NATURAL RESOURCES INSTITUTE

Improving the Competitiveness and Marketability of Locally-Produced Rice in Ghana

3. An Assessment of Post-Harvest Systems

Project R6688

Department for International Development (DFID)
Crop Post Harvest Programme

DFID Department for International Development

Natural Resources Institute

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3. An Assessment of Rice Post-Harvest Systems

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January 1999

Acknowledgements.

This report summarises information gathered for a number of specific studies undertaken as part of the DFID-funded project 'Improving the competitiveness and marketability of locally produced rice in Ghana,' and for which separate reports have been prepared. The contributions of the collaborators both in UK and Ghana are gratefully acknowledged.

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Summary

This report provides a broad overview of the rice post-harvest system in Ghana, the causes and importance of both quantitative and qualitative losses in the major post-harvest operations and the constraints faced by the various actors at different stages of the system.

Three basic rice-farming systems can be identified in Ghana: the irrigated schemes, inland valley systems and upland rice systems. Post-harvest operations are broadly similar across the three rice production systems although there are minor regional differences and differences associated with varieties of rice produced, farm size, and the extent to which farmers benefit from services offered by farmers' associations and irrigation schemes.

An assessment is made of each of the major operations in the post-harvest system. It is concluded that, although some physical loss of paddy occurs during harvesting, threshing, drying and storage, the loss is generally low. There is wider concern about the qualitative loss of paddy and rice. Extensive qualitative loss occurs during harvesting, threshing, drying and parboiling and is exemplified by excessive amounts of foreign matter, especially stones, in both paddy and rice, and high levels of broken grains in milled rice.

Not all local rice is of poor quality; some of the irrigated rice schemes with industrial milling facilities produce good quality rice which competes favourably with some types of imported rice, and good quality, parboiled rice is produced in parts of northern Ghana. The opportunity exists for encouraging a change in attitude towards the quality of locally produced rice. The critical points at which qualitative deterioration arises are identified, and possible solutions targeted at farmers, parboilers and millers are discussed.

1. Introduction

The importance of rice as a staple cereal in Ghana is increasing, mainly as a result of urbanisation. However, it is estimated that the area under rice production accounts for less than 10% of total cultivated area. Rice imports have been increasing steadily since the 1980s and are thought to contribute more than 50% of all rice consumed. Imported rice is perceived to be of better quality than local rice and is thereby reported to command higher prices.

It has been recognised for some time that there is generally little incentive for farmers to take steps to improve the quality of their produce as there is no price differential based on quality. Despite the perceived inferior quality, farmers seem to have little difficulty in selling their rice. It has been suggested that for the local rice industry to survive, local rice must be able to compete with imported rice in terms of quality.

The quality of milled rice will be influenced by the quality of paddy at the time of processing and the quality of paddy is, in turn, influenced by production, and more particularly, post-production practices. Although quality loss is important, physical loss during post-production handling and the associated financial loss may also be important.

This report provides a broad overview of the rice post-harvest system in Ghana, the causes and importance of both quantitative and qualitative losses in the major post-harvest operations and the constraints faced by the various actors at different stages of the system. It draws upon information gathered for a number of specific studies undertaken as part of the DFID-funded project 'Improving the competitiveness and marketability of locally produced rice in Ghana.' The separate reports by Day *et al* (1997), Ofusu *et al* (1998), Manful and Hammond (1998), Bam *et al* (1998) and Manful *et al* (1998), provide details of survey design and methodologies.

2. Rice farming systems in Ghana

Three basic rice-farming systems can be identified in Ghana. These are:

- the irrigated schemes that can produce two crops a year;
- inland valley systems, where rice is rain-fed, but water is retained in the soil due to the hydromorphic nature of the soils and topography; and,
- upland rice systems, where soil is not classed as hydromorphic and production depends on sufficient and continuous rainfall.

Of these, the irrigated schemes and inland valley systems are the major contributors to total rice production. Upland rice production was once important, but the area under production is now thought to be as low as 1,000 ha. The irrigated rice schemes are mainly in the south, but there are significant schemes in Northern and Upper East Regions. The total irrigated area is relatively small (7,000 ha), but with yields averaging 4.5 tonnes per ha, the area contributes 25% or more of the rice production. The predominant rice farming system is, however, the inland valley system, where yields are of the order of 1.5 to 2.0 tonnes per ha. Two distinct areas are found; one in central Ghana and one in the north of the country.

Currently, rice production is mainly in the hands of smallholders with holdings of less than 1ha. Much of the rice is grown from impure seed, with mixed varieties resulting in uneven grain maturity at harvest. It also results in a product with wide variations in size and shape of grains, all of which will adversely affect the quality of the milled rice. Non-irrigated areas frequently suffer from a water deficit that may affect the degree of grain filling and maturation and thus have an effect on the quality of milled rice. Larger scale farmers face difficulties of high input costs and hire charges for machinery and an overall shortage of machinery in good working order.

