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Some Chemical and Physical Characteristics of *Wari*, an Indian Fermented Food

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ABSTRACT

Wari *(plural: warian) is a hollow brittle cake of 2–30 cm^2 spread and 1–30 g in weight. It is produced on the Indian subcontinent and consists of pieces of legume dough, often fermented, which are sun-dried. The proximate analysis of 16 samples is given and the extent of any fermentation assessed by determination of* L- *and* D- *lactic acid. Drying causes case hardening resulting in a cavity or porous structure of the product. These and other physical characteristics of* warian *are evaluated.*

INTRODUCTION

Wari (plural: *warian*) is a hollow brittle cake of 2–30 cm^2 spread and 1–30 g in weight. These cakes are made from various legumes indigenous to India. From the dehulled legumes a dough is made which is usually fermented. This dough is then divided into small pats and sun-dried for storage. For use, *warian* are boiled together with rice or other vegetable stews.

Often, spices are incorporated into the dough and some typical ones are listed by Batra & Millner (1974). These authors list asafoetida, caraway, cardamom, cloves, fenugreek, ginger and red pepper. They also mention that salt is sometimes used. The object of their work was to isolate fungi from various eastern fermented products and in *warian* they found *Candida* sp. and *Saccharomyces cerevisiae*. The former was later identified as *C. krusei* (*Cast.*) *Berkhout* (Batra & Millner, 1976). Although bacteria were abundant in the fermenting dough, the specific microorganisms responsible for the fermentation were not identified.

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In 1986 Batra further reported on the microbiology of *wari* and similar fermented foods and pointed to the importance of acid-producing bacteria. Since no studies on the chemical and physical characteristics of *warian* appear to be available in the literature, the present work has been submitted.

MATERIALS AND METHODS

Figure 1 shows the flow diagram of the traditional processing of *warian* from black beans (*Vigna mungo* L.). The diagram is largely self-explanatory. If additives are used (e.g. salt, spices) these are added at the dough mixing stage. After fermentation, the small dough pieces are hand-moulded and sun-dried on palm or bamboo mats, cloth or polythene. Those products to which salt had been added are deep-fried, which renders them crisp and friable.

Figure 2 shows a few typical *warian* with their identification number. The sixteen samples of *warian* analysed were obtained from India or Pakistan, except for sample 8 which was obtained from a small ethnic supermarket in Leeds. It had been imported from Amritsar (India).

Black beans
↓
Water → Steeping
(room temp. 25–35°C over-night)
↓
Draining → Water
↓
Water → Dehulling → Water, hulls, germ and water solubles
↓
Mashing
↓
Spices, yogurt, water, salt → Dough mixing
↓
Fermentation
(25–35°C 14–22 h)
↓
Remixing
↓
Moulding
↓
Intermittent sun-drying
(3 to 10 days)
↓
Wari

Fig. 1. Traditional processing of *warian* from black beans.

