IMPROVEMENT IN THE COOKING AND PHYSICO-CHEMICAL CHARACTERISTICS OF HARD-TO-COOK COWPEAS BY PRE-CONDITIONING AND MICRONIZATION

Brasilino D.V. Salvador[1,3], Louis A.M. Pelembe[2], Amanda Minnaar[3]

[1]Department of Rural Engineering, Eduardo Mondlane University, Maputo, Mozambique, s24540146@tuks.co.za
[2]Department of Chemical Engineering, Food Technology and Biotechnology Section, Eduardo Mondlane University, Maputo, Mozambique
[3]Department of Food Science, University of Pretoria, Pretoria 0002, South Africa

INTRODUCTION

Cowpeas (*Vigna unguiculata* L. Walp) is a grain legume widely consumed in developing countries. Because cowpeas are an important source of proteins, calories and vitamins, they have the potential to alleviate protein-energy malnutrition (Ajibola *et al.*, 2003). However, the consumption of cowpeas is impaired by the hard-to-cook (HTC) defect, which develops when cowpeas are stored at high temperature and humidity conditions. HTC cowpeas require extended time to cook and have decreased protein, starch, vitamin availability and poor textural quality. The extended cooking time and poor textural quality reduce consumer preference and acceptability (Phillips *et al.,* 2003). Soaking cowpeas in water or in a solution containing Na^+ cations have been used by other researchers to reduce the cooking time of cowpeas (Sefa-Dedeh *et al.*, 1978) and beans (Jackson & Varriano-Marston, 1981), while micronization has been used to reduce the cooking time of normal cowpeas (Mwangwela *et al.*, 2006). Hence tempering in water or in a solution containing monovalent (Na^+) cations in combination with micronization, could have the potential to help in alleviating the HTC phenomenon in legume seeds, especially cowpeas. This study aimed to evaluate the potential of micronization and tempering in solution containing monovalent (Na^+) cations prior to micronization in reducing cooking time of HTC induced cowpeas.

MATERIALS AND METHODS

Inducement of HTC defect

The HTC defect was induced by incubating *Mogwe-o-Kgotsheng* cowpea seeds at 42ºC and 67% RH in a 57 cm x 46 cm x 33 cm container, over a saturated solution of KCl at the bottom of the container, for 21 days according to procedure of Shomer *et al.* (1990).

Cooking time

The cooking time was recorded as the time required for 80% of the 90 g pins (20) of the Mattson Bean Cooker to fall though the cooked seeds (Mwangwela *et al.*, 2006).

Texture measurements during cooking

Texture was measured according to the modified procedure of Mwangwela *et al.* (2006).

Soluble pectin
The soluble pectin was measured according to the modified procedure of Arntfield *et al.* (1997).

RESULTS AND DISSCUSION
The HTC defect was induced by storing cowpeas at adverse conditions (42ºC and 67% RH) for 3 weeks. The HTC defect was confirmed by the significant increase in cooking time (Table 1) and cooked texture (Table 2) compared with normal cowpeas. The most widely accepted theory to explain the HTC defect in legume seeds is based on pectin insolubilization via binding with divalent cations (e.g. Ca^{2+}, Mg^{2+}) resulting from phytate breakdown by phytase at relatively high temperatures and high relative humidities (Hentges *et al.*, 1991). Pectin insolubilization was confirmed by the significant ($P \leq 0.05$) decrease in the amount of soluble pectin in HTC cowpeas compared with normal cowpeas (Table 3). This study attempted to link the improvement of pectin solubility in the middle lamella of cowpeas with the decrease in the hardness of cooked seeds and the cooking time.