Post-harvest operations are broadly similar across the three rice production systems although there are minor regional differences and differences associated with varieties

of rice produced, farm size, and the extent to which farmers benefit from services offered by farmers' associations and irrigation schemes.

In the irrigated schemes in the south, farmers harvest by hand and thresh the paddy in the field. After drying, the crop is bagged for storage, or, more commonly for immediate sale to small-scale traders. The traders take the paddy to small local mills for milling. The majority of mills are of the Engelberg huller type and of variable quality, but there are some more modern Satake-type, rubber roll mills.

Farmers participating in some of the irrigation schemes sell paddy to large mills, either direct, or through a farmers' association. The larger mills, having more sophisticated machinery, including de-stoners prior to milling and a whitener after milling, produce a better quality rice than the small local mills.

Rice production in the inland valleys is usually on small, scattered, often isolated, plots. Farmers may thresh their paddy immediately after harvest and store it in bags in the house or they may store it on the panicle in special stores, threshing small batches as and when it is needed. Threshing is usually on bare earth floors, and drying is done in the sun on the same floor or on the roadside. Consequently, soil particles and stones become mixed with the paddy, which in turn leads to damage to milling equipment and low-grade rice.

In the inland valleys in northern Ghana, the climate is much drier during the main harvest season (December and January) and paddy has to be parboiled to prevent breakage during milling. Parboiling is a vast cottage industry, dominated by women who buy and parboil small quantities of paddy on a daily basis. The parboiled paddy is then milled locally and sold in a market nearby.

Both men and women participate in the post-harvest handling of rice. Family or communal labour may be used although farmers may also employ teams of casual labour, especially for cutting, stacking and threshing. There are, of course, regional variations but, generally, men are responsible for harvesting, threshing and storage

and women are responsible for cleaning (winnowing) and parboiling. In Upper West region women play a more important role in harvesting, although men alone are responsible for threshing. In Northern and Upper East regions and in at least one irrigated scheme in the south (Asutsuare in Greater Accra region), threshing is mainly carried out by women.

3. Harvesting

Some mechanical and combine harvesters are in use in northern Ghana but most paddy is harvested manually using a sickle or knife. The method of hand harvesting differs from region to region and even within regions, usually in relation to the length of straw left attached to panicles. For example, in Northern region, a sickle is used to cut the rice plant close to the ground leaving a long straw attached to the panicles, but in Upper West region, where harvesting is carried out mainly by women, individual panicle are cut with small knives. Farmers in Upper East region use both sickle and knife, but the plant is cut at the mid section leaving a short straw attached to the panicle.

Larger scale farmers in Northern region, especially in the large flood plain areas of Gushiegu-Karaga district, depend on machinery to harvest. However, they are severely disadvantaged by the increasing age and the shortage of reliable machines, especially combine harvesters, which makes it difficult to complete harvesting on time. A study of post-harvest practices has shown that severe delays in harvesting due to poor availability of combine harvesters resulted in much of the paddy being over dry (below 14% moisture content) when it was eventually harvested (Manful and Hammond, 1998). Many farmers complain that the costs of hiring combine harvesters are high yet the alternative of organising gangs of manual labourers for timely harvesting is difficult and often equally expensive.

The quality of combine harvested paddy is very variable; clean paddy will be produced if the fields themselves are clean, but this is rare. More commonly, combined paddy has a high level of weed seeds and other foreign matter, and

additional cleaning by winnowing is necessary. It is also widely recognised that rice produced from paddy that has been harvested by combine tends to have a higher proportion of broken grains than that harvested by hand..

In the irrigated schemes in the south of Ghana, harvesting is usually carried out when fields have been drained, although in some schemes harvesting may take place in partially drained or even waterlogged fields. This is because plots may be planted at different times due to difficulties over scheduling of and access to equipment for land preparation, so crops on adjacent plots may mature at different times. Problems with water management systems may not allow the mature plots that are located next to more immature ones to be drained. Thus, these plots must be harvested while still waterlogged and wet. The harvested panicles may remain on the field for several days before being moved to a dry threshing floor. There is, therefore, a risk of fungal infection and discoloration of grains; contamination with mud is common.

Quantitative losses during harvesting arise from shattering of over-ripe grains, incomplete harvesting of panicles, and loss of panicles after cutting. Among the factors influencing shattering are the methods of harvesting, the paddy variety and timeliness of harvesting.

