PN-ACN-995

CHEMICAL CHANGES IN FOOD GRAINS IN GOVERNMENT STORAGE

M. KABIRULLAH

MAHFOOZUR RAHMAN

FEBRUARY 2001

FMRSP Working Paper No. 21

FMRSP Bangladesh

Food Management & Research Support Project

Ministry of Food, Government of the People's Republic of Bangladesh

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This work was funded by the United States Agency for International Development (USAID)

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Contract Number: 388-C-00-97-00028-00

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The views expressed in this report are those of the author and do not necessarily reflect the official position of the Government of Bangladesh or USAID.

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ACKNOWLEDGEMENTS

The authors are grateful to IFPRI authorities for sponsoring this study, and to the personnel of the Directorate General of Food for their unconditional support and assistance during the progress of the study. The principal author is also grateful to the BCSIR authorities for allowing him to participate in the project. The contributions of the scientists of BCSIR in analysing the chemical parameters are also highly appreciated. The dedicated field staff of IFPRI, Dhaka, is acknowledged for their work in data and sample collection from government food godowns, many of them located in remote areas of the country.

The authors are grateful to the government officers and staff of the DG Food and the Ministry of Food, who assisted them in many ways. Any errors or omissions remaining in these papers are the authors, and in no manner reflect on the vast knowledge and expertise of the officials who were kind enough to share much of their long experience of storage and management of food grains.

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EXECUTIVE SUMMARY

BACKGROUND

The history of storing food grains is as old as human civilization. Seasonal variations in harvest need storage of stocks in excess of immediate requirements to adjust the mismatch between supply and demand. Grain quality can only be maintained over any period of time by proper storage. In Bangladesh, the main object of government storage of food grains is to ensure a safe buffer stock of food grains as an instrument of food security at the national levels. Food grains are also stocked by the government to service the needs of the Public Food Distribution System, and for programmes of social security and disaster management.

Farmers store food grains for their own consumption and seeds, or for selling through the commercial channels. At the farm level, storage is normally in the form of paddy, because paddy is less susceptible to deterioration in storage. The receptacles in use for storage vary in size and in the material used for construction. They may be temporary, or semi-permanent, but are always built of cheap materials. Cylindrical bins made of unbaked clay are very common. A larger receptacle (5000-7000kg capacity) may consist of a rectangular elevated structure of plaited bamboo built on piles and with a sloping thatched roof *(gola)*. Farmers also store rice in earthen bins (*motka)* for short periods. In some cases, the mouth of the bin is sealed with mud and straw and rice is stored for extended periods.

The majority of the rice mills store the paddy in *kothas,* a battery of rooms built of brick and mud or mortar and provided with a door and windows. Paddy is stored over a 15cm layer of paddy husk sprayed on the ground. In commercial storage, paddy is normally stored in jute bags, particularly when they are to be milled in the immediate future. Rice for commercial use is invariably stored in gunny bags in Bangladesh.

GOVERNMENT STORAGE

Cereals are stored in the government LSD, CSD and silos for a period normally covering two cropping seasons. At present, there are 607 LSDs, 13 CSDs and 4 silos in the country, having a total installed capacity of 1,566,850 MT. Such godowns are constructed in almost every upazilla of the country. In CSDs and LSDs, cereals are packed in gunny bags and stored on wooden dunnage. There is no facility to control humidity and temperature in the godowns. In silos, wheat is normally stored in bulk condition. In some of these godowns, there are facilities to measure moisture levels of the stored grains. Arrangements are also available to spray insecticides and to fumigate the stored grains to prevent the growth of microbes and to prevent and destroy insect pests.

STORAGE MANAGEMENT AND QUALITY DETERIORATION

Government godown management procedures determine safe storage life of the grains by numbering. These numbers indicate the period for the safe storage of the grains so classified, and they must be disposed of within this time period. The grains are thus classified as DSD-1, DSD-2 and DSD-3, and so on. These numbers indicate months within which the grains must be disposed of before deterioration makes the grain unfit for human consumption, or total stock loss may occur.

Relevant literature based upon long accumulated experience indicates that chemical changes in food grains are a natural process and occur continuously resulting in the loss/gain of weight, the changing of physical appearance, the loss of nutritional/food value, the loss of culinary properties, and ultimately, the total destruction of the grain stock. Stock deterioration is influenced mainly by post-harvest processing and storage conditions. Conditions in storage, such as humidity, temperature, presence and attacks by insects, rodents, fungus, etc. determine to a large extent safe storage life of food grains. Of all the parameters of chemical changes, moisture is the most important factor. The process of the breakdown of triglycerides, resulting in the production of free fatty acid

value and the breakdown of starch into smaller fractions resulting in the increase of reducing sugar add to the process of deterioration. Auto-oxidation of unsaturated fatty acids, producing peroxide and growth of fungus, has been recognized as the major parameters in changing the chemical composition of food grains. It may be noted that any change in protein occurs very slowly and thus may be ignored in any scientific study to find the determinants of chemical changes in grains.

CHEMICAL CHANGES IN FOOD GRAINS

In Bangladesh, the storing of cereal grains, especially rice, has a long history, though very few studies have been conducted on the chemical changes in stored food grains. Understanding of the chemical changes in food grains in storage is vital for developing a viable storage strategy and procedures. While literature exists generally describing such changes in food grains in storage, no data or formula is available to storage managers for ascertaining and/or predicting food grain conditions in storage over long periods of storage. The Ministry of Food, Government of Bangladesh has, therefore, decided to conduct a study to ascertain chemical changes in food grains in government storage. The study will help store managers to ascertain the quality of the stored food grains and act accordingly. The study has been designed to continue for a period of 5 months. This paper reports on the sampling techniques, physical conditions of the godowns and depots, and the chemical changes of grain samples drawn in the first round with a few preliminary observations.

STORAGE UNITS

Individual storage capacity of the sampled depots varies between 500 and above 5000MT each unit. These units were selected under a sound statistical sampling scheme aimed to draw a representative sample lot of the entire government stock of food grains. Stock of food grains in these godowns, as of 30th June 2000, ranged between 25% to above 100% of installed capacities. 24 godowns have an installed storage capacity of 500MT, 1 has 750 MT and 5 have 1000MT. All the depots store rice and wheat. Only 3

depots had oil and 9 stored paddy. Twelve godowns stored food grains more than their installed capacity. Nine godowns stored 75-99%, 7 godowns stored 50-75% and 2 godowns stored 25-50% of their installed capacity. All the grains were harvested in the summer of 2000 in the *boro* season. The samples were taken within a period between 7 days to 6 months of the date of stock entry; but almost half the samples were stored within a period of 3 to 5 months. This time gap between harvesting and stock entry into the food godowns is natural given the cropping pattern and government procurement and subsequent movement of stocks.

