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The effect of nematicides on the nutritive value and functional properties of cowpea seeds (*Vigna unguiculata* L. Walp)

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The effect of nematicides on the nutritive value and functional properties of cowpea seeds (*Vigna unguiculata* L. Walp) has been evaluated with respect to proximate chemical, amino-acid and mineral compositions and protein solubility properties. The cowpea seeds produced with the application of nematicides have crude protein contents in the range of 23·6–27·3%, which is slightly higher than the crude protein (23·3%) in the control sample. The amino-acid composition of the control sample and those produced by the application of nematicides were not significantly different. The amino-acid composition showed that cowpea seeds contained nutritionally useful quantities of essential amino-acids of between 38·9 and 44·1 g amino-acid/100 g protein. However, they are highly deficient in methionine.

The predominant mineral was potassium which varied from 1171 to 2753 mg/100 g sample. It was found that the nematicides do not inhibit the uptake of minerals from the soil by the cowpea plants, since there were no marked differences in the mineral compositions of the samples. It was also found that the cowpea protein has minimum solubility at pH 4·0. The solubility curves of the samples and the control were found to be similar. The industrial application of cowpea protein is discussed.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a herbaceous annual legume found in tropical regions. Cowpea is an important grain; it is a good source of protein and is low in antinutritional factors. Cowpea contains a well balanced complement of the essential amino-acids and to a lesser extent minerals, vitamins and carbohydrate (Oyenuga, 1968; Kay, 1979; Olaofe & Sanni, 1988; Aletor & Aladetimi, 1989). Cowpea forms complementary mixtures with other types of foodstuffs to produce a balanced diet (Uzogara *et al.*, 1988). As a result of economic recession, the majority of Nigerians now derive their protein mainly from cowpea varieties because Nigeria is faced with an acute shortage of animal protein which is often beyond the reach of an average Nigerian person. There is therefore a great need to improve the yield of cowpea.

The yield of cowpea is generally reduced by nematode attack (Ogunfowora, 1976; Olowe, 1981; Babatola & Adalemo, 1988). The control of plant parasitic nematodes in the soil may be achieved by the application of nematicides. Ethoprop 10G and Carbofuran 3G are examples of granular nematicides often used. A recent report (Babatola & Adalemo, 1988) indicated that the application of nematicides to cowpea plant led to a higher yield of cowpea seeds. However, there is no work reported on the effect on the nutritive value and functional properties of cowpea seeds grown with the application of nematicides. The present work therefore reports the effect of nematicides on the nutritive value and functional properties of cowpea seeds produced with their application.

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MATERIALS AND METHODS

Five cowpea seeds (*Vigna unguiculata* L.) Walp planted under different conditions on the Ilorin University Agricultural farm were used for the present study. Two sets (A14 and B24) were produced under the application of Carbofuran at two concentration levels, while one sample (D23) was produced under the application of Ethoprop; another sample (F14) was produced under the application of mixed nematicides (Carbofuran and Ethoprop), and a fifth sample (G22), the control, was produced without the application of nematicides.

Table 1. Proximate chemical composition of the cowpea samples

Composition	Samples					Mean (%)	SD[a]	CV[b]
	A14 (%)	B24 (%)	D23 (%)	F14 (%)	G22 (%)			
Moisture content	5·47	3·85	3·12	2·07	4·38	3·78	1·15	0·304
Dry matter	94·5	96·2	96·9	97·9	95·6	96·2	1·15	0·012
Ash	3·16	2·97	2·77	3·07	2·91	2·98	0·13	0·045
Crude protein	23·6	24·3	27·2	25·9	23·4	24·9	1·47	0·059
Fat	9·35	8·35	9·47	7·47	7·93	8·51	0·78	0·092
Carbohydrate by difference	54·4	60·5	57·4	61·5	61·4	59·1	2·76	0·047

[a] SD = Standard deviation.
[b] CV = Coefficient of variation.