Incomplete harvesting of panicles may be due, at least in part, to the carelessness of harvesters, although panicles may also be missed if they are covered by weeds. However, harvesting losses are generally low. For example, a field study in Northern, Upper East and Upper West regions showed that losses generally ranged from 1% to 5% although higher losses were experienced with certain varieties of paddy that are prone to shattering. Losses with the variety *Mandee* were higher (15%) than for other introduced varieties such as *Afife* (3%); *Dekuku* (7%) and *Rock 3* (7%) (Ofosu *et al* 1998).

Losses during combine harvesting may be related to the age of the machine, the standard of maintenance, and the skill of the operator. For example, the harvesting loss recorded for a new combine was 2.7% compared to 14.6% for an old machine.

However, lodged plants cannot be picked up by a combine harvester and will be missed (Ofosu *et al* 1998).

While harvesting loss represents a personal loss to the individual farmer, some grain may be recovered, since fields are usually gleaned by women and children, who collect much of the scattered grain and the loose panicles. The amount recovered depends on the diligence of the gleaner but recovery of between 0.5% and 2% of the obtained yield (quantity harvested by the farmer) is possible.

Timely harvesting is critical if both qualitative and quantitative losses are to be minimised. Late harvesting may increase the risk of shattering but it may also allow 'volunteer' plants to grow, thus increasing the level of immature grains when the crop is eventually harvested. Over-dried paddy will lead to high levels of broken grains during milling. Early harvesting of paddy may minimise shattering losses but is likely to result in a high proportion of immature grains leading to problems in drying or a poor quality milled rice. Harvesting early from irrigated fields when paddy is still wet leads to difficulties in drying and associated problems of the development of moulds and discoloration of rice grains.

The majority of farmers recognise the need for timely harvesting to minimise loss. For some, particularly those most dependent upon mechanisation for both land preparation and harvesting, this may be difficult to achieve since they may not have access to machinery at the optimum time. Improved and appropriate machinery for both land preparation and harvesting to allow the crop to be harvested at optimal maturity would be useful. However, the dispersed nature of the rice production in the inland valley systems and in the Northern and Upper regions would make the movement of large machinery expensive.

Many farmers in the north identify a shortage of labourers at harvest time and lack of money to hire labourers or combine harvesters as factors that delay harvesting. However, the underlying problem seems to be that the paddy harvest usually coincides with harvesting of staples such as maize, millet, sorghum or yam. Since

hand harvesting of paddy is slow and laborious it is usually the last crop to be harvested.

4. Threshing

Threshing of paddy is usually carried out manually by teams of family, communal or hired casual labour. Various threshing machines have been field tested in different parts of Ghana over the years but to date none has been widely adopted. A mechanical thresher available to farmers on the Tono irrigation scheme in Upper East region has not proved popular because of the relatively high hire charges. Farmers also complain that the machine is not always available when it is most needed.

In the inland valley systems, paddy is usually threshed by beating panicles with sticks on bare earth floors, thus contamination with soil particles and stones is common. This can lead to damage to milling machinery and to presence of stones in milled rice. In Upper West region, panicles are usually carried to the house to be threshed. Larger scale farmers who are unable to use combines face difficulties with organising labour (as in the case of harvesting) and so commonly use tractors to thresh by running the tractor round in a circle over the stacked straw. Alternatively, paddy may be threshed by oxen treading, although this is not common.

Concrete threshing floors are often provided in the irrigated rice schemes and so contamination with soil and stones should be less of a problem in paddy from these areas. However, the number of floors may be limited and/or centrally located on the irrigated estates and so not easily accessible from the majority of fields. Many farmers prefer to thresh at the field on temporary threshing floors rather than have the bundles of paddy head-loaded long distances to a concrete floor. As it is, women may carry head-loads of paddy up to 1 kilometre to a threshing floor.

In some of the irrigated schemes in the south, paddy may be threshed by beating panicles against stones placed on tarpaulins spread on the ground. Alternatively, bundles of panicles may be beaten against the sides of wooden threshing boxes, the

paddy being collected inside the box. It has been reported that losses through scattering can be high when using threshing boxes although attempts may be made to recover some of the scattered grain by placing the boxes on tarpaulins.

The more widespread use of tarpaulin sheets at threshing, especially in the inland valley systems would minimise admixture of soil particles with paddy grains and would result in a better quality product, but farmers claim that the sheets are too expensive and therefore are rarely used. More important, perhaps, is the lack of a financial incentive to the farmer to pay attention to the condition of paddy from the field. The farm-gate price of paddy is very similar for different varieties and irrespective of the quality.

Losses occurring during threshing may, therefore, be both quantitative and qualitative. Quantitative losses, consisting mainly of scattered grains, grains irretrievably mixed with the soil of the threshing floor and unseparated grains still attached to the straw, may be recoverable if threshing floors are gleaned on completion of the operation. Qualitative loss during hand threshing is usually regarded as being more important, and results mainly from contamination of paddy with soil and stones which may still be present in the milled rice. Although the physical hand beating of panicles is expected to increase the level of cracked grains, this does not appear to be critical. However, mechanised threshing including use of combine harvesters results in high levels of cracked and broken grains, thus seriously affecting rice quality and milling out-turn.