PHYSICAL CONDITION OF THE GODOWNS

All these storage units were constructed in a period starting early 1950s. Some of them were renovated and structurally modified during the intervening period that stretched to the 1990s. Most of the depots in the northwestern part of the country are located on flood free grounds. The high flood levels of 1988 did not affect any godown, though some of them were only marginally saved. On physical inspection, six godowns were found with damp walls. The floors of 9 godowns were in fair condition, and those of 5 were poor. The ceilings of 7 godowns were leaky. In summary, the physical condition of 5 godowns was bad. The doors and ventilation systems of all the godowns were found to be satisfactory.

PARAMETERS OF CHANGE

Parameters of chemical changes of the grain samples collected during the 1st round have been determined. The results were correlated with the elapsed period between the stock entry and the dates of sample drawn. The age of the sample varies between 7 to 180 days with an average of 101.90 days, having a standard deviation (SD) of 43.06. It may be noted that all the samples of grains were harvested during the summer season of 2000 so the net age of the sample appears to be almost identical. In order to track the changes in the chemical parameters of the grain in the stores, the date of stock entry was considered as the starting date and the results were correlated accordingly. The moisture

level of the grain samples ranged between 11.01- 14.66 % with the average of 13.72% having SD 0.74. Peroxide value ranged from 10.1 to 18.1 with an average of 14.5 and an SD of 2.26304 and shows co-relation with elapsed time, similar to that of acid value. It appears from the correlation coefficient (r) that the moisture level of the grains indicated a decreasing trend with age. It may also be noted that the moisture content of the grains naturally decrease with age but the rate depends on a number of variables, such as initial moisture level, degree of milling, physical conditions of storage, container, temperature, humidity etc. In Bangladesh government stores, there is no system to control these variables excepting a ventilation system using natural draught. Temperature and humidity at the geographical locations of the storage also decrease after the summer, and reach the lowest during the winter. These changes influence the moisture level in the grains stored in the government stores. The fat content of the grains normally depends on the degree of milling. Parboiled and mill-polished rice contains almost similar amounts of fat which decrease with the age of the grains. The acid value of the grain samples ranged between 10.1-17.39. The acid value of the samples is positively correlated with the age of the samples. The peroxide value ranged from 10.1 to 18.8, with an average of 14.15, and had a standard deviation of 2.26304 showing similar co-relation with acid values. The change in the reducing sugar was negligible. The fungal load of the grains varied widely, which may be due to variability of handling between the stores, where any unhygienic handling of the grains during processing, milling and packaging would have enhanced the fungal infestations. Only one sample of imported wheat was collected from a silo. The origin and age of the sample could not be ascertained. Results obtained with wheat also vary with those of rice samples but no attempt was made to correlate the results with those of rice samples, as they are totally different species of grains.

PRELIMINARY OBSERVATIONS AND CONCLUSIONS

The preliminary results of analysis conducted on the sampled grains indicate decreasing percentage of moisture and increasing acid and peroxide values with increased age (time period between stock entry and sampling date). The fungal load of the sampled

grains varies widely intra-sample. This variation is most probably attributable to the extent of contamination imparted to the grains during post harvest handling, processing, and storage.

The preliminary results reported here are only indicative of the chemical changes in food grains stored in government godowns by the first round of samples and analysis thereof. Conclusions may be drawn and appropriate recommendations may be made after completion of the 4th round of analysis covering 6 months of storage life.

1. INTRODUCTION

Cereals are members of the grass family (*Germineae*) cultivated primarily for their starchy seeds which are used for human food, livestock feed, and as raw materials for industrial starch and other products. Cereals were among the first plants to be domesticated and were grown long before the beginnings of recorded history. Long before the dawn of human civilisation, cereal grains have been a major source of food for mankind. Each of the world's great civilisations has depended upon cereals as a major food source. When people learned to collect cereal grains from wild plants and also cultivated cereals, they also learned to store and preserve the grains for the coming days. Storage of food was the first progressive step towards an agricultural society from a hunter-gatherer one. References may be taken from the Old Testament, where prayers were offered for plentiful harvests and protection from pests. For mankind, these prayers remain as relevant today, as they were millennia ago. The Diary of Samuel Pepys, 1633-1703, records the destruction of wheat storehouses in the Great Fire of London, 1966, and mentions the existence of these storehouses from the reign of Henry VIII, 1491-1547, (Encyclopaedia Britannica, 1978). In more modern times, seasonal variation in harvests require storage to tide over the mismatch of supply and demand. Besides, grains must be stored for times of crop failures, natural disaster and also for trade. But these aims may only be fulfilled if deterioration of grain quality can be prevented for the planned storage time.

The main objectives of the Bangladesh Government for storing food grains are to ensure a safe buffer stock for food security of the nation, for market intervention, to stabilize prices, and also to assist the nutritionally vulnerable groups of population through commodity specific assistance programmes (GOB, 1988).

2. PROCESSING OF FOOD GRAINS (RICE) IN BANGLADESH

Processing of rice involves a number of operations: harvesting of the grain from the fields, threshing out the grain from the straw, winnowing or cleaning the grain, parboiling, drying and milling. Processing procedures and efficiency of the processing operations have a considerable effect on the physical and nutritional quality of the grain, which ultimately affects storage life and commercial value of the grains. In a farmer's household, the efficiency of processing operations depends entirely on individual experience and cultural practices. The equipment used in grain processing is also mostly traditional or indigenous. Rice mills in Bangladesh are mostly small-scale industries located in rural areas, though a few large automatic mills also operate. Mechanical milling has largely replaced traditional milling by human labor though the technology of milling is still largely old and outdated. Properly harvested, parboiled, dried and milled rice has greater resistance to insect and fungal infestations. Such rice is reported to retain greater nutritional value, with improved culinary properties, and maintains moisture equilibrium in storage. It is superior to indifferently processed rice grains.

