Food Chemistry **15** (1984) 261–268

Lysine in Cassava Based Diets: I. A Note on the Effect of Heat on Digestibility and Available Lysine

S. R. A. Adewusi & O. L. Oke

Chemistry Department, University of Ife, Ile-Ife, Nigeria

(Received: 22 June, 1984)

ABSTRACT

Heating Conophor *seeds and* Amaranthus *leaf protein concentrate (LPC) for 24 h at 121 °C reduced the digestibility of their crude protein contents.*

Loss in available lysine was moderate in LPC alone and cassava–LPC mixtures heated for 24 h at 121 °C (≤45 % loss) but high in Conophor *seeds and glucose–LPC mixtures (72 and 80 % loss respectively).*

INTRODUCTION

The use of leaf protein concentrate (LPC) as a protein supplement and cassava as an energy source in the developing countries has been advocated (Oke, 1975). However, Knipfel *et al.* (1975) pointed out that heating protein alone or protein–carbohydrate mixtures reduced feed intake, weight gain and digestibility of crude protein in rats. It is well known that during processing of feedstuffs and other foods a lot of heat is either used or generated. When LPC and cassava are processed into feeds and stored in the hot and humid climates of the tropics damage due to the Maillard reaction is possible.

The purpose of this study is to investigate heat damage to protein–carbohydrate mixtures during processing. In this paper, we report the effect of heat on *Conophor* seeds (model for a naturally occurring protein–carbohydrate–oil mixture (Oke & Fafunson, 1975)), LPC–cassava and LPC–glucose mixtures (models for feed protein–carbohydrate mixtures), and LPC alone (model for protein in the absence

Food Chemistry 0308-8146/84/$03·00

of carbohydrate). The heat effect was assessed by determining *in vitro* digestibility and available lysine. Several methods were used and results compared.

MATERIALS AND METHODS

LPC was obtained from *Amaranthus* spp. using IBP pulper and press. *Conophor tetracarpidium* seeds were purchased locally, dried and milled to a fine powder.

Authentic samples for available lysine assay were obtained from Dr K. J. Carpenter (Cambridge University, UK). Cassava flour was prepared in the Teaching and Research Farm, University of Ife. *In vitro* digestibility was determined by the pepsin–pancreatin procedure (Saunders *et al.*, 1973) and papain digestion (Buchanan & Byers, 1969). Nitrogen in the residue was analysed by the micro-Kjeldahl method.

Sugar content of cassava flour was determined by the procedure outlined by Ketiku & Oyenuga (1972). Cassava flour and LPC were mixed together in the ratios 1:1, 1:2 and 2:1 by weight. Glucose and LPC were also mixed in the same ratios. All samples were spread thinly on aluminium foil and heated at 121 °C.

Available lysine was determined by the FDNB method of Carpenter (1960) as modified by Booth (1971) and also by the TNBS method of Kakade & Liener (1969).

RESULTS AND DISCUSSION

The LPC used in this experiment contained 67 % crude protein (CP), 6·7 and 5·0 g of available lysine by FDNB and TNBS methods, respectively, per 16 g N. *Conophor* seeds contained 25 % CP, 7·1 and 5·6 g of available lysine by FDNB and TNBS methods, respectively, per 16 g N.

To demonstrate the reliability of results obtained in our laboratory, we analysed samples obtained from Dr Carpenter's laboratory and compared both sets of results as shown in Table 1. These results indicate that the TNBS assay consistently gave lower values than the FDNB assay.

The sugar content of cassava flour presented in Table 2 shows that values for total sugar content and reducing sugars which may react with lysine in Maillard reactions are small but vary from sample to sample.

TABLE 1
Available Lysine Contents of Some Protein Samples as Determined by FDNB and TNBS Methods and Compared to Literature Values

Sample	*% Crude protein*	*FDNB*	*TNBS*	*Literature value (FDNB)*
		(g available lysine per 16 gN)		
Amaranthus LPC	67·0	6·7	5·0	ND[a]
Conophor seeds	25·0	7·1	5·6	ND
BPA X 841[b]	89·0	12·26	9·82	12·20[b]
Chicken muscle—X902[b]	91·0	8·60	6·98	8·94[b]
X902 heated 8 h at 121 °C[b]	87·0	8·10	7·20	7·26[b]
Groundnut meal[b]	44·2	3·00	2·58	3·19[b]
Groundnut meal heated 4 h at 121 °C	41·6	1·80	1·44	1·61[b]
Casein	84·0	7·80	5·54	8·17[c]

[a] ND, not determined.
[b] Samples and FDNB available lysine values were obtained from Dr Carpenter's laboratory, while at University of Cambridge, UK.
[c] Value obtained from Friedman & Finley (1975).

