Milling experiments with parboiled paddy

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Summary

Detailed experiments with parboiled paddy, *i.e.* paddy soaked in hot water before boiling and then artificially dried and milled, had not yet been conducted in the Federal Republic of Nigeria. In this paper the results of a series of milling experiments with the rice varieties *BG 79, D 99, D 114, G.E.B. 24/37, KAV. 12* and *MAS 2401,* of which samples were soaked in water at 60° C, 70° C, 80° C and 90° C for times varying from 1/4 to 9 hours as a pre-boiling treatment are described.

The out-turn of the varieties after parboiling was higher than when milled raw. This was particularly noticeable in the variety *D 114.* The favourable effect on the percentage of broken grain in the final product was demonstrated by comparing the effect of the milling results of raw paddy with those of properly parboiled paddy.

The optimum soaking time was reduced at higher temperatures and varied according to the variety and the temperature of the soaking water. There are indications that *D 114* should be parboiled with care. Soaking in water at 90° C did not give a good final product and 80° C seemed to be a critical temperature for *D 114* and *KAV. 12.* Cracks which developed in the grains treated in this way suggest that they start on the inside of the kernel.

The lowest broken-grain percentage in the milled product was obtained with the varieties *G.E.B. 24/37, KAV. 12* and *MAS 2401.*

A longer soaking time resulted in the disappearance of the white centre in the kernel. A translucent grain did not always coincide with the optimum soaking time.

Parboiling at high soaking temperatures reduced the smell of the final product after milling and cooking.

1. Introduction

Parboiled paddy is paddy soaked in water for a certain time and boiled or steamed afterwards. When soaking in water at outdoor temperatures is applied, the soaking time may vary between one and three days, depending on local custom and preferences. Apart from the long soaking time involved, the prolonged soaking at temperatures usually prevalent in tropical climates act favourable upon the growth of yeasts and bacteria, causing fermentation during the process and an off-smell of the final product (DESIKACHAR *et al.*, 1955, 1957).

Almost all the paddy produced in the Federal Republic of Nigeria is parboiled before milling. The soaking time is 24 hours or longer when the temperature of the water is not raised and 18 hours or more when the paddy is soaked in heated water during the morning and allowed to cool until the following day (SLUYTERS, 1962, 1964a). The latter process, which is very similar to the Indian process "Do-Bhanpa", does not

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reduce the off-smell of the final product satisfactorily (SUBRAHMANYAN *et al.*, 1955). In order to reduce the soaking time and the off-smell, soaking at a high and constant temperature is now advised in the Indian literature. With this method, yeasts and bacteria growth as well as the soaking time are reduced.

KIK (1951) gives detailed results of the effect of milling on the thiamine content, appearance and breakage in the milled product of the variety *Zenith* at different water temperatures and soaking times before steaming. As most of the paddy in Nigeria is not steamed, but boiled or partially steamed and the influence of soaking in hot water on the percentage of broken grain has not yet been studied, the effect of milling after soaking in water at various temperatures followed by boiling, was studied in the laboratory of the Federal Rice Research Station. The optimum soaking times were determined for different varieties at various temperatures. The optimum soaking time is the time in which a translucent grain and the lowest percentage of broken grain after milling is obtained.

2. Materials and method

The following rice varieties (*Oryza sativa* L.) were used for the experiments, *viz. BG 79, D 99, D 114, G.E.B. 24/37, KAV. 12* and *MAS 2401*. Varieties *BG 79, D 99, D 114* and *MAS 2401* are recommended in different parts of Northern Nigeria; *G.E.B. 24/37* is a popular variety in certain parts of the Republic and *KAV. 12* is recommended in areas where enough water is available for a crop with a growing period of seven months (SLUYTERS, 1963, 1964b).

All varieties were grown in the irrigated paddy fields of the Federal Rice Research Station in 1962 and harvested between 23 October (*MAS 2401*) and 31 December (*KAV. 12*) 1962.

The parboiling and milling experiments were made between 16 October 1963 and 3 February 1964. 110 g of paddy were soaked in water at 60° C, 70° C, 80° C and 90° C. The soaking time varied from $^1/_4$ to 9 hours. Three samples were soaked at the same time and each time placed in the same position in the waterbath. After soaking, the samples were boiled for 15 minutes and dried in an oven. A detailed description of the oven used is given by DUYVERMAN (1948). The relative humidity outside the oven was about 50 % during the time of drying and the drying temperature varied from 30° C to 35° C.

Initial drying experiments with parboiled paddy in this oven suggested that when the paddy was dried to a moisture content of 12—15 %, the moisture content did not have much influence on the broken-grain percentage of the milled product. For this reason the paddy samples in our experiments were dried to that percentage as much as possible. Moisture determinations were carried out with a Steinlite Moisture Tester.

After storing the paddy for 48 hours in sealed bottles, each sample was divided into two lots of 50 g each. Each lot was milled in a laboratory Minghetti Mill which was pre-set for each variety. The percentage of broken grain was calculated after sorting out of the broken grain in a small Minghetti hand trieur.