HARVESTING

Harvesting is the most important and first step of rice processing. This step lays the foundation of the quality of the grain. The yield of the crop also depends on the right harvesting practices. Harvesting of the grains sometimes depends on the weather and drainage facilities in the fields. The traditional varieties of *aus* rice, *boro* and deep-water *aman* are harvested in the water. Most varieties of aman are harvested under dry weather conditions. The water content of field soil influences the process of ripening of the grains. Draining the water 15-20 days before harvest, when the grains reach the dough stage, is said to lead to uniform ripening of the grains and facilitate harvesting and threshing. The moisture content of the grains at harvest and the methods adopted to reduce it before threshing and storing are said to have a considerable influence later on

the milling quality of the paddy. Generally, early maturing varieties can be harvested one month after full flowering, while late maturing varieties cannot be reaped before 6 weeks after flowering. Different varieties have shown different optimum times for harvesting from the point of view of yield; maximum yield is obtained after 38, 46 and 54 days from full flowering for *Kersail, Badshabhog* and *Nagra* types respectively. (Ghose et al. 1960; Subbiah Pillai, 1958)

The determination of the optimum stage for harvesting, threshing, storing and milling is accomplished by eye estimation in Bangladesh. Harvesting the crop while the straw is still somewhat green and slow drying of the sheaves before threshing lead to better milling quality. In villages, farmers dry the sheaves for several days and then stack them, threshing being done several days or weeks later. It is claimed that by this practice, threshing is made easier and the grain retains a good milling quality. In many parts of Bangladesh, where dry weather prevails at harvest time and the land dries up quickly, moisture content in the grain is never more than 18-20%. This may be the right condition for further reducing the moisture to 16% before threshing. In Japan, the moisture content of rice grain is about 20% at the time of harvest and is reduced to 16% at the time of threshing, and further reduced to 13% by further drying of the grain before it is husked. In Thailand, which is known to produce good quality rice, rice crop is harvested when the grain has a moisture content as high as 25% or more. In the U.S.A., it has been found that with a moisture content of 20-27% before harvest, the grain has a high milling quality, while moisture content below 20% results in a low mill yield (Grist, 1959). In some cases, especially in the winter season in Bangladesh, moisture content in rice may reduce to 14 or 15% even before harvest and the straw becomes quite dry. The quantity of moisture that can be safely left in the grain is said to be about 10-12%.

THRESHING AND CLEANING

The two most common threshing practices in this country are: (1) beating the sheaves against a hard surface, and (2) allowing the sheaves to be trodden by animals.

The beating may be done immediately after harvest, in the field itself, or in the homestead. The treading by animals is invariably done in the homestead in the yard specifically prepared for the purpose. With the existing threshing practice, the grain remains mixed with chaff, pieces of straw, mud particles and half-filled light grains. The usual method of winnowing against the prevailing wind removes only chaff and pieces of straw. (Subbiah Pillai, 1958). A pedal thresher used in Japan has been introduced in Bangladesh and has been found to be satisfactory at farmer level usage. Use of a power thresher driven by an internal combustion engine or electric power has been tried in some places and has proven to be satisfactory. In addition to threshing, power driven machines perform the sieving and winnowing functions at the same time. A pedal thresher has an output of about 100kg paddy/hour while a power thresher of 1.0 HP has a capacity of about 270kg paddy/hour (Ghose et al. 60, Grist, 1959).

PARBOILING

Rice is consumed after removing the outer husk and polishing by a milling process. Quite often the paddy is subjected to a hydrothermal treatment before milling known as parboiling, which involves soaking the paddy in water, steaming in hot water and drying it in the sun. The husked grain obtained by milling without any pre-treatment is known as Raw Rice (*Atap* Rice in Bangladesh) as opposed to parboiled rice obtained after parboiling. The process of parboiling originated in the Indian sub-continent and has been widely practiced in this country since ancient times. In this process, paddy soaked in water for some time is heated once or twice in steam and dried before milling. It is estimated that most of the rice crop in Bangladesh is parboiled before hulling. Parboiling is particularly significant in the case of coarse and medium rice of soft and chalky structure, because such rice suffers excessive breakage when milled raw. Of the total production of parboiled rice in Bangladesh, coarse type constitutes about 60%, medium about 30%, and fine about 10%.

Parboiling is done both at the household level and on a commercial scale. The household methods followed in different parts of the country are essentially the same, but the time allowed for steeping and heating, and equipment used may vary. Paddy mixed with water is heated to the simmering or boiling point for a few minutes, after which it is transferred to cold water to steep for a period of 24 – 36 hours. It is then boiled again and dried slowly, usually in the sun, to be husked after drying. Parboiled rice prepared by household methods is generally retained for home consumption. Domestic parboiled rice is incompletely gelatinized and has an opaque core, which is preferred by certain sections of rice eaters. It is also generally less smelly or colored than commercial parboiled rice; however, it is not as hard as the latter and suffers comparatively higher breakage during milling.

There are two commercial processes of parboiling commonly employed in Bangladesh, viz. double boiling and single boiling (or cold soaking). In the double boiling process, paddy is placed dry in mild steel cylindrical containers and subjected to low- pressure steam for about one minute to obtain a light colored parboiled rice, or for about 5 minutes if a yellow colored parboiled rice is desired. The paddy is then discharged into large cement tanks, where it is steeped in cold water for 18-36 hours. Changing the soak water frequently can reduce the fermentation that sets in during soaking. After draining out the water, the steeped paddy is conveyed back to the steaming cylinders and given a second application of steam, for about 5 minutes (for light colored rice) or 9-10 minutes (for yellow tinted rice), which completely gelatinizes the grain. The paddy is then spread out on cement floors for drying. It is dried slowly and uniformly; sun drying usually gives satisfactory results. In the single boiling process, paddy, after being steeped in cold water for 1-3 days, is subjected to steam for a period of up to 10 minutes and then dried. This method is generally employed where a light colored product is preferred.

Parboiling of paddy has several advantages. Steaming splits the husk making its subsequent removal easier; the grain is toughened resulting in reduced breakage during

milling and polishing, so that there is a greater out-turn of head rice. Milled parboiled rice has greater resistance to insects and fungus infections and a better keeping quality than raw rice. Also, parboiled rice retains more of nutrients during milling, washing and cooking. During steaming, thiamin and water-soluble nutrients, originally concentrated in the germ and aleurone layer, diffuse through the grain; with proper parboiling they are more or less homogeneously distributed throughout the whole kernel. When the germ and aleurone layer are removed by milling, the loss of water-soluble vitamins is, therefore, much less than that occurring in milling of raw rice. Finally parboiled rice cooks better raw rice. It does not tend to turn into glutinous mass and it retains its freshness after cooking for longer hours than raw rice. (Ref. FAO, 1954; Subrahmanyan et al, 1955; Desikachar et al. 1957; Bull. Cent. Fd technol. Res. Inst., Mysore, 1955-56)

DRYING

Drying paddy is the process of removing moisture from the grain; it is often called moisture extraction. Drying is required because most paddy is harvested at a relatively high moisture level of up to 26% and would deteriorate rapidly if stored wet. The safe moisture level for paddy storage depends on the grain quality, and climatic and storage conditions. Generally, paddy can be stored safely up to 2 or 3 months at a moisture content of 13-14%. For storage beyond 3 months, rice grains should be dried to 12-12.5%. Most paddy deteriorates rapidly after harvesting and requires immediate drying. Some new varieties should be dried immediately because they have a short dormancy period and will germinate within a few days after harvest. In the drying process, heat is used to evaporate the moisture from the grain and hot hair is moved mechanically to carry away the evaporated moisture. Drying rate is determined by grain quality, its initial moisture content, ambient temperature, and variety. Air temperature, relative humidity, and the volume of air passing through the grain also affect the rate. The drying method, type of dryer, and efficiency of equipment also affect the rate of drying. The higher the initial moisture content of grain, the longer it will take to dry. In general, the higher the drying temperature, the faster is the drying rate. However, too high an air temperature

may cause checking of the grain, which in turn causes breakage during milling and reduced out-turn. Air with high relative humidity dries slowly if at all. Air with low relative humidity has the ability to absorb more moisture and dries the paddy faster. Paddy is hygroscopic, and will gain or lose moisture until it is in equilibrium with ambient air. The equilibrium moisture content is dependent primarily on the relative humidity and ambient temperature but it varies to a lesser degree with air temperature.