5. Drying

Generally, drying poses no particular problem for farmers in the Northern region of Ghana. Paddy is usually very dry at harvest. In the irrigated areas, rice harvested in the off-season (June), can often be milled directly, although in some cases it may require some drying. If irrigated fields cannot be drained properly at harvest time the moisture content of the paddy may be as high as 20.0-23.0% (Manful and Hammond, 1998). On the other hand, the main season rice and non-irrigated rice, harvested in

December when the humidity is very low, may be too dry, with moisture contents of 12% or below. This will result in shattering of grains during handling and severe breakage of rice during milling. However, the latter problem is addressed through the process of parboiling (see below).

In Upper East and Upper West regions the majority of farmers sun-dry their paddy, either on the flat roofs of their houses or on beaten earth floors in the compounds, but again, drying is not a particular problem. However, elsewhere, in Ghana, and especially in the irrigation schemes in the south, both traders and millers perceive drying as a major problem particularly during the rainy months of June/July.

Paddy is dried in the sun on beaten earth floors, on the roadside or on specially constructed concrete drying floors. If the beaten earth floors are not well prepared, paddy may be admixed with soil particles, stones and other foreign matter. However, more important is the unacceptably high level of broken rice grains that result from milling of poorly or inadequately dried paddy. Traders are reportedly less concerned about the proportion of broken grains per se, but high levels of broken grains reducing the milling out-turn, a key determinant of overall profitability. Millers also cite a problem of caking of mill screens as a result of milling poorly dried paddy. Traders generally seem to have little faith in farmers' ability or willingness to dry paddy properly, and they often purchase the paddy when it is still on the drying floor in order to be able to supervise the final stages of drying and cleaning themselves. Even when paddy is purchased ready bagged direct from farmers, many traders feel that the grain needs to be re-dried and/or re-cleaned, and therefore employ their own labourers to do this, thereby incurring additional costs. However, the price paid to farmers for the paddy does not vary according to quality, hence there is little incentive for farmers to spend time and effort in drying and cleaning when their aim is to maximise the volume and weight of the product sold.

Traders may not always dry their paddy to an optimum moisture content for milling. Since rice is sold by volume, they prefer to mill paddy that is not properly dried because a larger volume of rice is obtained. Retailers then face a problem of mould

development or discoloration of the rice if it is not sold very quickly. Traders will also avoid milling over-dried or unevenly dried paddy because the grains tend to break during milling and there will be significant loss when the grain is winnowed.

The qualitative losses occurring during drying through: (a) mixing of foreign matter with paddy, and (b) high levels of broken grains in milled rice arising from poor drying, are more important than quantitative loss. Physical loss of grains from the drying floor is generally insignificant but can occur through consumption of grain by birds or domestic animals and spillage or scattering during handling. Many of the beaten earth drying floors used by small-scale farmers are often so pitted or cracked that recovery of all grain is difficult or virtually impossible.

6. Cleaning

Cleaning (winnowing) of paddy is usually carried out soon after threshing. Although pieces of straw and other light foreign matter are carried off by the wind, heavier impurities (stones, soil particles etc.) remain in the paddy since there is no further screening or sieving. Quantitative loss (of small grains) during winnowing is usually insignificant, however, in some areas, especially in the north of Ghana, women may re-winnow or screen chaff to recover grains that might be regarded as a loss to the farmer.

Traders and processors frequently cite winnowing as a problem area. The use of volume measures for virtually all transactions, and the absence of a grading system for paddy, means that farmers have little incentive to supply clean paddy. In this respect it is in the traders' interest to enter into credit relationships with farmers, allowing the process of purchasing to be pre-scheduled with the trader playing a fuller, supervisory role in overseeing both the drying and winnowing of paddy. Poor winnowing directly affects the traders' profits by reducing milling recovery rates.

Among the irrigated rice schemes in the south, Asutsuare appears to have a particular problem with the chaff content of paddy. The high levels of chaff, that pose special

problems in winnowing, reportedly have been associated with low levels of fertiliser application. In this situation traders always supervise winnowing to ensure the best quality product.

7. Storage

The pattern of on-farm storage of paddy in Ghana is very variable. Some farmers may sell their entire crop immediately after harvest to repay personal loans or to fulfil other household and family commitments. Others may store all, or part of their crop, usually as threshed paddy in a loose bulk or in bags. Some farmers use traditional basket stores or mud silos, but bag storage inside the house is most common as it is considered the most secure method of storage. Farmers in some central inland valley systems store unthreshed panicles. Paddy stored on the panicle may be kept in a special wooden store raised off the ground and below which is the cooking fire. The heat and smoke wafting upwards from the fire into the storage area is said to keep the paddy dry and free from insect pests. Paddy is threshed in small batches as and when it is required.