3. Results

3.1. Out-turn

By out-turn is meant the percentage of rice produced after the paddy sample has been

milled and it includes the whole and the broken grains. The mean out-turn percentage of each variety, soaked in water at 60° C, 70° C, 80° C and 90° C for times varying between 1/4 and 9 hours, is given in TABLE 1.

TABLE 1. Mean out-turn percentages of six paddy varieties milled when raw and after soaking in water at various temperatures during the parboiling process

Variety	Raw	Temperature of soaking water			
		60° C	70° C	80° C	90° C
BG 79	60.0	67.8	68.3	67.8	66.6
D 99	59.5	66.4	66.6	66.6	65.4
D 114	54.0	67.9	69.3	67.7	64.2
G.E.B. 24/37	61.0	67.1	67.6	67.3	65.7
KAV. 12	62.0	69.4	69.7	69.2	67.0
MAS 2401	64.5	70.2	69.9	70.6	70.0

The out-turn was higher for all samples when milled after being parboiled compared to samples milled when raw, *D 114* showing the greatest difference. In the parboiled series, *D 99* gave the lowest out-turn. Within each of these series the out-turn at 90° C was the lowest, except for *MAS 2401*.

The values at 60° C, 70° C and 80° C did not vary much. The original figures showed that in the lower ranges of the soaking times the out-turn generally increased by some percentages when compared with that of raw-milled paddy; at a soaking temperature of 90° C the out-turn decreased by a few percentages.

3.2. Results of milling

The percentage of broken grain in the milled product of the varieties soaked in water at various temperatures and for various times is given in TABLE 2. The figures in bold print indicate the samples without cracks and with completely translucent kernels after milling.

With increasing soaking times the broken-grain percentage generally decreased to a minimum value and increased afterwards. The translucency of the kernels increased with longer soaking times. This was observed by a gradual disappearing of the white centre in the kernels. The experiments with soaking treatments at 90° C were not carried on until complete translucency as cracks appeared in almost all the kernels with long soaking times, thus never giving a good milled product; the grain had a brittle appearance as several cracks appeared in the same kernel. Similar cracks were also noticed in the variety *KAV. 12* when soaked in water at 80° C for 1 and 1½ hour and in *D 114* when soaked for 4 and 4½ hours at 80° C, but in the latter case they were less numerous.

TABLE 2 also shows that each variety had its own optimum soaking time at each temperature of the water. These soaking times varied from 6 to 9 hours at a water temperature of 60° C, from 4 to 7 hours at one of 70° C and from 3 to 4½ hours at 80° C.

Comparing the effect of milling on the samples soaked at the optimum soaking time, it appears that *G.E.B. 24/37, KAV. 12* and *MAS 2401* gave the best results, followed by *BG 79* and *D 114*; *D 99* had the highest broken-grain percentage.

4. Discussion

The favourable effect of parboiling paddy on the broken-grain percentage in the

milled product is shown in TABLE 2 where the values in bold print are lower than those of paddy milled raw. However, the same table shows that when the paddy is not properly parboiled, the results can be quite the opposite.
In earlier experiments five paddy varieties were parboiled without soaking. Boiling for 15 minutes only gave 100 % of broken grain in *BG 79, MAS 2401, D 114* and *D 99*; *KAV. 12* gave 87.7 %. These values compared with those of TABLE 2 indicate that soaking before boiling is necessary in order to obtain a good final product. This is in accordance with KIK (1951) who states that starch cannot be dextrinised when dry.
The experiments further show that at a higher temperature of the soaking water, the optimum soaking time can be reduced considerably, depending on temperature and variety. Unpublished experiments with paddy soaked in water at a temperature of

TABLE 2. Broken-grain percentages in six paddy varieties, soaked in water at various temperatures and for various times before boiling, and then dried and milled