Paddy should not be dried too fast. The drying process should be slow and uniform to maintain quality. Paddy gives up surface moisture easily and quickly, but holds moisture in the centre of the grain longer. Fast drying causes internal grain stress, which leads to checking and subsequent breakage during milling. If surface moisture is removed too rapidly, the outer layer contracts and the high temperature used for drying causes expansion that results in more internal stress. The most common paddy drying method is by the sun-drying method. It is first used when the paddy is standing in the field before harvesting. It is often used after harvest and threshing when the paddy is spread on drying floors. Sun drying requires constant turning to prevent the top layers from over drying and to permit the bottom layers to receive heat and air movement necessary for drying. Sun drying requires considerable capital investment in land and waterproof flooring, which can be quite high. It is a labor-intensive operation; therefore, its costs vary considerably depending on local land and labor costs. Losses during sun-drying process may be due to rodents and birds. However, the largest problem in sun drying is its dependency on good weather.

The alternative to sun drying is mechanical drying, which uses mechanical equipment for holding the paddy, blowing air through the grain mass and heating air to remove moisture from the grains. A number of mechanical dryers and drying techniques have proven satisfactory and economical for paddy drying. These are identified as batch-in-bin, recirculating batch, or continuous–flow LSU type dryers. No one drying method is superior to the other. Each has its place and all are frequently compared in terms of

capacity, power, drying temperature, airflow, labor requirement, operating cost, management, drying capacity, and investment cost (Wimberly, J.E., 1983).

MILLING

Paddy is milled in Bangladesh either by home pounding, by using such devices as wooden pestle and mortar or *chakki* (stone mill), or in small power-driven hullers and large mechanized rice mills. In the village areas rice is de-hulled mainly with the *dhenki* and wooden pestle and mortar. Nowadays, the use of small-scale huller and *chakki* are also gaining popularity. Home pounding is most commonly done with mortar and pestle made of wood and worked by hand or by foot. In hand pounding, paddy placed in a mortar is pounded by a heavy wooden pestle, about 2 meters long, fitted with an iron hub at one end and iron ring at the other. The type worked by foot is known as *dhenki* and handles comparatively larger quantities of paddy. It consists of a short pestle, about 30cm in length, fixed on the underside of a beam of wood that is about 3 meters long and placed on a fulcrum. Milling by power driven machines is a well-established small-scale industry in Bangladesh. These rice mills are generally located around the regions of production. Two types of rice mills are commonly used in Bangladesh, viz. the hullers and the large automatic types. The product, which emerges from a huller, contains white rice and broken grains, and is mixed with bran and finely crushed husk, which can be separated by shifting. The grain suffers excessive breakage in hullers, and the bran, which gets mixed up with powdered husk, is generally not recovered in pure form. In the automatic rubber-roll sheller type mills, the cleaning, husking, winnowing, polishing and final sieving are all done automatically in a continuous process, delivering finally the rice, husk, bran, etc. separately. The sheller mills yield considerably more head rice than huller mills.

The milling quality of paddy is adversely affected if the crop is harvested over-ripe. Parboiling toughens the kernel and minimizes breakage during hulling. Additionally, comparatively less bran is removed and there is a higher recovery of rice,

including broken rice, then on hulling untreated rice. Drying paddy prior to milling reduces breakage; thus the recovery of head rice is greater from old paddy, which has a lower moisture content than new paddy.

3. STORAGE OF FOOD GRAINS IN BANGLADESH

FARMERS' STORAGE

In Bangladesh, the main objective of the government to store food grains is to ensure a safe buffer stock of food grains for the food security of the nation. Government supplies food grain to the markets in times of crises, and also assists nutritionally vulnerable groups of population (GOB, 1988). Farmers store food grains for their own consumption and seed or for selling to the markets. In has been observed that in this region, losses due to bad storage are even more important than losses due to other stages of processing. At the farmers' level, the storage is entirely in the shape of paddy, because paddy is less susceptible to deterioration in storage. The receptacles in use for storage vary in size and in the material used for construction. They may be temporary or semi-permanent but are always cheap. Cylindrical bins made of unbaked clay are very common. The capacity of bins may vary from 500 to 2000kg. Similar bins of baked clay or galvanized sheets are also used. Even jute bags of 70-80kg capacity are often used. These bags are usually kept inside the dwelling house or under a protected roof. A larger receptacle (5000-7000kg capacity) may consist of a rectangular elevated structure of plaited bamboo build on piles and with a sloping thatched roof (*Gola*). There are also large rectangular bins, constructed indoors with walls made of wooden planks or galvanized iron sheets on all sides with a narrow outlet on one side. Often temporary circular bins of 2000-5000kg capacity are constructed of twisted rice straw on masonry floors. Paddy is also stored in underground pits with a narrow mouth that is sealed off with a flat stone slab plastered with mud after the pit is filled. The underground method of storage is preferred in some places as it is said that the milling quality of the paddy and the cooking quality of the milled rice improve by such storing. The farmers used to store rice in earthen bins (*Motka)* for short period between milling of paddy and consumption

of rice. In some cases the mouth of the bin is sealed with mud and straw and preserves rice for more than a couple of months.

STORAGE AT RICE MILLS

The majority of the rice mills store the paddy in *kothas,* a battery of rooms built of brick and mud or mortar and provided with a doors and window. The paddy is stored over a 15cm layer of paddy husk sprayed on the ground. Occasionally the paddy is stored in jute bags, particularly when they are to be milled in the near future.

GOVERNMENT STORAGE UNITS

At the government level, cereals are stored in the LSDs, CSDs and silos for a period normally covering two cropping seasons. Cereals, normally packed in gunny bags (80-100kg) are stored in the godowns on a wooden base. There is no system to control humidity and temperature in the godown. In silos, normally wheat is stored in an unpacked condition. The Directorate General of Food, Government of the People's Republic of Bangladesh, is responsible for collecting, storing and distribution of food grains in the country. At present there are 607 LSDs, 13 CSDs and 4 silos in the country having the installed capacity of storing 15,66,850 MT. The godowns are constructed in almost every upazilla. The government started to build godowns with concrete from 1950s. Before 1950, all the godowns were built with corrugated iron sheets for walls and roof. Most of them are now out of use. In some godowns, there are facilities to measure the moisture level of the stored grains. There are also some arrangements to spray insecticides and fumigate the stored grains to prevent the growth of microbes and rodents.