Table 1. The effect of tempering alone and in combination with micronization on the cooking time of normal and HTC cowpeas

Treatments	**Cooking time (min)**	
	Normal	**HTC**
Control	89 ± 3.2 e	270* g
Tempered in H_2O alone	44 ± 4.8 c	270* g
Tempered in monovalent (Na^+) cations alone	43 ± 5.3 bc	150 ± 9.6 f
Micronized after tempering in H_2O	37 ± 3.4 ab	148 ± 9.2f
Micronized after tempering in monovalent (Na^+) cations solution	30 ± 5.0 a	59 ± 4.0 d

Means followed by the same letter in cell are not significantly different at level $P>0.05$
* The cowpeas remained uncooked after 4.5 h of cooking

Table 2. The effect of micronization after tempering cowpeas in a solution containing monovalent (Na^+) cations on the texture of cooked seeds of normal and HTC cowpeas

Treatments	**Texture of 180 min cooked cowpeas (N.mm)[1]**		**Overall Micronization Effect[2]**
	Normal	**HTC**	
Control	4.5 ± 0.9 b	5.5 ± 1.5 d	5.0 ± 0.6 c
Micronized after tempering in H_2O	4.0 ± 1.1 a	4.9 ± 1.7 c	4.4 ± 0.6 b
Micronized after tempering in monovalent (Na^+) cations	3.8 ± 1.2 a	4.5 ± 1.0 b	4.1 ± 0.4 a
Overall HTC effect[3]	4.1 ± 0.4 a	4.96 ± 0.5 b	

[1]Means followed by the same letter in cell are not significantly different at level $P>0.05$
[2]Means followed by the same letter in the column are not significantly different at level $P>0.05$
[3]Means followed by the same letter in a row are not significantly different at level $P>0.05$

Tempering in water or in a solution containing monovalent (Na^+) cations had the same effect in terms of reducing the cooking time of normal cowpeas (Table 1). For HTC cowpeas, tempering in a solution containing monovalent (Na^+) cations reduced the cooking time of HTC cowpeas significantly as compared with tempering in water alone (Table 1).

Table 3. The effect tempering cowpeas in a solution containing monovalent (Na^+) cations in combination with micronization on the soluble pectin of normal and HTC cowpeas

Treatments	Soluble pectin ($mg.g^{-1}$) (dry basis)	
	Normal	**HTC**
Control	5.6 ± 0.2 b	3.7 ± 0.3 a
Micronized after tempering in H_2O	12.4 ± 0.6 c	12.3 ± 0.3 c
Micronized after tempering in monovalent (Na^+) cations solution	17.2 ± 0.7 e	15.0 ± 0.7 d
	Soluble pectin ($mg.g^{-1}$) (as is)	
Control	4.9 ± 0.4 b	3.2 ± 0.5 a
Tempered in H_2O alone	7.4 ± 0.5 c	5.3 ± 0.4 b
Tempered in monovalent (Na^+) cations alone	8.1 ± 0.7 d	6.9 ± 0.5 c
Micronized after tempering in H_2O	10.8 ± 0.5 f	9.9 ± 0.5 e
Micronized after tempering in monovalent (Na^+) cations solution	14.2 ± 0.9 h	11.8 ± 0.9 g

Means followed by the same letter in cell are not significantly different at level *P>0.05*
a Moisture content for these samples was not determined

Tempering cowpeas in water or in a solution containing monovalent (Na^+) cations in combination with micronization did not differ significantly in terms of reducing the cooking time of normal cowpeas (Table 1). For HTC cowpeas, only the presence of monovalent (Na^+) cations in the tempering solution showed significant reduction in the cooking time (Table 1). Tempering cowpeas in water or in a solution containing monovalent (Na^+) cations in combination with micronization did not differ significantly in terms of reducing the cooking time of normal cowpeas (Table 1). However, for HTC cowpeas tempering in a solution containing monovalent (Na^+) cations combined with micronization was the most effective technique to reduce the cooking time (Table 1).

The overall reduction in the hardness of cooked cowpea seeds when tempered in water or in a solution containing monovalent (Na^+) cations followed by micronization could be associated with the significant increase in the amount of soluble pectin (Table 2).

