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Effect of heat treatment on selected functional properties of cowpea flour

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Abstract *Cowpea seeds (*Vigna unguiculata*) were tempered so as to increase the moisture content to about 36%, equilibrated for 2 h, dried at a temperature of 30°C for 16 h and between 60 and 120°C for 0–3 h, dehulled and milled into flour. Functional properties which are known to affect 'akara' (fried cowpea paste) and 'moin-moin' (steamed cowpea paste) were determined on samples taken at 30-min intervals during drying. The hydrothermal treatment applied to the cowpea seeds decreased such functional properties as nitrogen solubility, water absorption, swelling and foaming propensities, but increased the least gelling concentration of the resulting flour.*

Keywords: Cowpea, *Vigna unguiculata*, drying, flour, functional properties.

Introduction

The cowpea (*Vigna unguiculata*), a commonly known grain legume, is widely distributed in tropical and temperate climates. It has many varieties which differ in shape, size and colour of seed coat. Varieties available in Nigeria include brown beans, ACE, Vita and AIR. Cowpea is important in the human diet because it contains 20–30% protein, with an amino-acid pattern complementary to that of the cereal grains, 55–58% carbohydrates, 2–3% fat, and 2–3% minerals and vitamins.

In the utilization of cowpea for food, the pods are eaten as green vegetables or as dry, mature seeds called pulses. The pulses can be converted to foods, for example, cooked dehulled or undehulled seeds, fried sponge such as akara, steamed paste such as moin-moin, fermented foods such as tutu in Brazil, idhli and dhosal in India; or it can be made into soups and stews. Cowpea seeds can be processed into flour or powder, protein concentrate and isolate and starch (Siegel and Fawcett, 1976).

Techniques for processing or converting cowpea into food include soaking, tempering, boiling, steaming, germinating, drying, roasting, toasting, dehulling, fermenting and milling (Dovlo, Williams and Zoaka, 1976; Siegel and Fawcett, 1976; Onoja, 1982).

The functionality of cowpea flour and paste systems results from a unique interaction of the starch and protein hydrocolloids and water and is affected by temperature and concentration regimes (Sherman, 1982). In the preparation of cowpea flour or paste, the

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seeds are usually dehulled prior to milling so as to eliminate the seed coat and the dark hilum which cause discolouration of the paste or flour and have been associated with the incidence of flatulence among consumers of whole cowpeas. Traditionally, the preparation of the paste is done by the combined processes of soaking, dehulling and wet-milling. This is both time-consuming and labour-intensive. Therefore, the production of a flour with optimal functional properties which can easily be converted into paste by the addition of water, will be of considerable advantage. Processed cowpea flour in the Nigerian food market has been studied by Dovlo *et al.* (1976) and McWatters (1983). Both workers reported that akara made from the flour now commercially available is dense and heavy with a thick outer skin. As a consequence, the flour has experienced low market acceptability. In order to produce processed cowpea flour of acceptable quality, studies have been carried out to determine optimal processing variables for tempering, drying and dehulling (Uzo, 1981; Onoja, 1982; Uchendu, 1982).

The objective of the present study is to determine the effect of different tempering and drying conditions on selected functional properties of cowpea flour, namely: nitrogen solubility, water absorption, swelling, least gelling concentration and foaming propensity. These attributes have been shown by McWatters (1983) and Enwere (1985) to have significant effects on akara (a sponge made by frying cowpea paste in hot oil) and moin-moin (steamed cowpea paste). These two products are both popular and important dishes which can be prepared by the pasting of cowpea flour. The production of cowpea flour of quality suitable for the making of akara and moin-moin would be of considerable interest to Nigerian consumers, and perhaps those in other countries also.

Materials and methods

Large black eye Kano-white cowpea seeds were obtained from Orba market near Nsukka. Although the previous history and source of the seeds were not known specifically, they were carefully selected to typify seeds traditionally available in the Nigerian retail chain for food grains. The cowpea seeds were cleaned by manual removal of stones, sand, dust, pod fragments, weevils and weevilled seeds, immature beans and other contaminants. The moisture content of the seeds was then determined according to the method recommended for grain and feeding stuffs as described by Joslyn (1970). In order to temper the cowpea seeds, the moisture content was increased to 36% following the method of Onoja (1982). The tempered seeds were equilibrated for 2 h and later dried in batches in a convection air oven. The first batch was dried at a temperature of 30°C for 16 h. Subsequent batches were dried at temperatures of between 60 and 120°C for periods varying from 0 to 3 h. Samples were taken at 30-min intervals and moisture content determined. The cowpea seeds were then dehulled either manually if wet or in the polisher of the Engelberg Rice Mill if dried down to 8% moisture content wet basis or below. The dehulled seeds were subsequently milled in a hammer mill so as to produce flour capable of passing through 48-mesh sieve. The resulting flour was packed in polythene bags and stored in a refrigerator at 4°C until the analyses were completed.