The godown management follows a system to determine the storage life of the grains that ascertains the date of disposal of the stored grains. They are termed as DSD-1, DSD-2 and DSD-3. DSD-1, meaning that such grains should be disposed off within one month, and DSD-2 means the grains should be disposed within 2 months, and so on.

FUNCTIONAL REQUIREMENT FOOD GRAIN STORAGE

The history of storing food grains is as old as the history of human civilization. Pingale (1978) reviewed and summarized the handling and storage of food grains in the Indian subcontinent. Bala (1997) has analysed the factors affecting storage of food grains. Starting from the domestic method of storing foods, there is a wide range of storing system befitting to the requirement of the consumer. With the modern international cereal trade, huge silos are now found at the main points of export and at the docks of importing countries. Modern storage facilities, whether they are meant for bulk or small-scale storage, have to satisfy a number of basic requirements. Stahl (1950) summarized the functional requirement of storage facilities to protect the grain from excessive temperature, moisture, and from attacks of insect and rodents. Barre (1954) discussed the conditions of safe storage wherein mainly the moisture limits are considered. Pingale (1961) considered an ideal structure to be capable of maintaining grain cool and free from temperature fluctuations. Goulumbic and Laudani (1966) stated that the structure should be weather-tight and be provided with screens to keep out insects, birds, rodents and other animals. Pingale (1978) has reviewed and summarized the requirements of safe storage of food grains.

4. CHEMICAL CHANGES IN STORED FOOD GRAINS

A good number of investigators studied various aspects of storing grains in different types of stores. Karon and Adams (1949) investigated the rate of absorption and de-sorption of moisture by rough rice, head rice, bran, polish and hulls over the range of 11-93% RH at 25°C. Desikachar (1956) reported the changes of culinary properties of rice on storage. He reported that fresh rice upon cooking lost more solids into the cooking water than stored rice. Solutions of amylose and starch isolated from fresh rice have a slightly higher specific viscosity than the corresponding constituents from old rice. Rao *et al.* (1954) has reported the effect of storage on the chemical composition of husked, under-milled and milled rice, stored in gunny bags and kept free from infestation for one year. They reported that the amylase activity in freshly harvested rice decreased rapidly; there was an improvement in the cooking quality. There was an increase in acidity and the peroxide value of the fat present in the different samples of rice, in increase being at a maximum for husked rice. The lives for the various samples, as estimated by plotting the peroxide value of the fat against the storage period for all the samples in conjunction with organoleptic tests at the end of one year, are approximately as follows: raw husked rice, 7 months; raw under milled rice, 12 months; parboiled under-milled rice, 11 months; and raw milled rice, 13 months. Bautista, et al. (1964) recommended that glutamic acid decarboxylase activity (GADA) was a more reliable index than fat acidity of the viability of stored rice. Yasumatsu, et al. (1966a; 1966b); Tsuzuki et al. (1981) reported the effect of temperature on the quality deterioration of rice due to the production of off-flavour produced by the fat oxidation. Daftary and Pomeranz (1965) reported the changes in lipid composition in wheat during storage deterioration. Houston, et al. (1954) reported the deteriorative changes in the oil fraction of stored parboiled rice. Again Houston, et al. (1963) reported that the total extractable and organic acids decreased during maturation but increased during storage; more strongly as

moisture or temperature increased. They observed that grain deterioration was accompanied by the lowering of polar lipids. Lee, et al. (1965) observed the increase in oleic acid and that linoleic acid decreased with storage time. The same trend was observed in fraction containing free fatty acids and mono- and diglyceride. Sabularse, et al. (1991) has reported the effect of gamma irradiation of the storage and cooking quality of rice. Storage of irradiated rice produced similar changes of those of non-irradiated rice. Iwasaki and Tani (1967) studied the effect of oxygen concentration on the deteriorative mechanisms of rice during storage. Rice stored in low oxygen showed decreases in acidity of water-extract and great increase in reducing sugars during storage. Houston, et al. (1956) reported the changes of color of various rice, stored at different temperature, caused by the non-enzymatic. Further, browning accompanied by losses of reducing sugars, amino nitrogen, and free amino acids also occurred. Perdon, et al. (1997) reported the effect of rough rice storage conditions on the amylograph and cooking properties of medium grain rice cv. Bengal. The amylograph overall paste viscosity of the milled rice increased during storage and the water absorption ratio of the samples during cooking in excess water increased by an average of 15% over 6 months of storage. Villareal, et al (1976), Indudhara, Swamy et al (1978), Hamaker, et al. (1993) also reported a dramatic increase in paste viscosity during storage. Attempts to explain these functional changes have focused on the properties of rice components such as starch, protein and lipids and the interactions among them during storage (Chrastil 1994).

5. MICROBIOLOGICAL ASPECTS OF STORED FOOD GRAIN STORAGE

Teunisson (1954) studied the influence of storage on the microbial population of rough rice. He reported that rice with 18 to 20% moisture content, sealed in gas-lined bin for 7 months became sour. Some moulds survived but did not increase; the facultative anaerobic organisms markedly increased and yeast increased tremendously in most of the layers of the piles of rice. Prado and Christensen (1952) reported that moulds did not increase in rice stored in sealed bottles at moisture contents of 14% and below, nor in rice stored at higher moisture contents at temperature of 23°F and 37°F for 21 days. Pingale, et al. (1957) studied the effect of insect infections on stored husked, hand-pounded and milled raw rice and parboiled milled rice. The husked rice was infested to a greater extent than the other samples and developed an unhealthy appearance within two months of infestation. Houston, et al. (1959) reported preservation of rough rice by cold storage and observed that yeast count fluctuated markedly and viability of the higher-moisture rice decreased markedly. Joarder, et al (1980) studies the incidence of fungal flora determination of aflatoxin in rice in Bangladesh. They reported on average quite high loads of fungal growth in both un-husked rice and husked rice samples collected from various government and private storage depots and markets. The moisture content has been found to influence favourably the higher loads of fungi. But storage period has little influence on the fungal content when the moisture content of the stored samples remains below 16%. Out of 1184 samples analysed, it was found that at least 3.9% of the samples contained aflatoxin and only 2 samples contained non-acceptable levels of aflatoxin.