Storage periods also vary. For example, most farmers in the central valley systems grow rice as a cash crop with sales taking place immediately, or very soon after harvest. These early sales occur even though there appears to be widespread awareness of the seasonality of rice prices. A small proportion of the paddy (around 10%) may be kept for home use. In some parts of Western region, however, all rice is consumed and hence stored at the farm. In northern Ghana, (Northern, Upper East and Upper West regions) farmers rarely store for less than two months. The majority of farmers in Northern and Upper West Regions and many in Upper East region store up to the beginning of the next planting season (5-6 months) when paddy becomes scarce and prices rise, or until they are sure of the next rice harvest (>6 months). However, small quantities of paddy may be sold at any time when there is a need for cash.

Although insects sometimes infest farm-stored paddy, most farmers do not consider the infestation serious enough to warrant the use of insecticides. Rodents are usually regarded as the main storage pest problem. The common storage insect pests of paddy include *Sitophilus* spp. and *Rhyzopertha dominica,* and moths - *Corcyra cephalonica*, *Ephestia cautella* and *Sitotroga cereallela*. Paddy stored unthreshed on panicles tends to suffer higher levels of infestation, particularly of *Sitophilus* spp and *S. cereallela*. Infestation is generally low when paddy is stored in bags at low moisture content (<12%) as in northern Ghana.

Long-term storage may be undertaken by farmers' associations or by a major irrigation scheme operator to ensure that members benefit from any seasonal price rises. Paddy is usually well dried (11-12% moisture content) and stored in bags in a central warehouse. Generally, storage losses do not appear to be significant and are not perceived by farmers or traders to be a problem, although rodent damage to bags and stored produce is reported occasionally.

8. Parboiling

Parboiling of paddy is routinely practised in Northern, Upper East and Upper West regions. The high ambient temperatures and low humidity at the main harvest time (November to January) mean that paddy is very dry. If milled directly, this paddy would produce rice with a very high level of broken grains because of stress fractures in the grains. Parboiling is therefore widespread. The process involves soaking of paddy in warm water for some time (usually overnight), steaming and drying before milling. The process leads to gelatinization of the grain and seals cracks thus reducing the proportion of broken grains in the milled product. Most paddy destined for parboiling is hand harvested and threshed; paddy that has been mechanically harvested/threshed is purchased for parboiling only as a last resort since the process will not 'repair' the high levels of broken grains present.

Parboiling is more or less a cottage industry, dominated by female labour. There are slight variations in the techniques used from region to region, but in all cases the

process is carried out in small batches. Paddy is soaked in water overnight, steamed in the morning and dried in the sun. In Northern region sun drying is a single stage process whereas in Upper East and Upper West regions drying is a two-stage process. Paddy is dried in the sun up to about midday and then piled and covered. After about two or three hours, the paddy is spread out again to dry until sunset. Dried paddy is always kept overnight and milled the following day.

Parboiled paddy is dried to a lower moisture content in Upper East and Upper West regions (averages of 12.6% and 11.0% respectively) than in Northern region (average 15.8%) (Manful *et al*, 1998). The higher moisture content obviously has implications for storage, although most parboiled paddy appears to be milled and sold within a few days of processing.

The women engaged in parboiling in Upper East region, especially in the Navorongo area are considered to be experts, producing a high quality, white rice, with few broken grains. Similarly, rice parboiled in Upper West region is considered superior to that produced in Northern region. However, traders who assemble the crop and also engage in parboiling seem to be less concerned with quality even though it would appear that there might be opportunities for improving the rice quality through attention to better parboiling.

It has been observed that the presence of stones in milled rice is a common problem as far as consumers are concerned. However, studies in Upper East and Upper West regions have shown that the incidence of stones in rice is generally low (Manful *et al* 1998). This may be attributed to diligent cleaning or sorting of parboiled paddy during drying. The proportion of stones in paddy samples collected in Northern region was high and may be associated with poor cleaning or sorting during drying or the use an inferior type of drying floor.

The proportion of immature grains in parboiled paddy produced in Upper East and Upper West regions was also lower than in that from Northern region. This probably

reflects the more careful washing and frequent skimming of lighter grains from the surface of the water in which paddy is steeped.