Analyses of the following selected functional properties were carried out:

(i) Nitrogen solubility;
(ii) Hot water absorption capacity;
(iii) Swelling capacity;
(iv) Least gelling concentration;
(v) Whippability, foaming and foam stability.

These functional properties were chosen for study for two reasons: firstly, their simplicity and comparative ease of determination with minimal laboratory facilities and secondly, their proven effect on the performance of cowpea flour and their possible use in the assessment of flour quality for the preparation of akara and moin-moin recipes.

Nitrogen solubility, whippability, foaming and foam stability of flour are significant in akara quality while hot water absorption, swelling and gelling characteristics are important with regard to moin-moin quality (Enwere, 1985).

Nitrogen solubility was determined by a modification of Lyman's method, described by Dovlo (1981); hot water absorption by the centrifuge method of Sosulski (1962), swelling capacity by the method of Lin, Humbert and Sosulski (1974); least gelling concentration by the method of Sathe and Salukhe (1981) and Morris and Belton (1982). The method of Lin *et al.* (1974) was used for determining whippability, foaming and foam stability. Results were calculated on a dry-weight basis.

Results and discussion

The nitrogen solubility index (NSI) decreased as the temperature used for drying the cowpea seeds increased. This is given in Table 1 and illustrated in Figure 1. The decrease in the NSI was more drastic from the temperature of 90°C upwards. Fennema (1977) has shown that the loss of solubility in proteins during heating is associated with both denaturation and aggregation. The relative importance of one or other of these phenomena depends on the particular system and the heating conditions (Rosario and Flores, 1981; Welsby, McCarthy and Doolan, 1982).

Water absorption of cowpea flour produced from the dried cowpea seeds decreased with increasing temperature and time of drying, as given in Table 1 and shown in Figure 2. The decrease is more pronounced at higher temperatures. The decrease in water absorption as a result of heat treatment of cowpea seeds and flour had been observed and reported before by Sefa-Dedeh and Stanley (1979) and Uchendu (1982). The decrease in water absorption with increase in heat treatment might be attributed to predenaturation of protein, gelatinization and alteration of starch granules and cellwall materials during the drying of wetted cowpea seeds. According to Joslyn (1975) and Ledward (1979), water absorption of proteins in food is markedly decreased by protein aggregation and precipitation which may occur spontaneously following denaturation of proteins.

The swelling capacity of cowpea flour as a function of heat treatment is given in Table 1 and illustrated in Figure 3. It is observed that the swelling capacity of cowpea flour decreased with increase in the temperature used for drying the cowpea seeds destined for flour production. This is in agreement with the earlier report of Uchendu

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Table 1. Nitrogen solubility index, water absorption, swelling capacity and least gelling concentration of cowpea flour as a function of heat treatment

Temperature of drying (°C)	Time of drying (h)	Nitrogen solubility index	Water absorption (ml g^{-1})	Swelling capacity	Least gelling concentration (%)
30	0	7·59	4·78	4·63	5·5
	16	7·59	4·78	4·62	5·5
60	0	7·59	4·78	4·63	5·5
	½		4·78	4·61	5·5
	1	7·33	4·77	4·59	5·5
	1½	7·22	4·75	4·53	5·5
	2	6·91	4·72	4·38	5·5
	2½	6·91	4·72	4·34	5·5
	3	6·85	4·71	4·28	5·5
70	0	7·59	4·78	4·63	5·5
	½	7·58	4·75	4·59	5·5
	1	7·06	4·73	4·54	6·0
	1½	6·96	4·71	4·39	6·0
	2	6·85	4·69	4·36	6·5
	2½	6·69	4·68	4·20	6·5
	3	6·64	4·68	4·22	6·5
80	0	7·59	4·78	4·63	5·5
	½	7·04	4·70	4·54	6·0
	1	6·85	4·64	4·42	6·0
	1½	6·67	4·62	4·35	6·5
	2	6·59	4·58	4·26	7·0
	2½	6·31	4·56	4·14	7·0
	3	6·11	4·54	4·07	7·0
90	0	7·59	4·78	4·63	5·5
	½	6·69	4·67	4·41	6·5
	1	5·95	4·58	4·31	6·5
	1½	5·58	4·53	4·15	7·0
	2	5·42	4·50	4·02	7·0
	2½	5·16	4·44	3·81	7·5
	3	4·95	4·41	3·63	7·5
100	0	7·59	4·78	4·63	5·5
	½	6·61	4·41	4·39	7·0
	1	5·32	4·21	4·25	7·5
	1½	4·55	4·10	3·88	8·0
	2	3·97	4·01	3·66	8·0
	2½	3·45	3·91	3·51	8·5
	3	3·00	3·75	3·26	9·0
120	0	7·59	4·78	4·63	5·5
	½	4·29	4·05	3·51	7·5
	1	3·23	3·75	3·02	8·0
	1½	2·41	3·55	2·79	8·5
	2	1·91	3·16	2·64	9·0
	2½	1·48	3·02	2·39	9·5
	3	1·32	2·85	2·31	10·0