From the review of the literatures, it is observed that the chemical changes in food grains are a natural process and occur continuously resulting in the loss/gain of weight, changing of physical appearance, loss of nutritional/food value, loss of culinary properties, and ultimately, total destruction of the grain. The process is influenced by a

number of factors namely post harvest processing, and storage conditions such as humidity, temperature, attack of insects, rodents, fungus etc. Of all the parameters of chemical changes, changes in moisture content are the most important factor. Breakdown of triglycerides, resulting in the production of free fatty acids and acid value and the breakdown of starch into smaller fractions result in an increase of reducing sugar. Autoxidation of unsaturated fatty acids, producing peroxide and growth of fungus have been recognized as other major parameters. It may be noted that the change in protein occurs very slowly and thus may be ignored for practical purposes.

6. OBJECTIVES OF THE STUDY

In Bangladesh, storing of cereal grains, especially rice, is mostly practiced by tradition and hardly any scientific method of storage is in general use. Very few studies were conducted on the chemical changes in the stored food grains in Bangladesh. Most of the studies were conducted on the production and economic aspects of rice, especially of the high yielding varieties (BANSDOC, 1997) but understanding of the chemical changes in food grains in storage is vital for developing a viable storage strategy and procedures. While literature exists generally describing such changes in food grains in storage, no data or formula is available to storage managers for ascertaining and/or predicting food grain conditions in storage over long periods of storage. Ministry of Food, Government of Bangladesh has decided to conduct a study for ascertaining the chemical changes in food grains in government storage. This study will help the storage managers to ascertain the quality of the stored food grains and follow a scientifically determined procedure. This study has been designed to continue for a period of five months. The current paper reports the preliminary results so far obtained. It also reports on the sampling techniques of the food grains, physical condition and storage condition of the godowns and the depots, and the chemical changes of grain samples drawn in the first round of samples.

7. EXPERIMENTAL METHODOLOGY

SAMPLING DESIGN

At first, geographical locations of the grain depots were plotted on a map of Bangladesh. Since there are 607 LSDs, 13 CSDs and 4 silos, it was decided to draw 28 samples from LSDs, 1 sample from CSDs and 1 sample from a silo. Because of practical limitations of time constraints, this was considered to be the minimum number that may produce a statistically sound sample. For drawing representative samples, rice stock on July 2000 was taken into consideration. For this, the total cumulative stock of rice was calculated. Then total cumulative stock was divided by the number of expected samples, i.e. for LSD (3744441/28)= 13372.89, which became 'The STEP' for drawing samples. Then a random number was drawn between 0 and 1, which was 0.658217. This random number was then multiplied by the STEP, i.e. (0.658217 X 13372.89) = 8802.26. Since the result is not an integer, it was made into an integer, and the value corresponding to this in cumulative stock was selected as the first sample. To get the second sample, the STEP was added with the first sample and the value corresponding to this in cumulative stock was selected as the second sample. Similarly, all the 28 samples were drawn from the LSDs in the same ways. Samples from CSD and silos were drawn under similar sampling schemes using sound statistical methods. (Table 1) (Annexure 1) (Singh & Chuddar, 1986, Spiegel, 1972).

SELECTION OF GODOWNS

In all the sampled depots, except the one at Rangamati, there is more than one godown. The selection of godowns was determined by using Simple Random Sampling by a Random Number Table Method (Annexure 2) (Spiegel, 1972).

Table 1 — Number of LSDs, CSDs and SILOs Selected *

Type of Depots	# of Depots	# of Samples	%
Total # of LSD	607	28	4.6
Total # of CSD	13	1	7.6
Total # of SILO	4	1	25

* Stock on 30.6.2000

SELECTION OF STACKS

From the sampled godowns, sampled stacks were selected by a similar procedure.

SELECTION OF BAGS

Sampled bags were selected from the sampled stack by using a random number table. At first, a column was selected from the random number table. Then a two-digit number was selected from the left side of that column, which was then applied to determine the first sampled bag. If the two digit number exceeded the total number of bags in the selected stack, then the next number of that column in the table was selected as the first sample, and so on. The second sample was selected by taking next value of the column after the first sample. Similarly, the 3rd, 4th and 5th bags were selected. These bags were marked and preserved for the study period of 6 months by special arrangement of the Directorate General of Food.

PLANNED DATES OF DRAWING SAMPLES

The time time of drawing the first sample ranged from the 26th October to 27th November 2000. As planned, the second round of drawing samples was completed between 26th December and 27th of January 2001. The third round of drawing samples will be done between 26th February and 27th March 2001. The fourth round of drawing samples will be done between 26th March and 27th April 2001 (Table 2) (Annexure 3).

Table 2 — Planned Dates of Drawing Samples

Rounds of Sample Collection	Dates
1st Round	26.10.2000- 27.11.2000
2nd Round	26.12.2001- 27.1.2001
3rd Round	26.2 2001-27.3.2001
4th Round	26.3.2001-27.4.2001

INFORMATION ABOUT THE PHYSICAL CONDITION OF THE STORAGE GODOWNS

A questionnaire (Annexure 4) was developed to collect the names and addresses of the storage. The year of construction, storage capacity, last date of structural modification, types and amount of grains stored, identification of the sampled godown, stack and bags, physical condition of the godown, door system, ventilation facilities, records of the use of insecticides, and water level during the 1988 flood were some of the other data collected from these storage units.

ANALYSIS OF THE CHEMICAL PARAMETERS

Moisture

The Moisture Analyzer MA30 (Sartorius, Germany) was used to determine the moisture content of the food grains. The Analyzer is equipped with a weighing system that has a 30g capacity and a one mg resolution. Approximately 0.5g powdered (60mesh) grain samples were placed in the aluminium sample dish. The sample was evenly distributed over the dish and the moisture level is recorded automatically.

Fat

A quantity of 10-15g of powdered (60 mesh) rice sample was placed in a thimble (size 25 g) and fat was extracted with petroleum ether (40-60) for 8 hours. Fat was determined by the difference of weight and expressed as the percentage.

Acid value

The principle of this methodology states that the acid value of the fat extracted from the grains equals the number of mgs KOH required to neutralize 1g of the fat. About 0.5-1.0g of the fat extracted from the grain by petroleum ether (40-60) was weighed into an Erlenmeyer flask. A solution of 50-100mL alcohol-ether mixture and 0.1 mL of phenophthaline was added to the mixture. This mixture was treated with 0.1N alc. KOH until permanent paint pink appears and persisted for ≥10 seconds. (JAOAC, 1969)

Acid value = mL alc. KOH x normality alc. KOH soln. x 56.1/g sample.

Peroxide value

A quantity of 0.5-1.0g of sample was weighed into a 250mL flask. Then, 30 mL of OHAc-$CHCl_3$ was added to the sample and the sample was dissolved. A solution of 0.5 mL KI soln. was added from Mohr pipet with occasional shaking for 1 min and 30 mL H_2O was added. The sample was slowly titrated with 0.N $Na_2S_2O_3$ with vigorous shaking until the yellow color was almost gone. Then ca. 0.5 mL 1% starch solution was added and the titration was continued, shaking vigorously to release all iodine from $CHCl_3$ layer until the blue color disappeared. A blank titration was done and subtracted from the sample titration. (J Am Oil Chem. Soc.1949) (AOCS Method Cd 8-53).