The solubilization of pectins during tempering was probably due to the solubilization effect of water (Clemente *et al.,* 1998) and a possible conversion of insoluble to soluble pectins in the middle lamella by the action of monovalent (Na^+) cations (Vidal-Valverde *et al.*, 1992). Micronization improved pectin solubility by breaking pectin molecules into lower and more soluble fractions, probably via the β-elimination reaction (Liu *et al.*, 1993). Although all treatments improved pectin solubility of HTC cowpeas more extensively than that of normal cowpeas, this was not the case for reduction in cooking time. This suggests that factors other than pectin solubility influence the cooking time of HTC cowpeas.

CONCLUSIONS

For normal cowpeas, pre-conditioning in water without micronization is effective in reducing the cooking time from 89 to 44 min. The reduction in the cooking time of normal cowpeas as a result of tempering in water is attributed in part to partial solubilization of pectins in the middle lamella.

Micronization of HTC cowpeas pre-conditioned in a solution with monovalent (Na^+) cations reduces the cooking time of HTC cowpeas (*Mogwe-o-Kgotsheng*) by approximately 80%. Pre-conditioning in monovalent (Na^+) cations improves the solubility of pectins due to the solubilization effect of water and a conversion of insoluble to soluble pectins by monovalent cations. Micronization improves pectin solubility further by breaking pectin molecules into lower and more soluble fractions, probably via the β-elimination reaction. However, although the combination of these two treatments had more extensive solubilization of pectins as compared with normal cowpeas, this is not the case with the reduction in cooking time. Factors such as protein denaturation and insolubilization, which develops during storage at adverse conditions due to low pH (Liu *et al.,* 1992) and starch behaviour during adverse storage, should be considered in future studies.

REFERENCES

Ajibola, O.O., Aviara, N.A. & Ajetumobi., 2003. J. Food Eng. 58: 317-324

Arntfield, S.D., Scanlon, M.G., Malcolmson, L.J., Watts, B., Ryland, D. & Savoie, V., 1997. Food Res. Int 30: 371-380.

Clemente, A., Sánchez-Vioque, R., Vioque, J., Bautista, J. & Millán, F., 1998. J. Sci. Food Agric 78: 169-174.

Hentges, D.L., Weaver, C.M., & Nielsen, S.S., 1991. J. Food Science 56: 436-442.

Jackson, G.M. & Varriano-Marston, E., 1981. J. Food Sci. 46: 799-803

Léon, L.F., Elías, L.G. & Bressani, R., 1992. Food Res. Int. 25: 131-136

Liu, K., Phillips, R.D. & Mcwatters, K.H., 1993. J. Agric.Food Chem 41: 1476-1480.

Liu, K., Phillips, R.D., Hung, Y.C., Shewfelt, R.L. & McWatters, K.H., 1992. J. Food Sci. 57: 1155-1160

Mwangwela, A.M., Waniska, R.D. & Minnaar, A., 2006. J. Sci. Food Agric. 86: 35-45.

Nozzolillo, C. & Bezada, M.D. 1984. Can. J. Plant Sci. 64: 815-824.

Phillips, R.D., McWatters, K.H., Chinnan, M.S., Hung, Y.C., Beuchat, L.R., Sefa-Dedeh, S., Sakyi-Dawson, E., Ngoddy, P., Nnanyelugo, D., Enwere, J., Komoy, N.S., Liu, K., Mensa-Wilmot, Y., Nnanna, I.A., Okeke. C., Prinyawiwatkul, W. & Saalia, F.K., 2003. Field Crops Res. 82: 193-213

Sefa-Dedeh, S., Stanley, D.W. & Voisey, P.W., 1978. J. Food Sci. 43: 1832-1838

Shomer, I., Paster, N., Lindner, P. & Vasiliver, R., 1990. Food Struct. 9: 139-149.

Vidal-Valverde, C., Frías, J. & Esteban, R. 1992. J. Food Sci. 57: 1161-1163.