These results are in agreement with those reported by Nikokoyris and Kandylis [5], Nugdallah and El Tinay [15] and El Fiel, El Tinay and El Sheikh [16]. Cooking of soybean flour decreased the albumin and globulin fractions, the decrease in such fractions was found to be accompanied by a significant increase in true-glutelin fraction. The results obtained are in agreement with those reported by Nugdallah and El Tinay [15] for two cultivars of cowpea and El Fiel, El Tinay and El Sheikh [16] for faba beans after cooking.

Effect of Supplementation and Cooking of Pearl Millet on Protein Solubility Fractions: The percentages of protein fractions of pearl millet cultivar supplemented with 5, 10 and 15% soybean protein are shown in Table 2. The globulin fraction of pearl millet increased significantly ($P \leq 0.05$) as the level of soybean protein supplement increased and was found to be 53.2, 63.1 and 69.8% when supplemented with 5, 10 and 15% soybean protein, respectively. The albumin fraction was 1.2 and 1.1% when supplemented with 5 and 10% soybean protein, respectively, but increased to 1.5% when supplemented with 15% soybean protein. The true-prolamin fraction decreased significantly ($P \leq 0.05$) with increasing the level of soybean protein supplement and it was found to be 19.2, 12.5 and 9.1%. The prolamin-like was 2.9, 1.5 and 2.0% when supplemented with 5, 10 and 15% soybean protein, respectively. The glutelin-like was 3.2% when supplemented with 5% soybean protein. However, it decreased to 2.6% when supplemented with 10 and 15% soybean protein. The true-glutelin fraction decreased significantly ($P \leq 0.05$) with increasing the level of soybean protein supplement and was found to be 21.3, 19.6 and 15.0%, while the insoluble protein was increased. The results obtained indicated that the globulin fraction of pearl millet was increased as a result of supplementation followed by a significant decrease in true-prolamin and true-glutelin fractions. The albumin plus globulin fraction had a higher level of the amino acid lysine as was reported by Wu and Wall [6]. As a result of supplementation with, the nutritional value of pearl millet would be expected to increase by increasing lysine level due to the increase in the globulin fraction. The percentages of protein fractions of cooked pearl millet cultivar supplemented with 5, 10 and 15% soybean protein are shown in Table 3. The globulin fraction increased significantly ($P \leq 0.05$) after cooking with increasing soybean protein level and was found to be 22.6, 27.5 and 31.6% when supplemented with 5, 10 and 15% soybean

Table 3: Effect of cooking of pearl millet supplemented with soybean protein at different levels (5%, 10% and 15%) on protein fractions (%).

Supplementation level (%)	Protein content	Globulin	Albumin	True prolamin	Prolamin like	Glutelin like	True glutelin	Insoluble protein	Total protein recovered
0	14.15 (±0.05)^{a}	15.73 (±0.34)^{b}	1.82 (±0.26)^{a}	29.45 (±0.46)^{b}	7.29 (±0.52)^{a}	4.00 (±0.37)^{a}	38.37 (±0.38)^{a}	5.04 (±0.09)^{a}	101.71 (±0.14)^{b}
5	20.60 (±0.05)^{c}	22.63 (±0.24)^{c}	1.12 (±0.10)^{a}	16.82 (±0.55)^{a}	5.87 (±0.21)^{a}	6.50 (±0.14)^{b}	44.79 (±0.26)^{c}	2.76 (±0.09)^{c}	100.48 (±0.20)^{c}
10	25.74 (±0.06)^{b}	27.52 (±0.19)^{b}	1.00 (±0.14)^{a}	8.95 (±0.24)^{b}	3.15 (±0.29)^{b}	6.91 (±0.20)^{a}	50.04 (±0.22)^{b}	3.94 (±0.09)^{a}	101.52 (±0.09)^{b}
15	31.58 (±0.05)^{a}	31.57 (±0.16)^{a}	0.93 (±0.12)^{a}	5.99 (±0.36)^{c}	3.19 (±0.13)^{b}	6.13 (±0.17)^{c}	51.10 (±0.18)^{a}	2.96 (±0.06)^{b}	101.88 (±0.15)^{a}

Each value is an average of three independent samples expressed on dry weight basis. Values are means (± SD). Means not sharing a common superscript letter in a column are significantly different at P$\leq$ 0.05 as assessed by Duncan's multiple range test.

