Studies on *koko*, a Ghanaian fermented maize porridge

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SUMMARY

Koko (maize porridge), also known in certain areas of Ghana as *akasa,* was prepared in the laboratory from Ghanaian maize. The effect of grinding and sieving on the protein content was determined. Protein losses were highest with the coarsest grinding. Starters were used in the fermentation, and were found to increase the rate of acid production. Preservation of *koko* was carried out by roller-drying, spray-drying, freeze-drying and canning. The volatile constituents of the flavours were lost during roller-drying and spray-drying. Freeze-drying was successful but would be too expensive for commercial production of *koko.* It could, however, be used in the laboratory for research work. Canning of *koko* was also successful, though more work on its micro-biological aspect is needed to give conclusive results. Thiamine and riboflavin contents were determined at various stages in the preparation of *koko.* Slight losses of these two vitamins occurred during steeping of maize. Fermentation increased thiamine considerably although only very slight increases were recorded for riboflavin.

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RÉSUMÉ

ANDAH, ABIGAIL & MULLER, H. G.: *Etudes sur le koko, une bouillie ghanéenne de maïs fermenté.* Le koko (bouillie de maïs) connu aussi dans certaines régions du Ghana sous le nom de akasa, a été préparé au laboratoire, à partir de maïs ghanéen. Les effets de la mouture et du blutage sur la teneur en protéines ont été déterminés. Les pertes en protéines ont été les plus fortes avec les moutures les plus grossières. Des levures ont été utilisées pour la fermentation; elles ont augmenté l'acidification. La conservation du koko a été essayée, par séchage sur rouleaux, séchage par pulvérisation, séchage par réfrigération et mise en boîtes. Les constituants volatils et le gôut du produit sont disparus au cours du séchage sur rouleaux et du séchage par pulvérisation. Les séchage par réfrigération a été un succès, mais il serait trop couteux pour une production commerciale du koko; il pourrait cependant être utilisé au laboratoire pour les travaux de recherches. La conservation en boîtes du koko semble aussi avoir été un succès, bien que davantage de travaux sur son aspect microbiologique soient nécessaires avant de conclure. La teneur en thiamine et en riboflavine a été déterminée à différents stades de la préparation du koko. De légères pertes de ces deux vitamines se sont produites lors du mouillage du maïs. La fermentation a augmenté considérablement la teneur en thiamine quoique seules de très légères augmentations de la teneur en riboflavine aient été observées.

Introduction

In a recent survey, the indigenous fermented cereal products of West Africa were classified into beverages, porridges, dumplings and baked and fried products (Muller, 1970). The most important porridges are the Nigerian *ogi* (Banigo & Muller, 1972) and the Ghanaian *koko* (Whitby, 1968). Studies on the latter form the subject of this paper.

A flow diagram of the traditional method of preparation of *koko* is given in Fig. 1. The maize is steeped in water over-night to soften. It is then strained and ground using traditionally a saddle stone or a pestle and mortar, or where available, a power driven mill. The steeping water is discarded. The meal is mixed into a dough with water and allowed to ferment at room temperature in a covered container. The sourness of the dough increases with fermentation time.

After fermentation, the dough is dispersed in water and filtered through a muslin cloth. The overtails are discarded. The suspension is boiled

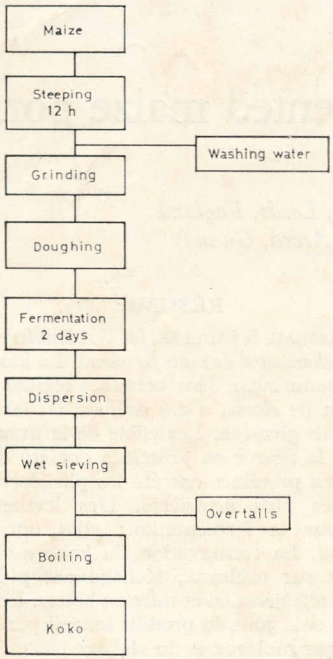

Fig. 1. Flow diagram of *koko* preparation.

under stirring until cooked. A white porridge is obtained which is referred to as *koko* in the Haussa language, or as *akasa* in Ga and Fanti, or *akatsa* in Ewe. If the wet sieving is omitted, a porridge of a coarser texture containing the whole grain is obtained which is referred to as *kpokponsu* or *pomponsu*. *Koko* is used as a breakfast food for adults and as a weaning food for infants at about 3 months. In Northern Ghana, sorghum may be used instead of maize.

Materials and methods

White flint maize of Ghanaian origin was used. The analysis was as follows: Moisture 13·2%, crude protein 9·6%, fat 4·3%, crude fibre 1·7%, ash 1·49% and carbohydrates by difference were 83%.