Generally glucose was present in the highest concentration (0·18–1·30 g/100 g) and maltose the lowest.

The effect of heat on the digestibility of crude protein of *Conophor* seeds and *Amaranthus* LPC shown in Figs 1 and 2 indicates that digestibility of *Conophor* seed protein was reduced by almost 60 % when heated for 24 h at 121 °C. The papain digestion method indicated no

TABLE 2
The Composition and Concentration of Sugars in Cassava Flour Preparations

Constituents	*Range (g/100 g dry sample)*[a]
Total sugar	0·72–4·50
Reducing sugar	0·30–2·76
Glucose	0·18–1·30
Fructose	0·10–0·99
Maltose	0–0·49[b]
Sucrose (by difference)	0·42–1·74

[a] Values show range of three determinations from cassava flour prepared at different times of the year.
[b] Maltose was not detected in one preparation.

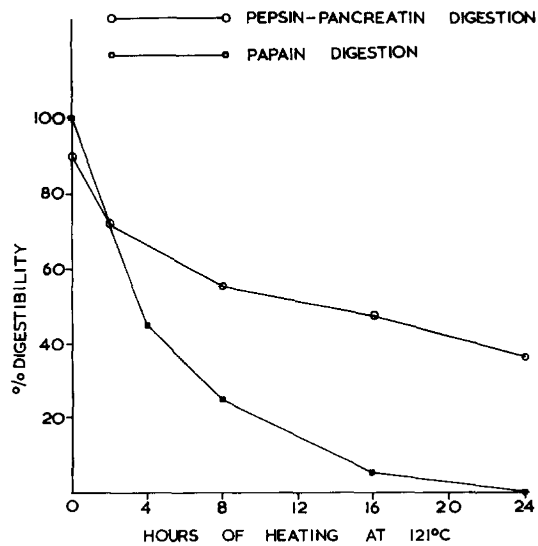

Fig. 1. *In vitro* digestibility of heated *Conophor* seeds using pepsin–pancreatin and papain methods.

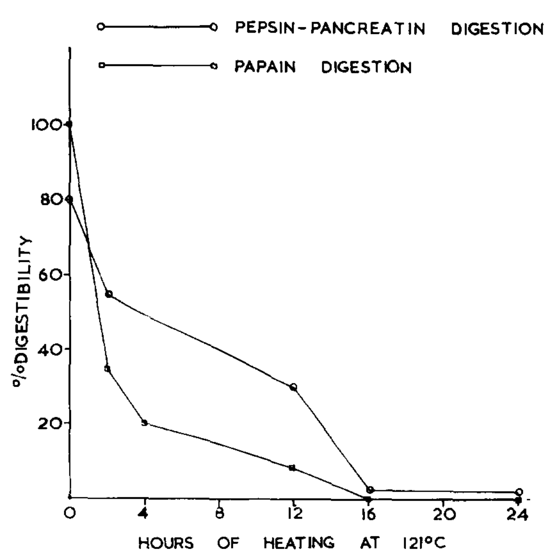

Fig. 2. *In vitro* digestibility of heated *Amaranthus* leaf protein concentrate using pepsin–pancreatin and papain methods.

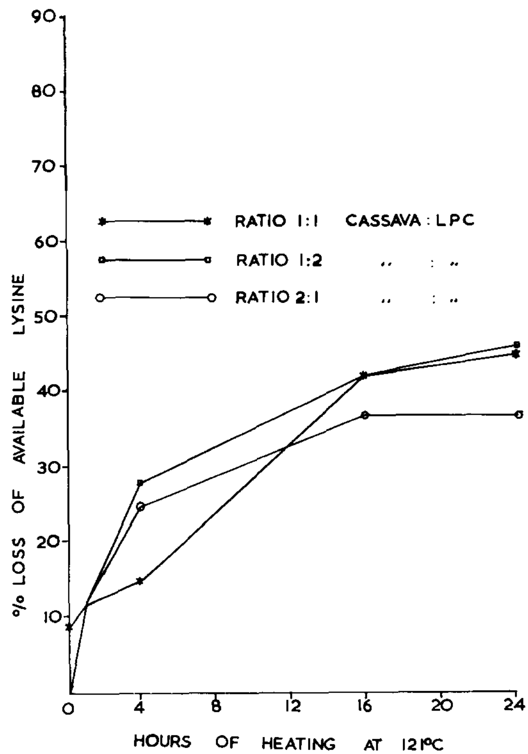

Fig. 3. The effect of heat on available lysine loss in cassava–leaf protein concentrate mixtures, using the FDNB method.