Each sample (about 5 kg) was blended using a Kenwood food mixer. The moisture and ash contents were determined using the air oven and dry ashing methods of Pearson (1976). The ash was digested with 3M HCl and mineral contents were determined by atomic absorption spectrophotometry (Vogel, 1962). The samples were analysed for crude protein and fat according to the methods of the Association of Official Analytical Chemists (AOAC, 1975). The analysis of the amino-acids was performed on samples hydrolysed at 150°C for 1 h 30 min using a modification of the Waters 'Picotag' system (Bidlingmeyer *et al.*, 1984). A detailed procedure for the amino-acid analyses is described by Gardener *et al.* (1991). The method described by Oshodi & Ekperigin (1989) was used for the determination of protein solubility at room temperature (25°C). The water absorption capacity, fat absorption capacity, foaming capacity and the least gelation concentration of the cowpea flour samples were determined by the methods of Sathe *et al.* (1982) and Sosulski (1962).

RESULTS AND DISCUSSION

Table 1 presents the proximate chemical composition of the cowpea samples. Moisture, ash, fat, crude protein and carbohydrate contents are recorded in percentages of the wet samples. Cowpea is known to be a good source of protein and essential amino-acids, and to a lesser extent, a good source of minerals. Hence the protein, amino-acids and minerals contents were used to measure the effect of nematicides on the nutritive values of the cowpea samples. The samples produced without the application of nematicides have the lowest mean crude protein content (23·4%). The mean crude protein content for the other samples ranged from

Table 2. The amino acid composition of cowpea samples

Amino acid	Samples (g amino acid/100 g protein)					Mean (g amino acid/ 100 g protein)	SD[a]	CV[b]	Soya bean flour[c] (g amino acid/ 100 g protein)
	A14	B24	D23	F14	G22				
Asp	12·4	12·4	12·3	11·8	12·3	12·3	0·22	0·018	
Glu	21·4	20·3	21·9	21·5	21·5	21·3	0·53	0·025	
Ser	5·22	5·93	5·27	7·52	4·92	5·77	0·93	0·162	
Gly	4·29	5·03	4·57	5·82	4·38	4·82	0·56	0·117	
His[c]	3·29	3·39	3·41	3·28	3·11	3·31	0·11	0·032	2·4
Arg[c]	4·21	4·29	4·31	4·41	4·21	4·29	0·07	0·017	7·3
Thr[c]	3·39	3·87	3·25	4·77	3·27	3·71	0·58	0·155	3·9
Ala	6·38	7·28	6·63	7·29	6·85	6·89	0·36	0·052	
Pro	4·99	5·89	5·36	6·47	5·17	5·58	0·54	0·097	
Tyr	0·56	0·51	0·19	0·68	0·85	0·56	0·23	0·391	
Val[c]	7·21	7·24	7·63	6·34	6·94	7·07	0·43	0·061	5·2
Met[c]	0·57	0·69	0	0·97	0·05	0·46	0·38	0·823	1·4
Cys	0	0·12	0	0	0·01	0·03	0·05	1·814	
Ile[c]	5·31	4·85	5·33	3·41	5·15	4·81	0·72	0·149	5·3
Leu[c]	10·1	9·21	10·1	7·24	9·46	9·23	1·06	0·115	7·7
Phe[c]	5·52	4·84	5·37	4·86	5·76	5·27	0·36	0·069	4·9
Lys[c]	4·64	4·11	4·18	3·64	5·73	4·46	0·71	0·159	6·3
EAA (%)[d]	44·2	42·5	43·6	38·9	44·1	42·6	1·96	0·046	44·4

[a] SD = Standard deviation.
[b] CV = Coefficient of variation.
[c] Altschul (1958).
[d] EAA = Essential amino acid.

Table 3. The mineral content of the cowpea samples

Mineral	Samples (mg/100 g)					Mean (mg/100 g)	SD[a]	CV[b]
	A14	B24	D23	F14	G22			
Calcium	3·88	4·08	3·45	3·62	3·66	3·74	0·22	0·059
Magnesium	132	138	138	137	137	136	2·24	0·016
Potassium	1 908	2 752	1 171	1 908	1 639	1 875	514	0·274
Sodium	358	334	422	332	312	352	38·1	0·108
Manganese	2·31	2·01	1·23	1·97	1·48	1·81	0·39	0·217
Iron	3·75	4·14	2·72	4·14	3·28	3·61	0·54	0·151
Copper	2·31	4·97	1·18	1·17	1·48	2·33	1·37	0·588
Zinc	4·28	4·77	3·22	4·54	3·28	4·02	0·65	0·161

[a] SD = Standard deviation.
[b] CV = Coefficient of variation.