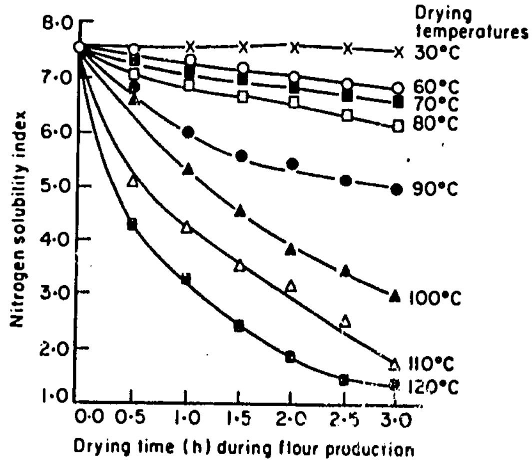

Figure 1. Nitrogen solubility index of cowpea flour as a function of heat treatment.

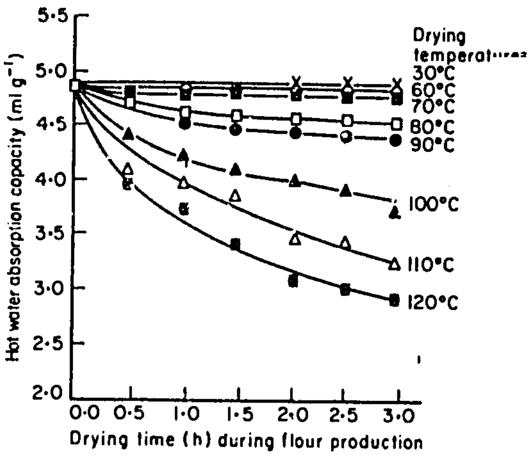

Figure 2. Hot water absorption capacity of cowpea flour as a function of heat treatment.

(1982). According to this report, the ability of cowpea flour to swell depends largely on its starch granules, which when heated in excess water above 60°C, absorb water, gelatinize and consequently swell to about 8·13 times the original volume. Proteins in cowpea also contribute to swelling, increasing to about 3·78 times the original volume in hot water. However, the ability of the starch and proteins to swell is adversely affected by both thermal and mechanical damage occurring during manufacture, as seen in the present study.

The least gelling concentration of cowpea flour is shown to increase with increase in temperature of drying, starting from 70°C as given in Table 1 and illustrated in Figure 4. However, drying at temperatures between 30 and 60°C did not cause any change in the least gelling concentration. The least gelling concentration increased from 5·5% (d.w.b.) for the untreated cowpea flour to 10% for cowpea flour produced from tempered cowpea

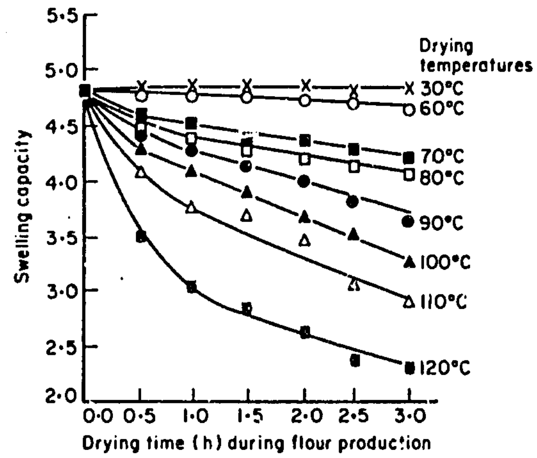

Figure 3. Swelling capacity of cowpea flour as a function of heat treatment.