Peroxide value (milli equivalent peroxide/kg sample) = S x N x 100/g sample,
where S= mL $Na_2S_2O_3$ (blank corrected) and N = normality $Na_2S_2O_3$ soln.

Reducing sugar

The reducing sugars were extracted from the rice flour (60 mesh) following the method of AOAC (1984) (Method No. 14.024). The reducing sugars in the extract were determined following the method of Somogy (1952).

Fungus

The samples of grains were collected in a plastic container previously sterilized with alcohol. Potato dextrose agar medium were used as an isolation media (Sharf, 1966). The samples were diluted as per serial dilution method and plating was done using standard microbial techniques. The plates were incubated for 72 to 96 hours at 30°C and visible colonies were counted. The results were calculated as number of colonies present per gram of grain sample.

8. RESULTS AND DISCUSSIONS

STORAGE POSITION OF FOOD GRAINS IN SAMPLED DEPOTS AND GODOWNS

A summary of the food grain storage capacity and stock position of the sampled depots as of June, 2000, has been shown in Table 3 and in Figure 1. The storage capacity of the sampled depots varies between 500 and above 5000MT. The level of stock of food grains on 30th June, 2000, ranged above 100% to about 25% of the installed capacity. All the depots stored rice and wheat. Only 3 depots had oil and 9 had stored paddy (Annexure 1).

Table 4 and Figure 2 show the storage capacity of the sampled godowns in the selected depots and stock position of food grains. 24 godowns have the installed storage capacity of 500MT, 1 has 750 MT and 5 has 1000MT. 12 godowns stored food grains more than their installed capacity, 9 godowns stored 75-99%, 7 godowns stored 50-75% and 2 godowns stored 25-50% of their installed capacity (Annexure 2).

Table 5 and Fig. 3 show the summary of the time gap between the dates of stock entry of the grains and sample drawn for analysis (Annexure 5). The stock entry date ranged between May to November, 2000. All the grains were harvested in the summer of 2000 and the grains were of the *boro* season. The time gap ranged between 7 days to 6 months, but almost half of the samples have a time gap of 3-5 months. Such a time gap between harvesting and stock entry into the food godowns is common and natural, given the government's procurement procedures.

Table 3 — Food Grains Storage Capacity and Stock Position in Sampled Depots*

Storage Capacity (MT)	# of Depots	Present Stock	# of Depots
500-1000	4	Above 100%	5
1001-2000	10	75-100%	9
2001-3000	2	50-75%	11
3001-4000	5	25-50%	5
4001-5000	1	Less than 25%	0
5000- above	8		

* Stock on 30.6.2000

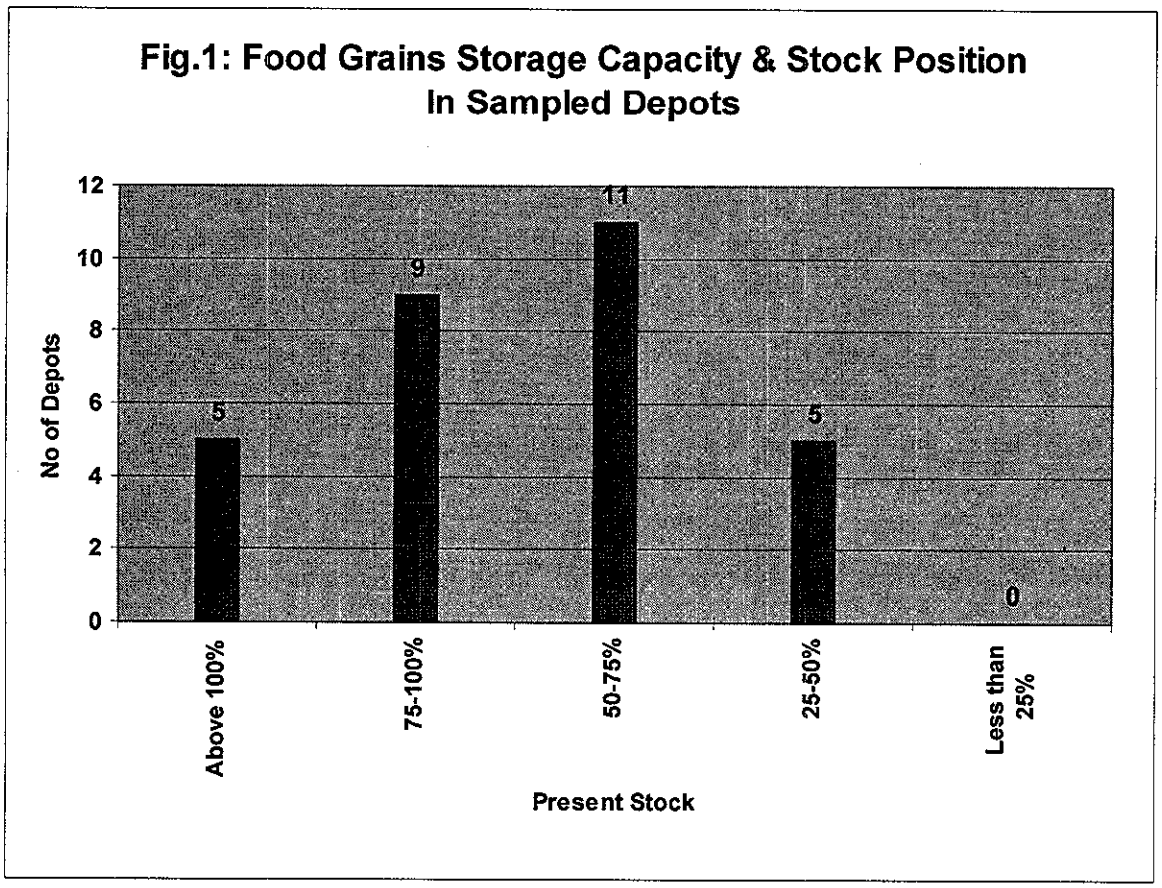


Table 4 — Storage Capacity and Present Stock of the Sampled Godown

Storage Capacity (MT)	# of Godowns	% of Storage Capacity used	# of Godowns
500	24	Above 100%	12
750	1	75-99%	9
1000	5	50-74%	7
		25-49%	2