23·6% to 27·3%. These values agree with those reported by Oyenuga (1968) (22·8%), Kay (1979) (23·4%), Uzogara *et al.* (1988) (24·2%), and Aletor & Aladetimi (1989) (22·5%). Kay (1979) has also reported that in some cultivars the crude protein content may be up to 35·5%. The coefficient of variation for crude protein between the samples is 5·9%, which suggests that there was no significant difference between the crude protein in the control (G22) and those (A14, B24, D23 and F14) produced by the application of nematicides, or those reported in the literature. The present observation probably suggests that the nematicides do not inhibit but slightly enhance the synthesis and the utilization of nitrogen.

Table 2 shows the amino-acid composition of the cowpea samples in g amino-acid/100 g protein or g amino-acid/16 g N protein. The present results indicate that aspartic (Asp) and glutamic (Glu) acids were the major abundant amino-acids in the cowpea samples. The sum of these two amino-acids ranged from 32·7% to 34·5%. The results presented in Table 2 reveal that there are no significant differences between the amino-acid profiles of the control and those samples produced with the application of nematicides. This is confirmed by the low coefficient of variation for most of the amino-acids (Table 2).

The isoleucine (Ile), leucine (Leu), lysine (Lys), threonine (Thr), phenylalanine (Phe) and valine (Val) values in cowpea samples are higher than the Food and Agriculture Organization (FAO, 1970) references values (4·2, 4·2, 4·2, 2·8, 2·8 and 4·2 g amino-acid/16 g N protein, respectively). However, the methionine (Met) values for the samples are much lower than the methionine FAO reference value of 2·2 g amino-acid/16 g N protein, which is the most essential amino-acid. The total essential amino-acids in cowpea samples varied from 38·9% to 44·1% which suggests that cowpea will contribute significantly to the supply of essential amino-acids in the diet. Cowpea samples are comparable to soybean flour in their content of all essential amino-acids except Met (Altschul, 1958) (Table 2). This indicates that the cowpea sample is a good source of essential amino-acids with the exception of methionine. The nutritional value of cowpea meal can be further improved by adding methionine.

The ash content of the control sample is 2·91% which lies in the range of ash contents, 2·77–3·16%, for cowpea samples produced with the application of nematicides. The present results are in fair agreement with those reported by Oyenuga (1968) (3·78%), Kay (1979) (3·6%), Olaofe & Sanni (1988) (6·2%), and Aletor & Aladetimi (1989) (3·36%). The slight differences are probably due to variation in the length of storage after harvesting and in the planting location. Olaofe *et al.* (1987) have shown that the ash or mineral contents of agricultural products vary with the planting location.

Table 3 presents the mineral content of cowpea samples in mg per 100 g sample. Potassium was the most abundant mineral ranging from 1171 to 2753 mg/100 g sample. This observation was in close agreement with the observation of Olaofe & Sanni (1988) and Aletor & Aladetimi (1989). Aletor & Aladetimi (1989) found that the potassium content in cowpea varieties ranged from 1·26% to 1·60% (1260–1600 mg/100 g) with a mean of 1·45% (1450 mg/100 g). The present results on calcium content are very close to the values reported by Kay (1979) (5·7 mg/100 g sample) and Oyenuga (1968) (5·6 mg/100 g sample), but very far from the range reported by Aletor & Aladetimi (1989) (40–80 mg/100 g sample). It is worth noting that the present results contained mineral contents of Fe, Cu, Zn and Mn, which have not been reported by other workers (Kay, 1979; Olaofe & Sanni, 1988; Aletor & Aladetimi, 1989). These minerals are also nutritionally important.

The coefficient of variation for ash content is 4·9%, while those for the minerals are generally low (Table 3). The mineral contents of each of the samples produced with the application of nematicides are in good agreement with the control sample (G22). This suggests that the nematicides do not inhibit the uptake of minerals from the soil by cowpea plants.