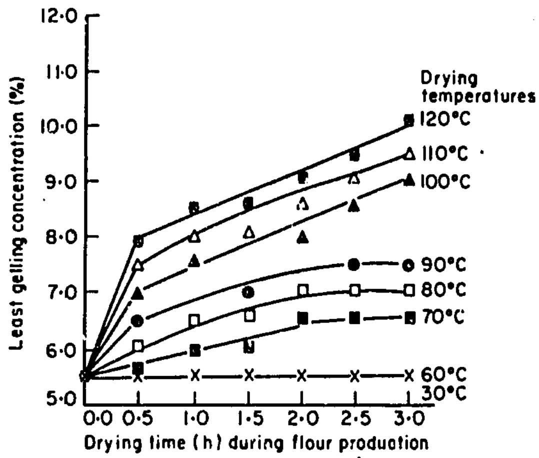

Figure 4. Least gelling concentration of cowpea flour as a function of heat treatment.

seeds dried at a temperature of 120°C for 3 h. The increase in the least gelling concentration, that is, the decrease in the ability of cowpea flour to form stable gels, is attributed to denaturation, aggregation and precipitation of proteins and pre-gelatinization and thermal degradation of starch (Ledward, 1979; Mauron, 1981).

The whippability, foaming and foam stability of cowpea flour also decreased as temperature and time of drying increased. These trends are given in Tables 2 and 3, and illustrated in Figures 5 and 6. According to Campbell, Penfield and Griswold (1980), the ability of food to foam and maintain stable foams is determined mainly by the solubility of its proteins in water. In earlier work by Yasumatsu *et al.* (1972), it was suggested that protein denaturation decreased protein solubility, which in turn decreased the foam capacity of foods. The foam quality and foaming capacity of cowpea flour and paste have been shown to affect the texture of akara balls (Dovlo *et al.*, 1976).

Table 2. Whippability, foam formation and foam stability of cowpea flour-water suspension as a function of heat treatment

Temperature drying (°C)	Time of drying (h)	Initial volume of suspension (ml)	Volume of whipped suspension (ml)	% Volume increase of whipped suspension	Foam stability—i.e., volume of foam in the whipped suspension after standing for a period (minutes)						
					0	1	5	10	30	60	120
30	0	101	260	157·4	171	169	168	168	155	153	138
	16	101	260	157·4	171	169	169	168	155	153	138
60	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	260	157·4	170	169	169	155	155	152	139
	1	101	260	157·4	170	170	169	167	155	154	138
	1½	101	260	157·4	169	169	169	165	151	148	136
	2	101	255	152·5	169	169	168	163	150	145	130
	2½	101	255	152·5	165	164	159	150	147	139	129
	3	101	250	147·5	166	164	153	147	142	138	120
70	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	260	157·4	170	169	169	160	154	141	130
	1	101	257	154·5	167	163	161	159	154	140	126
	1½	101	255	152·5	163	162	160	158	150	140	123
	2	101	250	147·5	163	160	158	155	139	125	120
	2½	101	250	147·5	160	160	156	151	138	120	110
	3	101	250	147·5	158	157	149	147	130	120	90
80	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	250	147·5	168	159	157	150	143	132	118
	1	101	254	142·6	156	146	140	137	129	120	112
	1½	101	237	134·7	146	143	138	135	121	118	110
	2	101	230	127·7	146	144	138	134	119	112	108
	2½	101	230	127·7	145	144	137	134	110	108	95
	3	101	230	127·7	145	144	136	133	104	100	87
90	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	240	137·6	150	143	138	122	110	102	88
	1	101	220	117·8	131	128	120	112	92	56	37
	1½	101	194	92·08	106	104	96	92	74	30	18
	2	101	190	88·1	102	101	92	82	72	21	12
	2½	101	188	86·1	100	98	86	80	70	20	12
	3	101	180	79·2	96	93	85	80	70	18	8
100	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	210	107·9	125	113	103	72	57	31	30
	1	101	184	82·1	98	92	82	58	18	14	10
	1½	101	170	68·3	88	80	73	46	16	14	9
	2	101	164	62·4	76	58	62	35	16	13	9
	2½	101	153	51·5	74	64	60	29	16	13	8
	3	101	140	38·6	72	64	54	20	16	11	8
110	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	190	88·1	83	75	51	31	18	6	1
	1	101	154	52·5	58	57	40	19	7	5	0
	1½	101	150	48·5	56	54	38	13	7	5	0
	2	101	140	38·6	56	52	52	11	6	4	0
	2½	101	136	34·7	50	43	20	8	4	3	0
	3	101	134	32·7	43	31	8	6	3	2	0
120	0	101	260	157·4	171	169	169	168	155	153	138
	½	101	162	60·4	60	43	15	10	5	1	0
	1	101	145	43·6	51	37	7	5	3	1	0
	1½	101	143	41·6	47	36	6	4	3	1	0
	2	101	140	38·6	44	34	5	4	3	1	0
	2½	101	135	33·7	39	24	2	1	0	0	0
	3	101	130	28·7	29	11	1	0	0	0	0