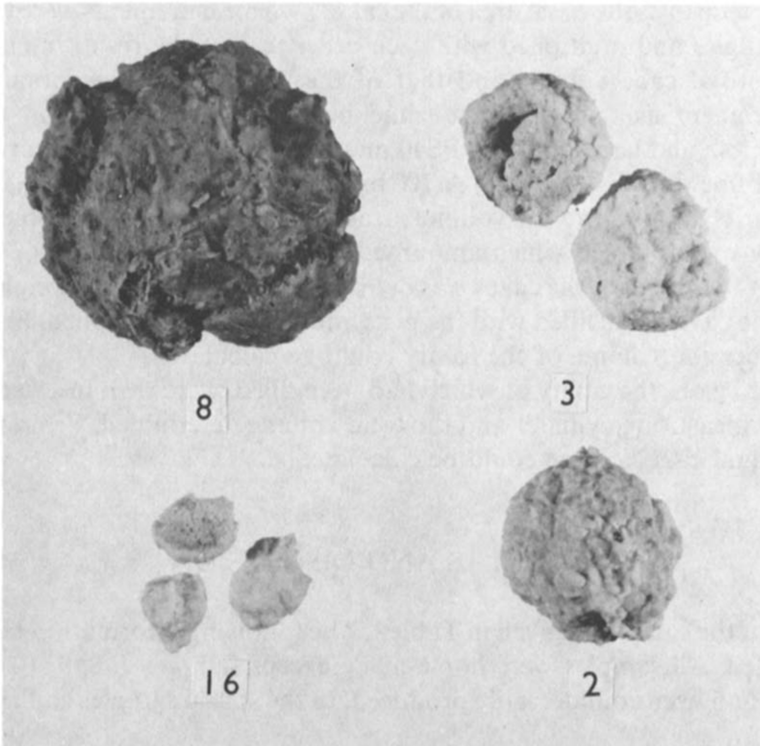

Fig. 2. Some of the traditional *wari* samples described in the text. (For identification see Table 1.)

For the proximate analysis, the methods of the American Association of Cereal Chemists were used (AACC, 1983). All samples were ground with a Hobart Coffee Mill and then reduced with pestle and mortar to pass 40 BS mesh. Moisture content was determined using method 44–40 (5 g of sample heated at 70°C and <60 mm pressure until constant weight was obtained). Protein was determined using the Kjeldahl method (46-12) with the aid of a copper catalyst and 4% boric acid solution ($N \times 6{\cdot}25$). Fat was determined using the Soxhlet method (30-26) (10 g sample, petroleum spirit b.p. 40–60°C). Method 32-10 was used for the crude fibre determination (2 g sample, filter cloth). Ash was determined by method 08-01 using 4 g with a furnace temperature of 600°C to constant weight.

In order to assess the extent of fermentation, the L- and D-lactic acid content was determined with the Boehringer (1986) test kit. Here the NADH produced from NAD in the presence of lactate dehydrogenase and glutamate-pyruvate transaminase is measured at 340 nm. The amount of NADH produced is stoichiometrically equivalent to the L- or D-lactic acid.

The 'spread' is the basal area of the cake. Two measurements were taken at right angles and multiplied with each other to give the result in cm^2.

The total cake volume and that of the cake cavity were obtained by displacement as follows. First some black beans were ground to pass BS30 mesh and be retained on BS40 mesh. (This particle size is equivalent to that of fine durum semolina.) A 100 ml volumetric cylinder was filled with these grits, tapped and the volume measured. From weight and volume the density was obtained which amounted to 0·769 g/ml.

Next the cavity of the cakes was determined. The cakes were weighed and then the cavity was filled with the grits and the cakes re-weighed. From the difference the volume of the cavity could be calculated.

Four cakes, the cavity of which had been filled, were then inserted into a 250 ml measuring cylinder and the total volume determined. From this the individual cake volume could be calculated.

RESULTS AND DISCUSSION

A list of the samples is given in Table 1. The following information had been provided. All samples were home-made except samples 3, 8, 9, 10 and 14 which had been commercially produced. In the spiced samples chilli pepper,

TABLE 1
Source, Legume Base and Ingredients of *Warian*

Sample No.	*Legume*	*Spice*	*Vegetable*	*Source*
1	Black bean	+	+	Punjab (India)
2	Black bean	+	–	Bihar (India)
3	Black bean	+	–	Bihar (India)
4	Black bean	–	+	Delhi (India)
5	Black bean	+	–	Delhi (India)
6	Black bean	+	+	Delhi (India)
7	Black bean	+	+	Delhi (India)
8	Black bean	+	–	Amritsar (India)
9	Black bean	+	–	Karachi (Pakistan)
10	Soybean	–	–	Delhi (India)
11	Mungbean	+	–	Bihar (India)
12	Mungbean	–	–	Delhi (India)
13	Mungbean	+	–	Delhi (India)
14	Mungbean	+	–	Karachi (Pakistan)
15	Chickpea	+	–	Bihar (India)
16	Black bean	–	–	Bihar (India)

Note: '+' indicates presence, '–' indicates absence of spice or vegetable component.

coriander, cumin, sesame and black pepper were occasionally observed on the surfaces of the cakes, although a careful microscopic examination was not made. Sample 16 was stated to contain salt and indeed tasted salty. Sample 10 was stated to be an extruded soybean product and is locally referred to as 'soybean *wari*'.

Proximate analysis

The proximate composition is given in Table 2. The relatively large variation in moisture content is probably a reflection of drying conditions. Three of the commercial samples tended to be high. Water activity and maximum moisture levels for safe storage of *warian* and similar traditional fermented products are unknown.