The grinding of the steeped maize presented initial difficulties but eventually an electric Hobart coffee mill Type E.2120 with glass hopper and receiving can was found suitable.

For the roller drying experiments, a Kestner Patent Laboratory Film Drier was used. 100 g of *koko* dough was mixed into a slurry with 250 cm^3 of water. This was heated for 10 min in a water bath at 70 °C. The resulting paste was applied to the roller.

Spray drying took place in a Kestner (Laboratory Size) spray drier using a spinning disc or atomizer. 150 g of dough was dispersed in 620 cm^3 of water and heated as described above, before spray drying.

For the freeze drying experiments, a suitable 'Quickfit' laboratory apparatus and Edwards High Vacuum Pump were assembled. A mixture of solid carbon dioxide and acetone was used as refrigerant.

The canning experiments were conducted using a rotary sterilizer (Fraser & Son Ltd., London). Water soluble acids, *p*H, thiamine and riboflavin were determined using the A.A.C.C. (1962) methods.

The thiamine content was determined by the Thiochrome method (A.A.C.C., 1962). All samples except the washing water and the overtails were ground to pass 20 mesh. They were then acidified and digested with Taka diastase to liberate bound thiamine. The thiamine solutions were then subject to column chromatography using activated Decalso as adsorbent. The washing water was acidified and applied without incubation. Technical difficulties prevented the re-grinding of the wet overtails. The efficiency of the adsorption column was 95%, which appeared to be adequate. A Hilger & Watts Flourimeter Type H960 was used for the determination and each performed in triplicate. The mean result was reported as μg/g on total solids.

For the determination of riboflavin, the fluorimetric method was used (A.A.C.C., 1962). In this method, bound riboflavin is released by heating the sample in acid in boiling water. The *p*H of the mixture was adjusted to 4·5 with 2·5 *M* sodium acetate solution. The mixture was filtered to remove solid particles. Impurities in the filtrate were separated by oxidizing with potassium permanganate solution. Hydrogen peroxide was then used to decolourize the purified riboflavin solution, the flourescence of which was measured before and after reduction with sodium hydrosulphite. The flourescence of the reduced riboflavin corresponded to the blank reading.

Results and discussion

The laboratory preparation of koko

The laboratory process was based on the traditional method but an attempt was made to standardize the various stages as closely as possible.

Steeping. As a standard method, 400 g of maize were steeped for 16 h in a 2 dm^3 flat bottom flask with 600 cm^3 of tap water. Throughout, the seeds were kept at 25 °C.

Grinding and sieving. Both the degree of grinding and the mesh used in wet sieving vary considerably in the traditional process. Both affect technical efficiency and commercial consideration and, as in European milling practice, influence the nutritional properties of the final product.

In these experiments the first criterion was consumer acceptance. A coarse and gritty texture in *koko* is undesirable and the coarsest acceptable sieve had a mesh size of 0·88 mm. A larger aperture would give a coarser product. A fine one would increase the amount of overtails unduly.

Table 1 gives the sieving analysis of ground maize using the five available settings on the Hobart grinder.

TABLE 1

Sieving Analysis of Maize Ground at Different Mill Settings (%)

Aperture (mm)	*Mill setting*				
	1	*2*	*3*	*4*	*5*
2·05	0	0·6	2·2	2·5	5·3
0·88	2·9	14·6	30·8	47·8	55·4
0·58	22·3	25·5	25·5	18·8	17·6
0·43	45·6	32·5	25·9	18·6	13·1
0·24	4·2	9·8	4·1	2·3	1·6
0·24	25·0	17·0	11·5	10·0	7·0

Table 2 shows the crude protein content of the throughs of the 0·88 mm sieve with different mill setting. It is apparent that both the highest yield and the highest protein content is achieved with the finest mill setting (1) and this was used in all subsequent experiments. The importance of fine grinding of *koko* resulting in higher protein yields in commercial practice, particularly in view of the all too common occurrence of Kwashiorkor amongst small children in Ghana (Williams, 1933) is obvious.

TABLE 2

Crude Protein Content of Throughs of 0·88 mm Sieve with Different Mill Settings ($N \times 6{\cdot}25\%$)

Mill setting	*Crude protein % D.B.**
1	10·6
2	10·2
3	9·3
4	8·3
5	6·9

*D.B. = Dry basis

An analysis of the various fractions is given in Tables 3 and 4.

Koko *fermentation*. It is traditional practice in the preparation of *koko* to use vessels which have not been cleaned too scrupulously. The same applies to European bakery practice wherever spontaneous fermentation is used.

Fig. 2 shows the effect of starters on fermentation as expressed in the change of titrable acidity. Curve 1 refers to the control dough, curve 2 using 7% of fermented dough as a starter, curve 3 using 1·8% of freeze dried dough as a starter and curve 4 using 0·7% of *Lactobacillus acidophilus* as a starter.