Table 3. Mean foam stability of cowpea flour processed at temperatures between 30 and 120°C

Temperature (°C)	Mean foam volume (ml) after standing for time (min)*					
	0	5	10	30	60	120
30	171·0	169·0	168·0	155·0	153·0	138·0
60	168·1	164·5	160·2	150·0	146·0	132·0
70	163·5	158·83	155·0	144·2	131·0	116·5
80	151·0	141·0	137·2	121·0	115·0	105·0
90	114·2	102·7	94·7	81·3	41·2	29·0
100	86·8	72·3	43·2	23·2	16·0	12·3
110	57·7	33·2	14·7	7·5	4·2	0·2
120	44·7	6·0	4·0	2·3	0·7	0·0

*Mean foam volume (ml) derived from averaging the foam stability data in Table 2.

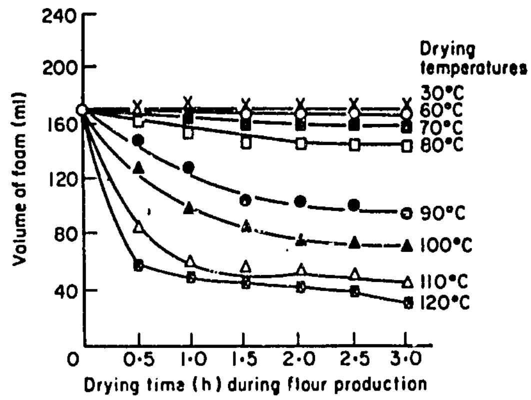

Figure 5. Foam formation of cowpea flour as a function of heat treatment.

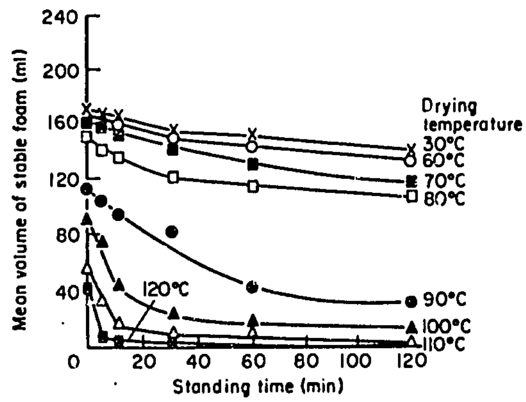

Figure 6. Mean foam stability of cowpea flour as a function of heat treatment.

Conclusion

This study has shown that drying tempered cowpea seeds at a temperature of 30°C for up to 16 h does not alter any of the selected functional properties. Drying at temperatures between 60 and 120°C decreased nitrogen solubility, hot water absorption, swelling capacity, whippability, foaming and foam stability but increased the least gelling concentration of the resulting cowpea flour. Up to the drying temperature of 60°C, change in flour performance, as inferred from the several measurements of functionality were minimal, suggesting that a versatile flour for making both akara and moin-moin can be manufactured at drying temperatures up to 60°C. Above 80°C, change in functionality is so pronounced for all the properties measured, that any form of flour manufacturing emphasizing temperatures above 80°C must be discouraged. Selective flours can be manufactured at drying temperatures between 60 and 80°C. However, such flours can only be used for products in which quality is relatively insensitive to foaming and foam stability. In the present context, an example of such a product is moin-moin.

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References

Campbell, A. M., Penfield, M. J. and Griswold, R. M. (1980) *The Experimental Study of Foods*, 2nd Edn. London: Constable.