Losses during parboiling are mainly qualitative though some (almost negligible) quantitative loss occurs through paddy grains being left on drying floors or consumption of paddy by domestic animals or birds during drying. Qualitative loss is exhibited by the difference in the appearance of milled rice, ranging from the darkish parboiled rice of the Northern Region and the much lighter, and therefore more attractive, parboiled rice of Upper East and Upper West regions. Measurements of the colour of milled rice samples showed the lightness of the parboiled rice from Upper East and Upper West regions to be comparable to that of raw rice. However, the parboiled rice was still more yellow than raw rice, although that from Upper East was a much paler yellow.

According to Gariboldi, (1974) the factors affecting the quality of parboiled rice include: the quality and temperature of the steeping water; length of steeping: the method of steeping; and the method of drying of the paddy. It is likely that the quality differences seen in different parts of northern Ghana may be due to some or all of these factors. The timely harvesting of paddy is also reported to contribute to the more attractive appearance of the rice in Upper East and Upper West regions.

Traders assess the quality of rice on its colour, the proportion of broken grains and stones. They generally recognise that rice from Upper East region has a better appearance and it seems that the more northerly the markets the more quality becomes important and buyers may pay a premium for a quality product.

9. Processing

The rice-processing sector in Ghana is informal, mills are not licensed and there is no central register of mills. Three levels of rice processing can be identified namely: small-scale (domestic) processing mainly for home consumption; medium-scale commercial milling; and large-scale commercial milling.

Small-scale domestic processing involves hand pounding of paddy using a wooden pestle and mortar. The brown rice is winnowed to remove chaff and then pounded again until all grains have been dehusked. The brown rice is polished by gentle hand pounding and winnowing to remove bran. Since hand pounding tends to result in high levels of broken grains, paddy may be parboiled first. Hand pounding is laborious and time consuming and is gradually being replaced as more communities are served by small-scale rice mills.

Rice processing in Ghana is dominated by small to medium-scale mills with a capacity of less than half a tonne per hour (5 bags per hour) with much of the milling being done on a custom basis.. The majority of the mills are small Engelberg-type steel hullers; many are locally-produced, based on designs of mills originally imported from Asia and Europe. They are usually poorly maintained and consequently suffer frequent and chronic maintenance problems. Shafts and screens are constantly patched up in a fairly rudimentary manner and use of genuine replacement parts is rare. Millers acknowledge that this seriously affects the quality of the milled product: the out-turn is poor and the rice dusty and may contain stones, chaff and unmilled paddy grains. In contrast, the newer Satake mini-mills using rubber rollers (more common in the south of the country where they are more suitable for milling raw paddy) yield a cleaner rice and have a higher out-turn (62-65% compared to 55-60% for huller mills). However, the presence of stones in paddy remains a major concern for millers.

Rice produced in Northern region is generally recognised as being of poor quality. This is due in part to deficiencies in the parboiling process but deficiencies in milling are also important. The mills in Northern region were found to be in a greater state of disrepair than those in Upper East and Upper West regions hence there was a high level of broken grains. Secondly, the rice is milled only once, consequently husk and bran is mixed with the rice, necessitating extensive winnowing (mills are rarely fitted with aspirators). The accumulation of husk and bran within the casing of the mill reduces friction and results in a low degree of milling. Rice from Upper east and Upper West regions is of superior quality and is often as well milled as rice from

commercial mills. In Upper West region paddy is usually passed through the huller twice. The second pass removes almost all the husk and bran that is mixed with rice after the first pass and it further polishes the rice grains. (Manful *et al* 1998).

Large-scale commercial mills produce better quality rice, but because of financial problems, few operate outside the irrigated rice production areas and rarely on a full time basis. In Upper East region, for example, the irrigation scheme mill does not operate during the December harvest season as it does not have parboiling facilities and the local parboilers take their paddy to small-scale mills and then trade their own rice in the market.

10. Marketing and consumer preferences

Marketing of paddy/rice poses no special problems, except in areas where poor road conditions make it difficult to transport the commodity from the producing to the consuming centres. There are ready markets for rice, especially in the urban centres and overall, the marketing system works efficiently. There are many traders and many mills competing for custom. Milling charges in the irrigated schemes in the south are considered to be the most competitive in the country. It is rare for farmers to face difficulties in selling their paddy although, where farmer organisations are weak many farmers may depend upon a single trader, because they have to borrow money from them at high interest rates.

There are many systems for paddy/rice marketing but marketing is mainly in the hands of small-scale women traders. They buy paddy from individual farmers or at the village level and then transport the assembled crop to nearby towns or villages for milling. The rice is then sold on to wholesalers, who themselves are mainly women. Trading is usually in relatively small quantities and the price is determined more by the availability of paddy rather than quality. Farmers may also take their own paddy for milling and then sell at the mill to itinerant traders. In such cases the millers may provide credit, allowing delayed payment of milling fees until the rice has been sold.