It is apparent that all these greatly accelerate fermentation. The flavour of the final product was acceptable in all cases except the last (*Lactobacillus* Curve 4).

Preservation of Koko

Roller drying. Two roller drying experiments at 121 °C and 126 °C resulted in a dark product which on reconstitution had lost the typical *koko* flavour. This was assumed to be due to a loss of volatiles. In both instances incomplete hydration resulted in a 'lumpy' product. It appears that unless special precautions are taken, roller drying is not a suitable method for preparing an 'instant' product.

Spray drying. Several experiments were conducted, none of them entirely successful. At an inlet temperature of 175 °C and an outlet temperature of 90 °C the product had a dark colour, lost

TABLE 3

Proximate Composition of Various Fractions in Koko *Manufacture*

Sample	*Crude protein* $N \times 6{\cdot}25\%$ *D.B.**	*Ash* % *D.B.**	*Crude fat*	*Crude fibre*	*Carbohydrate by difference*
Original maize	10·5	1·45	4·3	1·7	82
Fermented maize dough	10·5	1·50	4·2	1·9	82
Sieve slurry (uncooked *koko*) ..	10·1	1·62	4·0	1·0	83
Overtails (20 mesh)	13·2	0·56	4·1	4·4	78

* D.B. = Dry basis.

TABLE 4

Total Protein and Total Solids of Various Fractions in Koko *Manufacture*

Sample	*Total solids* % *of D.B.**	*Crude protein* $N \times 6{\cdot}25\%$ *D.B.**
Maize	100	10·5
Steeping water	0·4	0·1
Steeped maize	99·0	10·4
Fermented maize dough ..	96·2	10·2
Overtails (20 mesh) ..	16·8	2·4
Sieved slurry (uncooked *koko*)	79·5	8·0

*D.B. = Dry basis

all flavour and did not reconstitute properly. At respective inlet and outlet temperatures of 180 °C and 80 °C the colour and rehydration were satisfactory but although the product tasted sour, the typical flavour had been lost.

Freeze drying. Freeze dried *koko* had a satisfactory colour and flavour and reconstituted perfectly. Unfortunately while freeze drying is well suited to laboratory practice, it is at present too expensive for commercial exploitation.

Canning. Some maize dough was wet sieved (40 g to 250 cm^3 water), and 5 g sucrose added to each lot of 40 g sieved dough. The *p*H of the mixture was 4·0. Size A1 cans were filled leaving a headspace of 2·3 cm. The cans were sealed, fitted with a Minican Temperature Recorder and sterilized for 20 min at 100 °C. The heat penetration curve (Fig. 3) shows a 'break' if plotted logarithmically. This is due to gelatinization and typical for materals exhibiting a sol-gel change on heating.

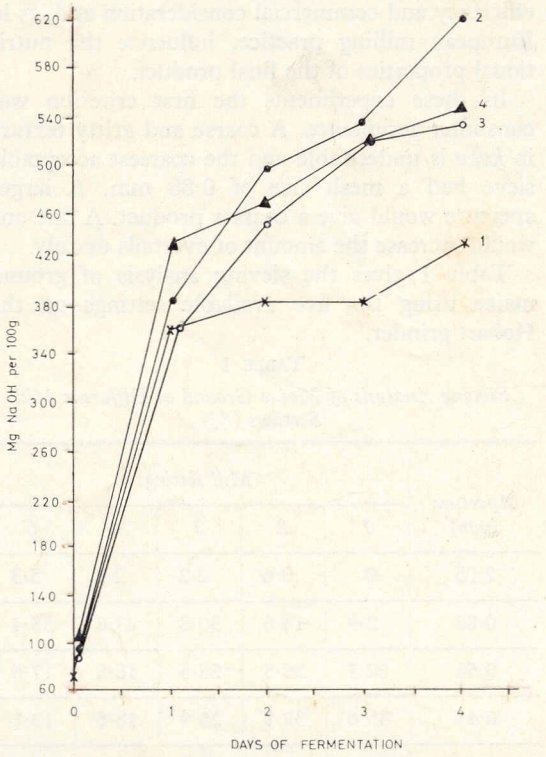

Fig. 2. The effect of starters on *koko* fermentation: 1. Control; 2. 7% fermented dough as starter; 3. 1·8% freeze dried dough as starter; 4. 0·7% *Lactobacillus acidophilus*.

Canning did not affect colour, texture or flavour, and the product was similar to the original *koko* porridge. Hence canning of *koko* may be feasible in commercial practice.