Dovlo, F. E., Williams, C. E. and Zoaka, L. (1976) *Cowpeas: Home Preparation and Use in West Africa*. IDRC 055e. International Development Research Centre (IDRC).

Dovlo, F. E. (1981) Criteria for cooking quality and acceptability of cowpeas. In *Nutritional Standards and Methods of Evaluation of Food for Legume Breeders*. J. H. Hulse, K. O. Rachie and L. W. Billingsten (Eds). Ottawa, Canada: IDRC. J57e.

Enwere, N. J. (1985) Effect of tempering and drying on selected functional properties and performance of cowpea flour during akara and moin-moin preparations. M.Sc. thesis, unpublished. Department of Food Science and Technology, University of Nigeria. Nsukka.

Fennema, O. (1977) Water and protein hydration. In *Food Proteins*. J. R. Whitaker and S. R. Tannenbaum (Eds). London: Applied Science Publishers Ltd.

Joslyn, M. A. (1970) (Ed.) *Methods in Food Analysis*. New York, San Francisco, London: Academic Press.

Joslyn, M. A. (1975) Food processing by drying and dehydration. In *Food Processing Operations*, Vol. II. J. L. Heid and M. A. Joslyn (Eds). Westport, CT: The AVI Publishing Co. Inc.

Ledward, D. A. (1979) Proteins. In *Effects of Heating on Food Stuffs*. R. J. Priestly (Ed.). London: Applied Science Publishers Ltd.

Lin, M. J. Y., Humbert, E. S. and Sosulski, F. W. (1974) Certain functional properties of sunflower meal products. *Journal of Food Science*, 39, 368.

Mauron, J. (1981) The maillard reactions in food. A critical review from nutritional standpoint. *Progress in Food and Nutrition Science*, 5, 5.

-9

McWatters, K. H. (1983) Compositional and sensory characteristics of akara processed from Nigerian cowpea flour. *Cereal Chemistry*, **60**, 333.

Morris, V. J. and Belton, P. S. (1982) The influence of cations: sodium, potassium and calcium on the gelation of iotacarrageenan. *Progress in Food and Nutrition Science*, **6**, 55.

Okaka, J. C. and Potter, N. N. (1979) Functional, nutritional and storage properties of cowpea powders processed to reduce beany flavour. *Journal of Food Science*, **44**, 1539.

Onoja, U. S. (1982) *Dehulling of Cowpeas*. B.Sc. Thesis, unpublished. Department of Food Science and Technology, University of Nigeria, Nsukka.

Rosario, R. R. and Flores, D. M. (1981) Functional properties of flour types of mung bean flours. *Journal of Science of Food and Agriculture*, **32**, 175.

Sathe, S. K. and Salunke, D. (1981) Isolation and partial characterization and modification of the great northern bean (*Phaseolus vulgaris*) starch. *Journal of Food Science*, **43**, 1832.

Sefa-Dedeh, S. and Stanley, D. W. (1979) Microstructure of cowpea variety, Adua ayera. *Cereal Chemistry*, **56**, 367.

Sherman, P. (1982) Hydrocolloid solutions and gels: sensory evaluation of some textural characteristics and their dependence on rheological properties. *Progress in Food and Nutrition Science*, **6**, 269.

Siegel, A. and Fawcett, B. (1976) *Food Legume Processing and Utilization*. Agriculture, Food and Nutrition Science Division. Ottawa, Canada: IDRC-TS-1.

Sosulski, F. W. (1962) The centrifuge method for determining flour absorption in hard red spring wheat. *Cereal Chemistry*, **39**, 344.

Uzo, F. N. A. (1981) *Dehulling of Cowpeas*. B.Sc. Thesis, unpublished. Department of Food Science and Technology, University of Nigeria, Nsukka.

Uchendu, U. I. E. (1982) *Some Functional Properties of Cowpea (*Vigna unguiculata*) Pasting Systems*. B.Sc. Thesis, unpublished. Department of Food and Science and Technology, University of Nigeria, Nsukka.

Welsby, D., McCarthy, M. and Doolan, D. (1982) The use of milk proteins as hydrocolloids in food systems. *Progress in Food and Nutrition Science*, **6**, 221.

Yasumatsu, K., Swada, K., Moritaka, S., Misaki, M., Toda, J., Wada, T. and Ishii, K. (1972) Whipping and emulsifying properties of soybean products. *Journal of Agriculture, Biology and Chemistry*, **36**, 719.

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