Parallel with this system are the larger-scale commercial mills that purchase paddy, mill and polish rice and engage in wholesaling themselves. However, the large mills rarely process paddy for a fee and so the trader's margins are greatly reduced, making selling to the mill unattractive to the trader. Traders, therefore, prefer to use small-scale mills as they act as trading points, and they may also provide storage facilities and millers usually allow traders to mill on credit.

The main problem with local rice is its perceived poor quality as exemplified by poor visual appearance, (colour), high levels of foreign matter and a high proportion of broken grains. Traders also identify the degree of milling as an important characteristic and consumers are concerned about the expansion ratio and aroma. Notwithstanding the perceived poor quality, local rice finds a ready market. In a survey of rice consumer preferences, the proportion of respondents reporting that they regularly purchase/consume local rice, in three major cities, Tamale, Accra and Kumasi, was 74%, 40% and 38.1% respectively (Bam *et al* 1998). Nationally there is a preference for imported rice (although in northern Ghana the local parboiled rice is preferred). Local raw rice generally does not appear to compete well with imported rice yet it is still preferred by many consumers for the preparation of special local dishes. However, locally produced rice from industrial mills associated with irrigation schemes is clean, white, with a low percentage of broken grains (<10%) and is on a par with some varieties of imported rice. Indeed, some of this rice is branded and graded and marketed competitively alongside imported rice in Accra markets.

11. Conclusions

It is evident that, although some physical loss of paddy occurs during harvesting, threshing, drying and storage, the loss is generally low or well contained. For example: women and children glean harvested paddy fields and recover grains left on threshing floors thus reducing the amount of grain lost from the system; and storage appears to pose no particular problems for individual farmers keeping paddy at the household level, nor for warehouse operators in the irrigation schemes.

There is wider concern about the qualitative loss of paddy and, more particularly, milled rice. Extensive qualitative loss occurs during harvesting, threshing, drying and parboiling. This is exemplified by excessive amounts of foreign matter, especially stones, in both paddy and rice, and high levels of broken grains in milled rice. Such loss arises from deficiencies in harvesting and post-harvest operations.

However, not all local rice is of poor quality. Some of the irrigated rice schemes with industrial milling facilities can produce a good quality rice with low levels of brokens which can compete favourably with some lower quality types of imported rice. In northern Ghana, especially in Upper East and Upper West regions, good quality, parboiled rice is available and, in some areas, buyers are known to pay a premium for the quality product. These examples may indicate that the opportunity exists for encouraging a change in attitude towards the quality of locally produced rice.

Studies have shown that, although qualitative deterioration arises mainly from deficiencies (or inefficiencies) in the post-production system, production factors are also implicated. In the system from production to retailer critical points at which quality is lost are as follows:

- *Planting - land preparation and seed quality* - shortage of labour or machinery for land preparation may delay planting and therefore lead to delays in harvesting (see below); admixture of varieties in seed lots leads to inconsistent rice quality

- *Early harvesting* - (especially in irrigated schemes and where farmers are dependent upon availability of machinery) leads to high levels of immature grains, problems in drying and an associated risk of fungal infection.

- *Delayed harvesting* - the main effects are high levels of broken grains and possible immature 'volunteer' seed admixture.

- *Threshing* - threshing on the ground leads to admixture of stones, soil and dust with paddy, some of which may be carried through to the milled product; high levels of broken grains are associated with combine harvesting.

- *Parboiling* - methods used in Northern region are inferior to those used in Upper East and Upper West regions, producing a darker and, therefore, less attractive rice.

- *Milling (especially huller mills)* - poor condition, poor maintenance and poor operator skill leads to high levels of brokens, dusty rice, and admixture of husk/bran.

Possible solutions to the constraints are addressed below.

Farm-level

Seed quality

In the irrigated areas good quality seed is generally available on credit from the scheme management. Such seed is not so readily available to inland valley farmers who often rely on supplies through informal channels. This seed may contain mixed varieties and weed seeds, thus the quality of the crop is compromised at the outset. An associated problem is the increasing cost of inputs and the consequent incorrect or inadequate use of fertilisers, fungicides, herbicides etc., so both crop yields and quality will be further compromised.

Harvesting

Timely harvesting may be particularly difficult for those most dependent upon availability of machinery. Development of improved and appropriate machinery, not only for harvesting, but also for land preparation to allow the crop to be harvested at optimal maturity would be useful. However, in areas where rice production is dispersed (as in northern Ghana) movement of large machines could be expensive.

Threshing

Reduction of the foreign matter content of paddy might be achieved by use of threshing machines or the more widespread use of concrete threshing floors or even tarpaulins. Attempts have been made in the past to introduce threshing machines but apparently with little success. The reasons for failure of such initiatives have not been documented and are perhaps worth investigation. Access to concrete threshing floors is difficult for some farmers and tarpaulins are said to be expensive and therefore rarely used.