Temperature during soaking	Soaking time (hrs)	Percentage of broken grain					
		BG 79	*D 99*	*D 114*	*G.E.B. 24/37*	*KAV. 12*	*MAS 2401*
	milled when raw:	60.2	57.2	100.0	20.7	66.9	38.0
60° C	1	41.6	82.9	100.0	17.9	80.9	66.7
	2	28.4	66.2	99.0	9.8	50.0	48.6
	3	29.4	67.5	94.8	12.1	53.6	46.8
	4	29.7	26.9	60.3	3.7	11.0	13.6
	5	22.8	21.5	47.5	3.8	8.6	7.8
	6	**22.5**	**22.4**	**40.7**	5.2	**8.6**	**8.3**
	7	**17.6**	**43.6**	**14.5**	**8.3**	**2.9**	**4.9**
	8	**17.3**	**28.7**	**15.7**	**5.2**	**3.6**	**7.0**
	9	**16.5**	**38.1**	**17.2**	**3.0**	**9.3**	**8.3**
70° C	1	47.4	59.4	97.7	17.6	45.7	50.8
	2	23.8	54.5	94.1	21.2	33.3	23.9
	3	20.2	51.9	67.4	14.7	12.9	19.3
	4	**16.1**	22.4	42.2	2.9	**4.3**	7.2
	5	**16.7**	**23.5**	24.8	**3.7**	**2.9**	**5.7**
	6	**18.5**	**32.9**	**18.4**	**3.0**	**5.8**	**4.3**
	7	—	**47.4**	**18.4**	—	**2.9**	**4.2**
	8	—	**57.4**	**45.0**	—	**4.3**	**7.0**
80° C	½	44.4	61.8	99.2	13.5	50.0	51.8
	1	33.9	52.7	97.0	11.2	23.9	32.9
	1½	41.2	70.5	89.0	14.2	38.7	31.7
	2	28.9	54.5	72.1	6.8	8.0	8.9
	2½	31.6	51.1	75.0	3.0	**4.3**	**4.9**
	3	37.5	**38.1**	58.1	**3.7**	**4.3**	**4.9**
	3½	**27.0**	**25.0**	**14.5**	—	**2.9**	**2.8**
	4	**23.9**	**23.5**	**31.9**	—	**2.9**	**2.9**
	4½	—	**27.4**	**46.0**	—	**2.9**	**2.9**
90° C	¼	52.7	70.7	98.4	32.9	42.7	43.9
	½	38.5	62.3	96.8	22.4	42.4	28.9
	¾	44.8	82.6	89.1	18.6	58.1	15.5
	1	35.8	56.0	71.7	19.7	33.1	60.0
	1½	48.2	77.5	91.0	15.8	17.5	25.6
	2	74.8	81.6	90.7	31.3	16.6	33.1

Figures in bold print indicate completely translucent grain without cracks.

about 30° C gave optimum times of 18 hours for *KAV. 12*, 36 hours for *BG 79* and *MAS 2401* and 48 hours for *D 99* and *D 114*. The optimum soaking time appears to be much shorter when the temperature of the water is higher. Soaking in water at 90° C never gave a satisfactory product. This treatment often gave a slimy product after boiling and an irregular shape of the kernels after drying. The kernels broke easily during milling as a result of the many cracks in the grain which did not extend to the outside of the kernel. This suggests that they start on the inside. HENDERSON (1954) found in raw paddy that the cracks started in the centre of the kernels.

A soaking temperature of 80° C was a critical one for some varieties. *D 114* soaked for 4 hours or longer and *KAV. 12* soaked for 1 or 1½ hours, showed the same kind of cracks in the grain as when treated with water at 90° C. Soaking at 80° C or higher can be compared with gelatinisation of the starch without being wet, resulting in a poor product. According to KIK (1951) gelatinisation of rice starch takes place at 80° C. The different reactions of the varieties used in the experiments might be attributed to the differing kinds of starch the kernels are probably composed of, combined with differences in the shape of the grain.

Some varieties gave similar results when milled after being soaked during their optimum soaking times. *G.E.B. 24/37, KAV. 12* and *MAS 2401* soaked at 60° C, 70° C and 80° C gave about the same and the best results of the varieties involved. *BG 79* gave similar results when soaked at 60° C and 70° C, but at 80° C the broken-grain percentage was higher than those at 60° C and 70° C. *D 99* gave a non-consistent result when soaked at 60° C for 6 hours or more; at 70° C and 80° C the results were the same. *D 114* gave a lower broken-grain percentage than *BG 79* and *D 99* when soaked at 60° C and 80° C. Soaking at 80° C indicates that *D 114* is sensitive to the right soaking time. The sensitivity of this variety to breakage is further demonstrated by the broken-grain percentage in the improperly parboiled samples, as it is always higher than those in comparable treatments of the other varieties. However, when properly parboiled, its results after milling can be better than or comparable to those of *BG 79* and *D 99*.

The gradual disappearing of the white centre in the kernel in longer soaking times combined with a quicker disappearing when soaked in water at higher temperatures suggests, that penetration of water into the kernel is an important part of the parboiling process. MECHAM *et al.* (1961) studied this more in detail and their experiments with the variety *Calrose* indicate that the distribution of the water in the grain is important in obtaining a good milled product. Although a quickly-obtained high moisture content of the grain during soaking resulted in a satisfactory milled product, the percentage of broken grain was even lower when this treatment was followed by a period of rest before milling.

It should be noted that a completely translucent grain does not necessarily coincides with a minimum broken-grain percentage in the final product. In all the samples soaked in hot water no averse smell was noticed in the milled product. This might be attributed to the small samples used in the experiments. The experience obtained was, however, applied to larger quantities. ½ cwt of various paddy varieties were soaked in hot water, boiled, dried in the sun and milled in a local rice mill. During the whole treatment the bad smell was considerably reduced in comparison with that when the usual method was followed. The milled product had a better appearance than that usually found on the local market, both in translucency and percentage of broken grain. After cooking there was far less smell than with the local product. However, it was not possible to reduce the smell completely.

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