Table 4: Sensory Quality (acceptability) of processed pearl millet flour supplemented with soybean protein at different levels (5%, 10% and 15%).

Supplementation level (%)	Colour	Flavour	Taste	Texture
0	1.70 (±0.26)^{b}	3.05 (±0.27)^{a}	2.85 (±0.29)^{a}	2.15 (±0.26)^{b}
5	2.60 (±0.18)^{a}	2.35 (±0.23)^{b}	2.80 (±0.21)^{a}	3.20 (±0.20)^{a}
10	3.00 (±0.18)^{a}	2.35 (±0.22)^{b}	2.35 (±0.15)^{ab}	2.85 (±0.18)^{a}
15	2.70 (±0.28)^{a}	2.25 (±0.26)^{b}	2.00 (±0.29)^{b}	1.80 (±0.24)^{b}

Values are means (± SD). Means not sharing a common superscript letter in a column are significantly different at P$\leq$ 0.05 as assessed by Duncan's multiple range test

protein, respectively. The results obtained were lower than those of uncooked pearl millet supplements, but higher than those of cooked unsupplemented pearl millet flour. The results indicated that the nutritional value of cooked pearl millet would be expected to increase by increasing the lysine level due to the increase in the globulin fraction as a result of supplementation with soybean protein. The albumin fraction was 1.1, 1.0 and 0.9% after cooking when pearl millet was supplemented with 5, 10 and 15% soybean protein. The true-prolamin fraction decreased significantly ($P \leq 0.05$) after cooking with increasing the level of soybean protein and was found to be 16.8, 9.0 and 6.0%. The results obtained were lower than those of uncooked pearl millet supplemented with soybean protein. The prolamin-like fraction after cooking was 5.9% when pearl millet was supplemented with 5% soybean protein and decreased significantly ($P \leq 0.05$) to 3.2% when pearl millet was supplemented with 10 and 15% soybean protein. The glutelin-like was 6.5, 6.9 and 6.1% after cooking of pearl millet supplemented with 5, 10 and 15% soybean protein, respectively.The true-glutelin fraction increased significantly ($P \leq 0.05$) after cooking with increasing the level of soybean protein supplement and was 44.8, 50.0 and 51.1% for the supplements, respectively. The results obtained were higher than those of uncooked pearl millet supplements. The insoluble protein was 2.8, 3.9 and 3.0% after cooking of pearl millet supplements (5, 10 and 15%). The results were higher than those of uncooked pearl millet supplements. It was clear that globulin and true-prolamin fractions decreased significantly ($P \leq 0.05$) after cooking of pearl millet even after supplementation while the true-glutelin fraction increased when compared with uncooked pearl millet supplements (5, 10 and 15%).

Effect of Soybean Protein Supplementation on Sensory Quality of Processed Pearl Millet Flour: Table 4 shows the mean scores for colour, flavor, taste and texture of the control pearl millet flour and processed one supplemented with 5, 10 and 15% soybean protein. The sensory preference of the colour of the supplements scored a high value while that of the flavor was scored low value when compared to the control. The results obtained indicated that the majority gave a low acceptability for the flavor of the processed supplements compared to the control. The result was in agreement with that reported by Wolf [17] who reported that raw soy flours and grits have a characteristic flavor unacceptable in many foods. The sensory preference of the processed supplements i.e. 5 and 10% soybean protein for the taste was similar to that of the control but scored lower value when supplemented with 15% soybean protein. For the texture of the processed supplements was similar to that of the control especially when the flour was supplemented with 15% soybean protein. However, it scored high value when supplemented with 5 and 10% soybean protein. The results obtained showed that the majority preferred the processed supplements contained 5 and 10% soybean protein especially for taste and texture more than the supplement contained 15% soybean protein as compared to the control. This was achieved with significantly increased protein content and quality over the unsupplemented pearl millet. Therefore, soybean protein would be expected to be used as functional ingredients supplying taste, texture, colour and other properties to variety of foods.

CONCLUSION

The results obtained showed that supplementation of pearl millet with soybean protein increased the globulin fraction before and after cooking. This is considered nutritionally desirable because it increase lysine content which caused an improvement in the nutritional value of pearl millet flour.

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