measurable digestibility after 24 h. Digestibility of *Amaranthus* LPC also decreased to about 0% by both papain and pepsin–pancreatin methods after 24-h heating at 121 °C.

The effect of heat on the available lysine content of cassava–LPC and glucose–LPC mixtures, LPC alone and *Conophor* seeds, shown in Figs 3 to 6, indicated the following:

(1) Cassava–LPC mixtures of ratio 1:2 seemed to be most affected, losing 45% of the available lysine when heated for 24 h at 121 °C.
(2) About 80% of the available lysine was lost when a glucose–LPC mixture (ratio 1:2) was heated for 24 h at 121 °C. This showed that the deleterious effect of the Maillard reaction increased because of the presence of reducing sugars (Knipfel *et al.*, 1975).
(3) When LPC was heated alone, about 45% of the available lysine was lost in 24 h.

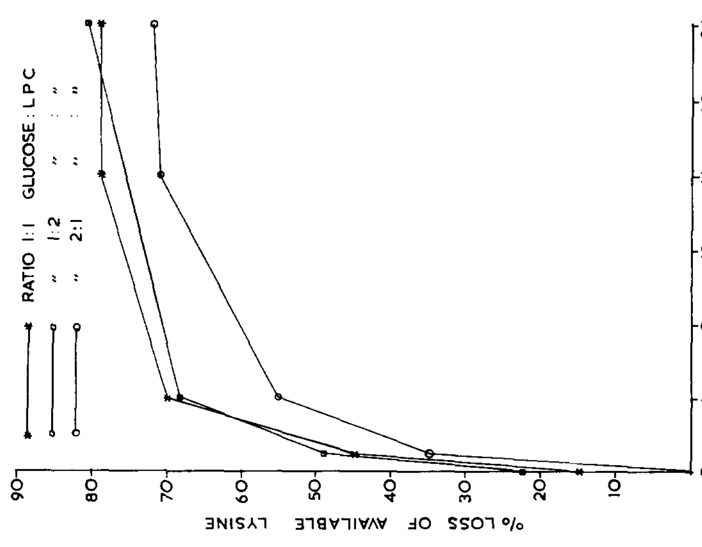

Fig. 4. The effect of heat on available lysine loss in glucose-leaf protein concentrate mixtures, using the FDNB method.

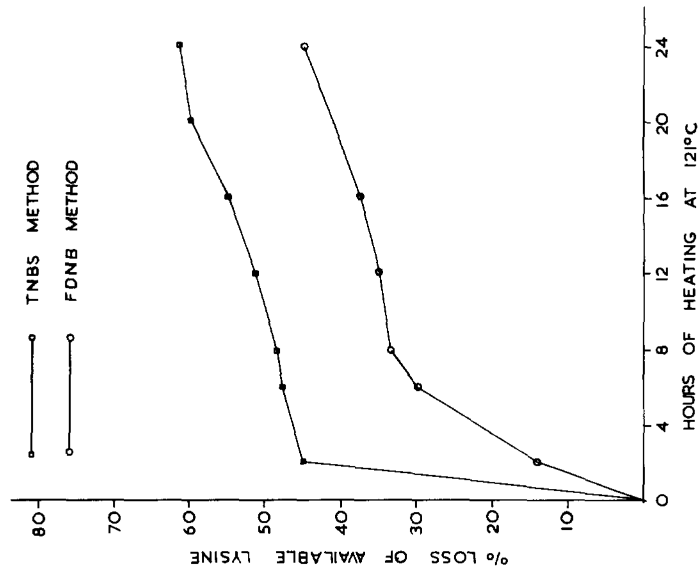

Fig. 5. The effect of heat on available lysine loss in *Amaranthus* leaf protein concentrate (LPC) alone using the FDNB and TNBS methods.

