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Effect of pH on some cooking properties of cowpea (*V. unguiculata*)

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Clean grains of a white cultivar of cowpea (*V. unguiculata*) were cooked and the cook weights, at different time and pH, and brown coloration were measured. The cook weights varied widely ($p < 0.05$) with the pH of the cook water, with the peak at pH 5. The maximum cook weight was attained at about 30 min at pH 12 and 40 min at pH 7. Boiling at pH 2 gave the lowest cook weight.

The browning observed, reached a maximum at pH 10–12 in raw beans. The intensity of browning increased significantly ($p < 0.05$) after boiling, with two peaks at pH 5–6 and pH 9–10 respectively.

The results suggested the use of alkaline pH to alleviate the problem of storage-induced hardness-to-cook and dehulling as a means of reducing the associated browning.

INTRODUCTION

Cowpea (*V. unguiculata*) is a widely consumed legume among Nigerians. Its nutritional significance resides especially in the relatively high protein content of 24–28% (Akinyele *et al.*, 1986). The most popular method of preparing cowpea for human consumption is by boiling in excess water until it becomes soft to touch. The seasonality of cowpea production in many countries necessitates storage which is very often prolonged enough to produce 'hard-to-cook' beans (Sefah-Dedeh *et al.*, 1979; Jackson & Varriano-Martson, 1981). This phenomenon increases the cooking time and reduces the extent of cowpea utilization. Addition of a rock salt (potash or natron), commonly referred to as 'kaun' or 'kaunwa' among Nigerians, is a traditional method of reducing the cooking time of cowpea in the Southern part of Nigeria. Although a reliable composition of kaun is not available, Davidson *et al.* (1974) reported the presence of hydrated carbonate, bicarbonate, sodium and potassium ions, respectively. About 2–5% solutions (w/v) of samples from a local market were observed, in this laboratory, to give a pH of 9·4–9·8. Hence this study was designed to investigate the specific effect of the pH of the cook-water on the cooking property of cowpea, and especially the cook time and cook weight.

MATERIALS AND METHODS

The white cowpea grains were purchased from a local market and sorted manually for clean matured seeds. The seeds were subsequently treated according to the assay.

pH and swelling

Distilled water was adjusted to a pH of 2 on a glass electrode pH-meter (Ken ELL, 7045/46) and the water was used to boil 50 g of beans for 40 min under reflux. The cook water was drained and the grains were weighed. The difference between the raw weight and cook weight was equated to the degree of swelling (or weight gain). The swelling coefficient was calculated as the increase in weight per unit raw weight of the seeds. The same procedure was repeated with the cook-water adjusted to an initial pH of 3–12 respectively, with 0·1 N HCl or 0·1 N KOH as appropriate.

pH and rate of cooking

One hundred clean seeds of cowpea were weighed and boiled under reflux in water adjusted to pH 2 (acidic), 7 (neutral) and 12 (alkaline), respectively. The boiling was done for 10 min and the degree of swelling was determined as described above. This was repeated for 20, 30 and 40 min boiling respectively. The cook-water, collected after boiling, was filtered through Whatman No. 1 filter paper and the pH was determined. The change in pH during cooking was then calculated for each of the initial pHs of 2, 7 and 12.

pH and browning (raw cowpea)

Clean grains of cowpea were milled to pass 40 mm mesh. Exactly 0·5 g of the flour was suspended in 20 ml

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distilled water adjusted to pH 2. The mixture was agitated for 30 min and filtered through Whatman No. 1 filter paper and the absorbance of the clear filtrate was measured on a colorimeter (Griffin, Model 40) at 430 nm. This procedure was repeated with the mixture adjusted to pH 3–12 as described above.

pH and browning (cooked cowpea)

Cowpea grains were boiled at different initial pHs under reflux as described for pH and swelling and the boiled grains, dried at 60°C, were milled to pass 40 mesh size. The flours were extracted and the browning was measured as described above.

Browning in seedcoat and cotyledon

Some grains of cowpea were soaked in distilled water for 15 min and the seed coats were removed manually. The seedcoats and the cotyledons were then separately dried at 60°C overnight (Gallenkhamp air-oven size 2) and milled into fine flour. The brown pigments in the flours were estimated as described above with the mixture adjusted to pH 5, 9 and 10 respectively.

RESULTS AND DISCUSSION

Table 1 shows the relative swelling capacity of cowpea at a pH range of 2–12. Boiling for about 40 min, the average cooking time for cowpea (Akinyele *et al.*, 1986), increased the weight of the beans from 50 g to 120 g at pH 2, 134 g at pH 5 and 138 g at pH 11. The cook weight, however, fell to 131 g at pH 12. The effect of duration of cooking (Table 2) shows that a maximum cook weight of 121·9 g was attained within 30 min when the initial pH of cook water was 12, whereas it took 40 min for the maximum cook weight to be attained at pH 7. The cook weight after boiling for 40 min at pH 2 was the lowest. The relative swelling capacity was further expressed per unit weight of the beans (swelling coefficient) as shown in Table 2. The pattern of changes in the cook weight suggested that the cooking quality of cowpea can be significantly affected by the pH of the medium. Changes in cook weight could have arisen from the combined effects of structural changes and the hydrolysis of the polymeric constituents under the appropriate pH conditions. Denaturation of both the carbohydrates and proteins increases the polymer–water interaction and consequently the water absorption capacity of the grains.