Protein and fat content are roughly in line with the composition of the original legumes (Muller, 1988). The soybean *wari* (No. 10) had a protein content of 60·6% and a fat content of 0·4%. This would indicate that it had been manufactured from extracted soybean meal. The crude fibre content of the samples is variable and reflects not only the extraction of the legume but also any admixtures of vegetable and spice. The addition of salt in sample 16 (see above) appears confirmed by the high ash content.

TABLE 2
Proximate Composition of *Warian* (% Dry Basis except Moisture)

Sample No.	*Moisture*	*Protein (N × 6·25)*	*Crude fat*	*Crude fibre*	*Ash*	*Carbohydrate (by difference)*
1	6·5	27·3	1·6	2·6	3·05	65·4
2	4·3	28·7	0·6	1·7	3·22	65·8
3	2·2	28·9	0·4	1·8	3·09	65·8
4	1·9	23·4	4·5	3·9	3·21	65·0
5	3·1	26·5	1·4	3·2	4·62	64·3
6	3·1	27·5	0·7	4·6	4·90	62·3
7	2·8	27·9	1·0	6·1	4·07	60·9
8	5·7	28·2	1·0	2·1	3·85	64·8
9	6·5	24·7	1·1	1·7	4·36	68·1
10	3·1	60·6	0·4	2·6	6·25	30·1
11	3·0	34·0	0·7	1·4	2·61	61·3
12	2·4	26·3	1·5	2·2	6·09	63·9
13	3·9	22·0	2·7	2·9	5·83	66·6
14	6·3	25·3	1·3	1·7	3·88	67·8
15	2·8	34·3	0·8	1·4	2·59	60·9
16	1·4	24·8	0·5	1·2	11·31	62·2

TABLE 3
Lactic Acid Content of *Warian* (% Dry Basis Mean Underlined)

Sample No.	L-*Lactic acid*	D-*Lactic acid*	*Total*
1	1·03, 1·13 1·08	1·21, 1·28 1·25	2·3
2	0·80, 0·64 0·72	0·92, 0·89 0·91	1·6
3	0·46, 0·82 0·64	0·47, 0·74 0·61	1·3
4	0·74, 0·72 0·73	0·01, 0·03 0·02	0·8
5	1·19, 1·21 1·20	0·01, 0·01 0·01	1·2
6	0·42, 0·42 0·42	0·49, 0·49 0·49	0·9
7	0·70, 0·82 0·76	0·17, 0·17 0·17	0·9
8	1·59, 1·89 1·74	1·04, 1·12 1·08	2·8
9	0·60, 0·72 0·66	0·47, 0·36 0·42	1·1
10	0·02, 0·02 0·02	0·00, 0·00 0·00	0·02
11	0·00, 0·02 0·01	0·09, 0·09 0·09	0·1
12	0·43, 0·40 0·42	0·31, 0·30 0·31	0·7
13	0·22, 0·16 0·19	0·12, 0·13 0·13	0·3
14	0·52, 0·61 0·57	0·01, 0·12 0·02	0·6
15	0·55, 0·63 0·59	0·41, 0·39 0·40	1·0
16	0·01, 0·00 0·01	0·07, 0·05 0·06	0·1

Lactic fermentation

Batra (1986) had pointed to the importance of acid-producing bacteria and indeed lactic acid-producing bacteria are very common in tropical food fermentations (Steinkraus, 1983; Hesseltine & Wang, 1986). For this reason and in order to assess the degree of fermentation both the L- and D-lactic acid contents of the samples were determined. The results are given in Table 3.

A detailed assessment of fermentation from these results is difficult. Bacterial action would proceed during the fermentation of the dough as well as during the earlier stages of sun-drying. Therefore larger pieces of *warian* would require a longer drying period associated with higher acid production. The bacteriostatic effect of salt and certain spices would reduce acid production while the addition of yoghurt starter culture would increase it.

Preliminary studies in this laboratory indicated that total lactic acid increased during 20 hours' fermentation at 30°C to 0·2%. During subsequent drying at 50°C over 24 h, to a moisture content of 4·4%, it increased to 0·3%. This would point to long periods of fermentation and/or drying of the samples discussed. Indeed, sun-drying periods of up to 10 days in India are not unknown.