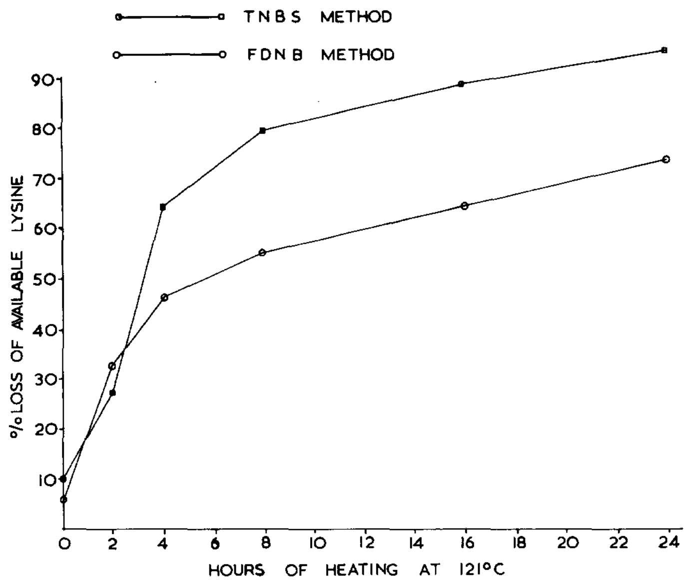

Fig. 6. The effect of heat on the available lysine loss of *Conophor* seeds using the FDNB and TNBS methods.

(4) The effect of heat on available lysine content of *Conophor* seeds was similar to that obtained for glucose–LPC mixtures (72% available lysine was lost in 24 h).

(5) In experiments where both FDNB and TNBS methods were used, the TNBS method appeared to be more sensitive but this impression might be due to the low available lysine values often obtained by this method.

In conclusion, it has been shown that the effect of heat on digestibility and available lysine increases with time and the presence of reducing sugars. Because cassava has a low level of reducing sugars, it appears that Maillard reactions will be insignificant in cassava based diets. In addition, the FDNB assay is recommended for quantitative estimation of available lysine while the less cumbersome TNBS (available lysine) and papain (*in vitro* digestibility) methods should be used in screening feeds and feedstuffs for heat damage.

ACKNOWLEDGEMENT

We are grateful to Dr O. A. Afolabi for a critical review of the manuscript.

REFERENCES

Booth, V. H. (1971). Problems in the determination of FDNB-available lysine. *J. Sci. Fd Agric.*, **22**, 658.

Buchanan, R. A. & Byers, M. (1969). Interference by cyanide with the measurement of papain hydrolysis. *J. Sci. Fd Agric.*, **20**, 364.

Carpenter, K. J. (1960). The estimation of the available lysine in animal protein foods. *Biochem. J.*, **77**, 604.

Friedman, M. & Finley, J. W. (1975). Vinyl compounds as reagents for available lysine in proteins. In: *Protein-nutritional quality in foods and feeds*, Part 1 (Friedman, M. (Ed.)). Marcel Dekker Inc., New York, p. 503.

Kakade, M. L. & Liener, I. E. (1969). Determination of available lysine in proteins. *Analyt. Biochem.*, **27**, 273.

Ketiku, A. O. & Oyenuga, V. A. (1972). Changes in the carbohydrate constituents of cassava root tuber during growth. *J. Sci. Fd Agric.*, **23**, 1451.

Knipfel, J. B., Botting, H. G. & McLaughlan, J. M. (1975). Nutritional quality of several proteins as affected by heating in the presence of carbohydrates. In: *Protein-nutritional quality of foods and feeds*, Part 2 (Friedman, M. (Ed.)). Marcel Dekker Inc., New York, p. 375.

Oke, O. L. (1975). A case for vegetable proteins in developing countries. *Wld Rev. Nutr. Diet.*, **23**, 259.

Oke, O. L. & Fafunson, M. A. (1975). Lesser known oil-seeds—the nutritional value of *Conophor* seeds *in vitro* and in rats. *Nutr. Rep. Intl*, **12**, 41.

Saunders, R. M., Connor, M. A., Booth, A. N., Bickoff, E. M. & Kohler, G. O. (1973). Measurement of digestibility of alfalfa protein concentrates by *in vitro* and *in vivo* methods. *J. Nutr.*, **103**, 530.