Thiamine and riboflavin content of koko

Table 5 shows the changes in thiamine content of maize during steeping. The decrease may be

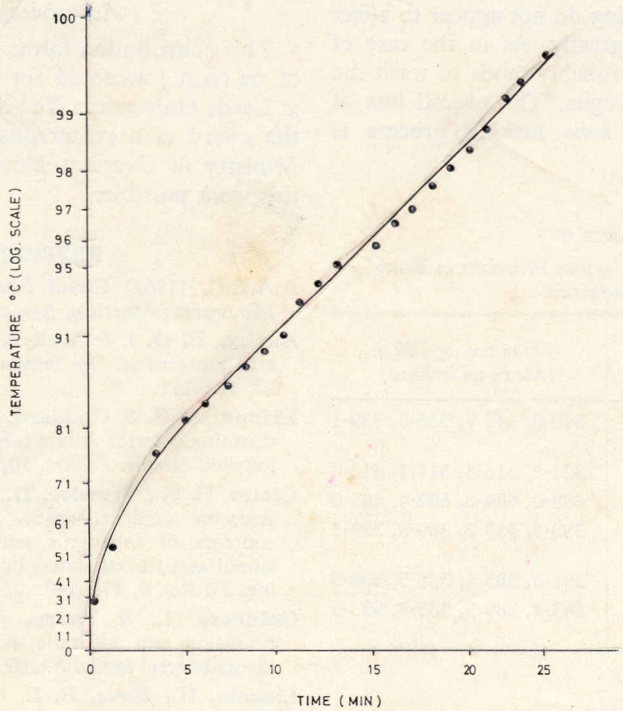

Fig. 3. Heat penetration curve of canned *koko*

TABLE 5

Change of Thiamine Content of Maize on Steeping

Steeping time (days)	*Thiamine μg/100 g (Mean underlined)*
0	340·0, 340·7, 336·6, 339·1
1	327·9, 328·3, 325·7, 327·3
2	330·5, 329·6, 328·1, 329·4
3	329·0, 334·2, 337·3, 333·5
4	335·9, 343·5, 339·7, 339·7

due to leaching, subsequent increase could be explained by microbial synthesis. The thiamine content at different stages of *koko* manufacture is given in Table 6. The value of thiamine in the overtails was too low to be measured with sufficient accuracy.

Although 18 h steeping reduces the thiamine content of maize, the loss is not serious. Subsequent fermentation seems to result in a considerable increase. This result appears to agree with the observation of Goldberg & Thorp (1946) who found an increase of about 30% during the fermentation of *leting*, a South African fermented maize product.

Changes in thiamine due to wet sieving and cooking are not great. Even the mild alkalinity of natural waters may cause destruction of thiamine on boiling of rice (Roy & Rao, 1963). On the other hand, brief cooking of breakfast cereals at *p*H 5·5 causes no destruction (Eklund & Goddard, 1945; Lincoln, Hove & Harrel, 1944; White, Nurray & Maveety, 1946). The *p*H of *koko* was 4·0 perhaps explaining the insignificant destruction.

Table 7 shows the riboflavin content of the same fraction as those listed in Table 6. Like thiamine, riboflavin is water soluble and apparently leached during steeping. There is little increase during fermentation. Either the fermentation micro-organisms do not produce riboflavin to a significant extent, or exposure to light could conceivably destroy it. Losses of 5–22% due to light have been observed by Gleim, Tressler & Fenton (1944) when vegetable was exposed to

light. Sieving and cooking do not appear to affect the riboflavin content greatly. As in the case of thiamine, wet sieving probably tends to wash the riboflavin into the throughs. The overall loss of riboflavin during the *koko* making process is significant.

TABLE 6

Thiamine Content of Various Fractions in Koko *Manufacture*

Sample	*Thiamine μg/100 g (Mean underlined)*
Maize	340·0, 340·7, 336·6, 339·1
Steeped maize (18h steeping)	321·5, 316·5, 316·1, 318·0
Steeping water	688·0, 684·6, 682·4, 685·0
Fermented maize dough ..	388·9, 389·2, 389·8, 389·3
Sieved slurry (uncooked *koko*) ..	391·6, 385·4, 388·5, 388·5
Cooked *koko*	383·4, 389·3, 385·8, 383·5

TABLE 7

Riboflavin Content of Various Fractions in Koko *Manufacture*

Sample	*Riboflavin μg/100 g (Mean underlined)*
Maize	146·8, 150·9, 151·2, 149·6
Steeped maize	106·0, 103·5, 102·4, 104·0
Steeping water	320·9, 318·6, 323·8, 321·1
Fermented maize dough ..	110·3, 104·4, 106·1, 108·6
Sieved slurry	91·0, 93·7, 93·1, 92·6
Cooked *koko*	90·3, 88·3, 89·9, 89·5
Canned *koko*	92·8, 89·2, 90·1, 90·7

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