Table 1. Effect of pH on the cook weight and browning of cowpea (*V. unguiculata*)

pH	Cook weight[a] (g)	Weight gain (g)	Swelling coefficient (g/g)	Browning[b] ($A_{430\ nm}$)	
				Raw	Boiled
2	120·0	70·0	1·40	0·02	0·25
3	124·4	74·4	1·49	0·15	0·70
4	125·7	75·7	1·51	0·18	0·76
5	133·9	83·9	1·68	0·18	1·30
6	132·0	82·0	1·64	0·18	1·51
7	132·6	82·6	1·65	0·20	0·36
8	131·8	81·8	1·64	0·17	0·75
9	132·5	82·5	1·65	0·18	1·51
10	131·7	81·7	1·63	0·35	1·50
11	138·4	88·4	1·77	0·45	0·88
12	131·0	81·0	1·62	0·48	0·77

[a] Initial weight = 50 g.
[b] 0·5 g sample in 20 ml water.

The hydrolysis of the polymeric nutrients, e.g. alkaline hydrolysis of carbohydrates (Smith, 1981), could explain the collapse of the moisture permeability barriers. The rupture of the seed coat on prolonged boiling and the consequent increase in the leached solids are likely reasons for the lower cook weight of cowpea boiled at pH 12 (Table 2).

The changes in the initial pH values of the cook water (Table 3) were consistent with the buffering behaviour of the amino acid side groups of the proteins. The remarkable drop in the pH from 12 can be attributed to the combined effects of the dissociation of the acidic groups. The relative pH stability at pH 2 suggested a relatively low level of basic residues whose protonation more than compensated for any dissociation of the carboxyl groups.

Relative estimation of brown coloration associated with the boiling of cowpea (Table 1) shows that the browning occurs spontaneously at room temperature under the appropriate pH conditions. This could be increased 5-to-10-fold by boiling, especially at pH 5–6 and pH 9–10 respectively. Since the excess moisture used in this study precluded heat-induced Maillard

Table 2. Effect of pH on the cooking time and the cook weight of cowpea (*V. unguiculata*)

Time (min)	Raw weight (g)	Cook weight (g)			Weight gain (g)			Swelling coefficient (g/g)		
		A[a]	B[b]	C[c]	A	B	C	A	B	C
10	50	93·7	105·5	113·6	43·7	55·5	63·6	0·87	1·11	1·27
20	50	98·2	104·7	118·2	48·2	54·7	68·2	0·96	1·09	1·36
30	50	105·7	106·8	121·9	55·7	56·8	71·9	1·11	1·14	1·44
40	50	112·8	122·3	106·6	62·8	72·3	56·6	1·26	1·45	1·13

[a] A = pH 2.
[b] B = pH 7.
[c] C = pH 12.

Table 3. Changes in the pH of the medium when cowpea (*V. unguiculata*) was boiled at different initial pH conditions for various times

Time of cooking (min)	Initial pH conditions					
	2		7		12	
	Final pH	pH change	Final pH	pH change	Final pH	pH change
10	5·2	3·2	6·3	0·7	11·7	0·3
20	5·4	3·4	6·3	0·7	11·2	0·8
30	5·5	3·5	6·3	0·7	10·0	2·0
40	5·5	3·5	6·5	0·5	10·0	2·0

browning and caramelization, the colour could have arisen from the oxidation of phenolic acids in the presence of atmospheric oxygen (Rivas & Whitaker, 1973; VaMos-Vigyazo, 1981). The occurrence of two absorbance maxima at pH 5–6 and pH 9–10 are, respectively, consistent with the release of the acid- and alkaline-soluble phenolics (Price *et al.*, 1979; Hahn *et al.*, 1984). The presence of tannins in cowpea has been reported (Akinyele *et al.*, 1986). Although the phenolic acids vary in both their chemical structures and distribution in grains (Hahn *et al.*, 1984), the consistently high browning potential of the seed coat (Table 4) suggests that the pigment compounds are more concentrated in the seed coat. Hence dehulling could be a means of reducing the browning associated with the tenderizing effect of alkaline pH.

Table 4. Browning in the seedcoat and cotyledons of cowpea (*V. unguiculata*) at different pHs

pH	Browning ($A_{430\ nm}$)	
	Seedcoat	Cotyledon
5	0·38	0·23
9	0·50	0·08
10	0·65	0·18

CONCLUSION

The storage-induced hardness-to-cook in cowpea can be alleviated by the use of alkaline cook water. This alternative method is questionable if the toxic effect of 'kaun' (Oyeleke, 1988) is found relevant to man. The associated browning can be minimized by dehulling before boiling.

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