During fermentation other organic acids are of course produced (e.g.

Banigo & Muller, 1972) which would affect the flavour of the product. However, a detailed analysis of these has not been made.

It would, however, appear that the extruded commercial sample (soybean *wari*, No. 10) has not been fermented or dried for any significant period. The soybean substrate may differ in chemical composition from traditional *wari* substrates, and may therefore support the growth of different microflora. This, coupled with the absence of spices in the soybean *wari*, might also account for the low lactic acid content of the sample.

Physical characteristics

During sun-drying, *warian* exhibit case hardening. This causes a contraction of the dough which results either in a spongy texture or more commonly in the formation of a cavity. Since the original dough weight varies, the cavity volume and the total volume (including cavity) have been divided by the cake weight. These results are shown in Table 4. It would appear that a desirable criterion of traditional *wari* quality is a large total volume ('lightness') which may or may not be associated with a large cavity. In spite of the fact that

TABLE 4
Physical Characteristics of *Warian*

Sample No.	*Weight (g)*	*Spread (cm^2)*	*Total volume (ml)*[a]	*Density (g/ml)*	*Cavity/ weight (ml/g)*	*Total volume*[a]/ *weight (ml/g)*
1	24·7	30·9	30·3	1·97	0·72	1·23
2	9·0	12·3	9·3	2·02	0·54	1·03
3	3·2	8·0	5·0	1·04	0·59	1·56
4	9·9	12·9	12·1	1·13	0·33	1·22
5	28·2	30·0	37·7	2·28	0·90	1·34
6	4·5	9·3	7·7	0·59	0·00	1·71
7	3·4	8·0	7·2	0·48	0·00	2·12
8	23·0	31·1	29·1	1·60	0·64	1·27
9	3·3	7·3	3·1	1·42	0·24	0·94
10	1·9	5·8	6·4	0·29	0·00	3·37
11	0·8	2·7	1·2	0·79	0·13	1·50
12	1·5	4·4	1·7	0·92	0·00	1·13
13	17·9	19·3	20·2	1·06	0·18	1·13
14	3·4	6·4	3·8	0·90	0·00	1·12
15	1·0	3·0	1·5	0·77	0·20	1·50
16	0·5	2·1	1·0	0·49	0·20	2·00

[a] Includes cavity.
Note: For all samples $n = 4$ except No. 5 for which $n = 1$.

there is no cavity in the industrially extruded soybean *wari* (No. 10), the product is porous, light and the density low. It is an acceptable product. There is a good correlation between weight and volume. The greater the weight, the larger the volume. However, for similar weights the density can vary greatly.

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REFERENCES

AACC (1983). *Approved Methods of the American Association of Cereal Chemists* (8th edn). St. Paul, Minnesota, USA.

Banigo, E. O. I. & Muller, H. G. (1972). Carboxylic acid patterns in *ogi* fermentation. *J. Sci. Fd Agric.*, **23**, 101–11.

Batra, L. R. (1986). Microbiology of some fermented cereals and grain legumes of India and vicinity. In *Indigenous Fermented Food of Non-Western Origin.* ed. C. W. Hesseltine & N. L. Wang, Cramer, Berlin, pp. 85–104.

Batra, L. R. & Millner, P. D. (1974). Some Asian foods and beverages and associated fungi. *Mycologia*, **66**, 942–50.

Batra, L. R. & Millner, P. D. (1976). Asian fermented foods and beverages. In *Developments in Industrial Microbiology*, Vol. 17, ed. L. A. Underkofler. American Institute of Biological Sciences, Washington D.C., pp. 117–28.

Boehringer Mannheim GmbH (1986). *Methods of Enzymatic Food Analysis*, Biochemica, Mannheim, FRG.

Hesseltine, C. W. & Wang, H. L. (Eds) (1986). *Indigenous Fermented Food of Non-Western Origin.* Cramer, Berlin.

Muller, H. G. (1988). *Introduction to Tropical Food Science.* Cambridge University Press, Cambridge, UK.

Steinkraus, K. H. (Ed.) (1983). *Handbook of Indigenous Fermented Foods.* Microbiology Series 9. Marcel Dekker, New York.