Protein sources or products should possess desirable functional properties to make them useful in food industries. Figure 1 shows the effect of pH on cowpea protein solubility. All the curves indicate a minimum solubility of cowpea protein at pH 4·0, which corresponds to the iso-electric point of the protein since proteins or amino-acids are least soluble at their iso-electric points. The occurrence of minimum cowpea protein solubility at pH 4·0 confirms the major abundance of

Table 4. Functional properties of cowpea samples

Functional properties	Samples					Mean (%)	SD[a]	CV[b]
	A14 (%)	B24 (%)	D23 (%)	F14 (%)	G22 (%)			
Fat absorption capacity	310	291	290	321	281	298·6	14·7	0·049
Water absorption capacity	251	212	245	275	245	245·6	20·1	0·082
Foaming capacity	40	80	44	50	50	52·8	14·1	0·267
Least gelation capacity	10·7	10	15	10	15	12·1	2·3	0·194

[a] SD = Standard deviation.
[b] CV = Coefficient of variation.

the Asp and Glu in the amino-acid composition (Table 2). Asp and Glu have their iso-electric points at pH 3·0 and 3·1, respectively. The remaining amino-acids have their iso-electric points at pH greater than 4·5.

Oshodi and Ekperigin (1989) found that the minimum solubility of pigeon pea flour (*Cajamus cajan*) occurred at pH 5·0, which is slightly higher than pH 4·0 observed in this study. The differences in the amino-acid composition of pigeon pea and cowpea might have accounted for the differences. For pH less than or greater than 4·0 the cowpea protein is highly soluble. The solubility of the cowpea protein at lower pH (acid region) and higher pH (basic region) suggests that it would probably be useful in the formulation of high acid foods/protein rich carbonated beverages (Kinsella, 1973) and very low acid foods/meat products or beverages which have high pH.

From Figure 1 there is no clear indication of whether cowpea protein has the lowest or highest solubility within the pH studied. However, the curve for the control sample (G22) lies within the other samples' curves at pH $< 6·0$ and lies above the other curves at pH $\geq 6·0$. One can therefore observe that the nematicides have no drastic effect on the solubility of cowpea protein.

Table 4 shows the other functional properties for the cowpea flour samples. The mean water and fat absorption capacities are 298·6% and 245·6% with standard deviation of 14·7% and 20·1% respectively. These values are much higher than those reported for soy flour–water absorption capacity (130%), with fat absorption capacity (84·2%) (Lin *et al.*, 1974); pigeon pea flour–water absorption capacity (138%), with fat absorption capacity (89·7%) (Oshodi & Ekperigin, 1989); defatted flours of oilseeds–water absorption capacity (100–266%) with fat absorption capacity (98·5–301·8%) (Ige *et al.*, 1984). The water and fat absorption capacities for the samples do not show marked differences as indicated by their respective coefficients of variation of 4·9% and 8·2%, respectively.

The mean foaming capacity and the least gelation concentration were found to be 52·8% and 12·1% with standard deviations of 14·1% and 2·3%, respectively. The present values are comparable with those reported for pigeon pea–foaming capacity (68%), with lowest gelation concentration (12%) (Oshodi & Ekperigin, 1989); lowest gelation concentration of 14% for lupin seed flour (Sathe *et al.*, 1982) and 10% for the great Northern bean flour (Sathe & Salunkhe, 1981); and defatted flours of oil seeds–foaming capacity (66–146·2%) (Ige *et al.*, 1984). Low marked differences were shown by the foaming capacity and least gelation contraction of the samples as judged by their respective coefficients of variation of 26·7% and 19·4%, respectively. The present results show that cowpea samples have good protein solubility, high fat and water absorption capacities and moderately low gelation concentration and foaming capacity, which make cowpea suitable for food formulations.

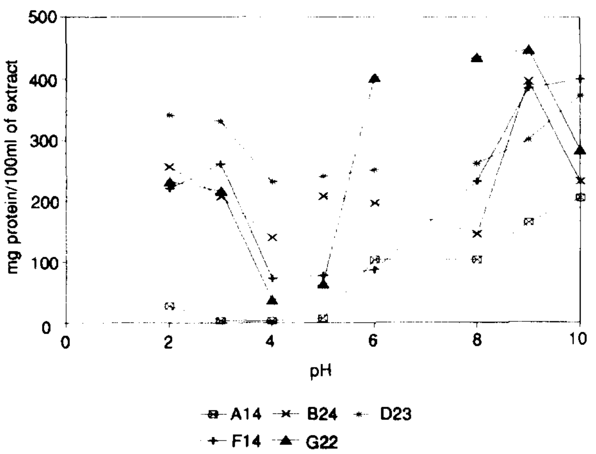

Fig. 1. The effect of pH on cowpea protein solubility.

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