Development of an efficient seed production and distribution system and introduction of an improved input supply would ensure that farmers had the means of producing a quality crop. However, there is little financial incentive to use improved seed, or to improve production, harvesting and post-harvest practices on the farm, when there is little, or no premium paid for quality paddy. The payment of a significant premium for quality is unlikely to occur until the processing of paddy is improved and the small mills, in particular, are able to produce a quality rice.

Parboiling

There is potential for improving the quality of the parboiled rice produced in Northern region, simply by transferring the technologies used by processors in Upper East and Upper West regions. However, because parboiling is mainly a cottage industry the techniques tend to be regionalised and information and knowledge are not readily transmitted between regions. An opportunity exists for researchers to take the lead here. There is a good understanding of the differences in the parboiling processes between the regions, and techniques can be matched to production of a good quality product. In the first instance, a pilot exercise might be undertaken to introduce techniques from Upper East region to selected areas of Northern region and to evaluate uptake. Such a project might involve researchers alone or preferably a team including researchers as (facilitators) and processors from Upper East region as 'trainers'.

Given that the supply of paddy is not a constraint, there may be opportunities for further improving the existing technologies so that larger volumes of paddy can be processed, with the dual objective of improving quality and lowering costs. Lower costs of parboiling could lead to improved prices being paid to farmers who supply paddy.

An important constraint to the expansion of parboiling activities is a shortage of firewood. Firewood is becoming scarce in many areas of northern Ghana, thus increasing costs and environmental pressures. Research might therefore be usefully conducted to investigate alternative fuels, for example rice husk, and appropriate, efficient burners.

Milling

Small-scale mills predominate in Ghana. The out-turn of rice from the huller mills is usually poor and the rice tends to be dusty, with high levels of brokens and containing stones. The quality of rice from the Satake-type rubber roll mills is better, although presence of stones will still reduce the quality of the product and increases the repair costs of the mill. A case might be made for the active promotion of rubber roll mills for processing of raw rice and the incorporation of a de-stoner to produce a stone-free rice. The use of a de-stoner would reduce operating costs (fewer repairs, less damage to rolls) and increase the out-turn of good quality rice. However, an appropriate de-stoner needs to be identified and an economic appraisal carried out.

Rice milled in huller mills in a single pass contains a mixture of husk and bran, thus necessitating winnowing and cleaning. The disposal of bran with husk has financial implications, since the potential income from sale of bran as animal feed is lost. Aspirators can be fitted to steel huller mills to remove husk and bran particles but their use in Ghana is rare. Further analysis of the costs and benefits of fitting aspirators and the potential for sale of bran is therefore required.

The quality of milled rice depends not only on the quality of paddy supplied but also on the condition of the milling equipment and the skill of the operator. It is evident that the majority of mill operators have received no training in the use and maintenance of milling machinery. The use of good quality spare parts is rare because of the high cost or lack of availability.

The success of milling businesses will depend on their cost effectiveness and financial management. Routine maintenance and repair costs are an important factor. Many mills, especially the huller mills, are in a poor state of repair and breakdowns are common. Repairs are makeshift and the quality of the product suffers. Few mills keep accurate records making financial assessments of the businesses virtually impossible.

It is claimed that since a market exists for rice, whatever its quality, there is little incentive for mill operators to improve their practices. However, small mills offering higher out-turn and cleaner, stone-free rice should be able to charge a higher milling fee as well as incurring lower maintenance costs. It is possible that millers do not have access to information on how to improve their techniques and the likely costs and benefits. If improvements can be introduced at the processing level and processors are able to benefit from production of high quality rice they may then be in a position to encourage farmers to supply better quality paddy.

Dissemination of Information

Who is to be involved in disseminating information? The milling sector is largely informal, but millers associations are known to exist, although little is known about their organisation, role and function. It is possible that rice millers' associations could provide a means of information dissemination, raising awareness of developments and market demands for quality. Stronger and more aggressive associations may be able to obtain a number of benefits for their members such as: arranging the purchase and distribution of genuine spare parts; organisation of training; facilitating technical, financial and business management advice and providing access to credit.

It has been mentioned that the parboiling sector is more or less a cottage industry. It is not known whether organised associations exist but it is conceivable that processors belong to informal associations or women's groups, and such groups might be used in the technology transfer process.

It is generally accepted that farmers pay little attention to producing quality paddy because they are usually assured of a market. However, if improvements are made in the milling sector which stimulates a demand for quality paddy, farmers will need advice and information from the Extension Department of the Ministry of Food and Agriculture. It is unlikely that the Department routinely gives such advice and specific training would be needed for extension staff operating in rice producing areas of the country.

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