* Stock on 30.6.2000

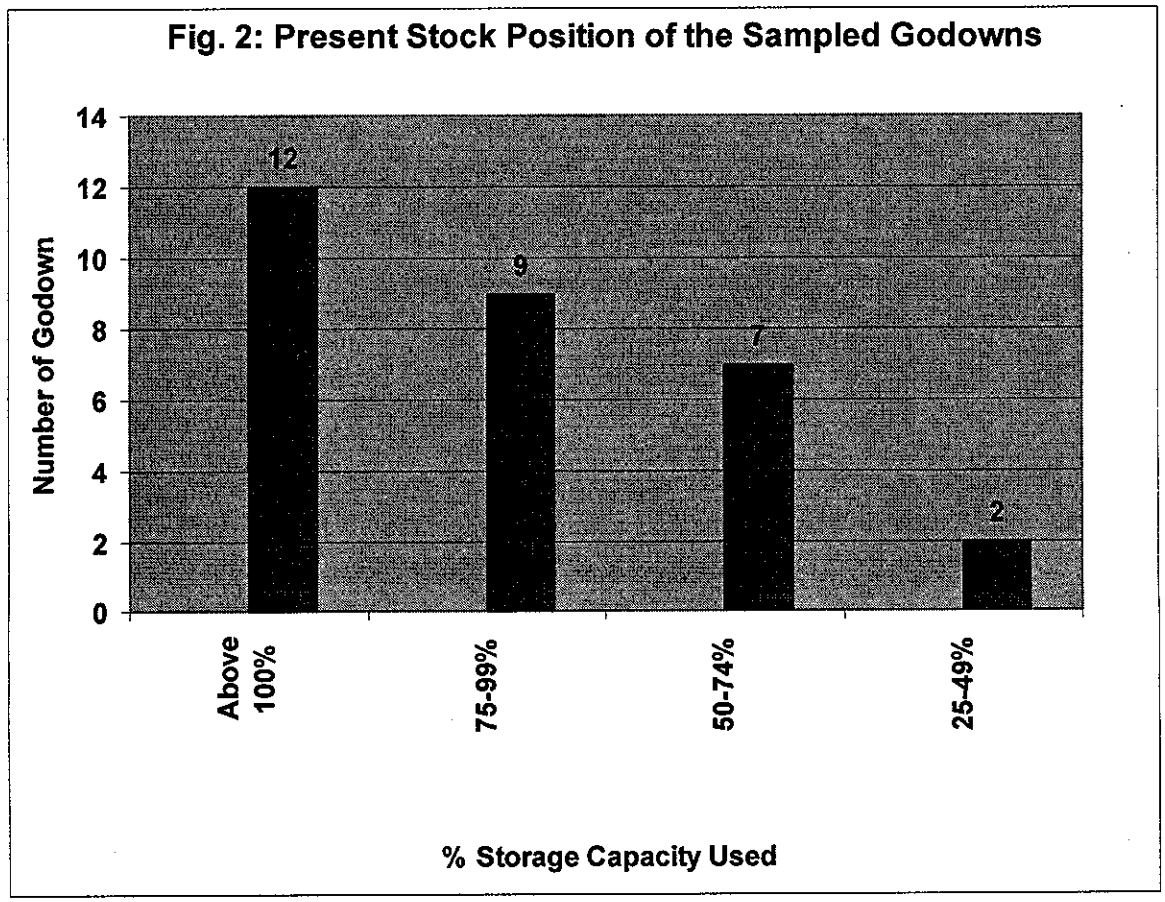


Table 5 — Time Gap Between Stock Entry and Sample Drawn

Time Interval	# of Samples
7 days to 1 month	3
1month to 2 months	3
2 months to 3 months	3
3 months to 4 months	7
4 months to 5 months	12
5 months to 6 months	2

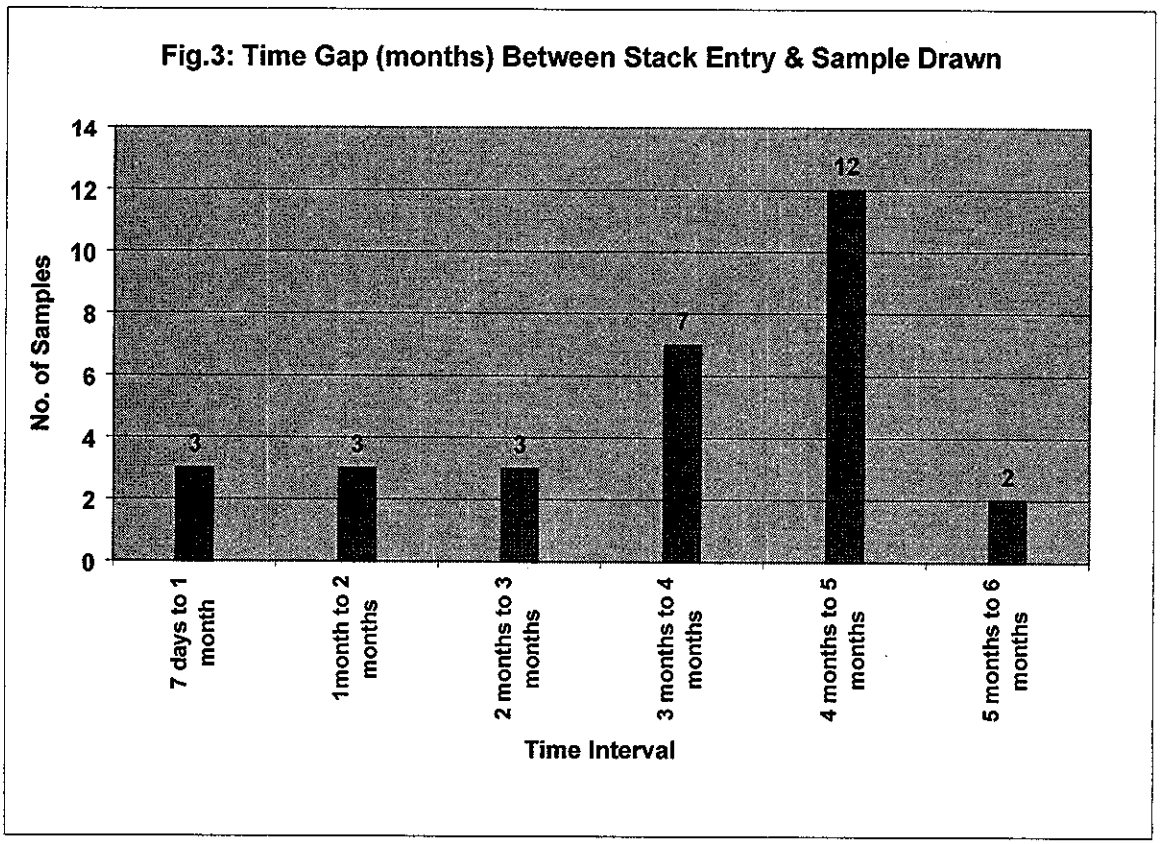


Table 6 — Year of Construction and Physical Condition of the Sampled Godowns

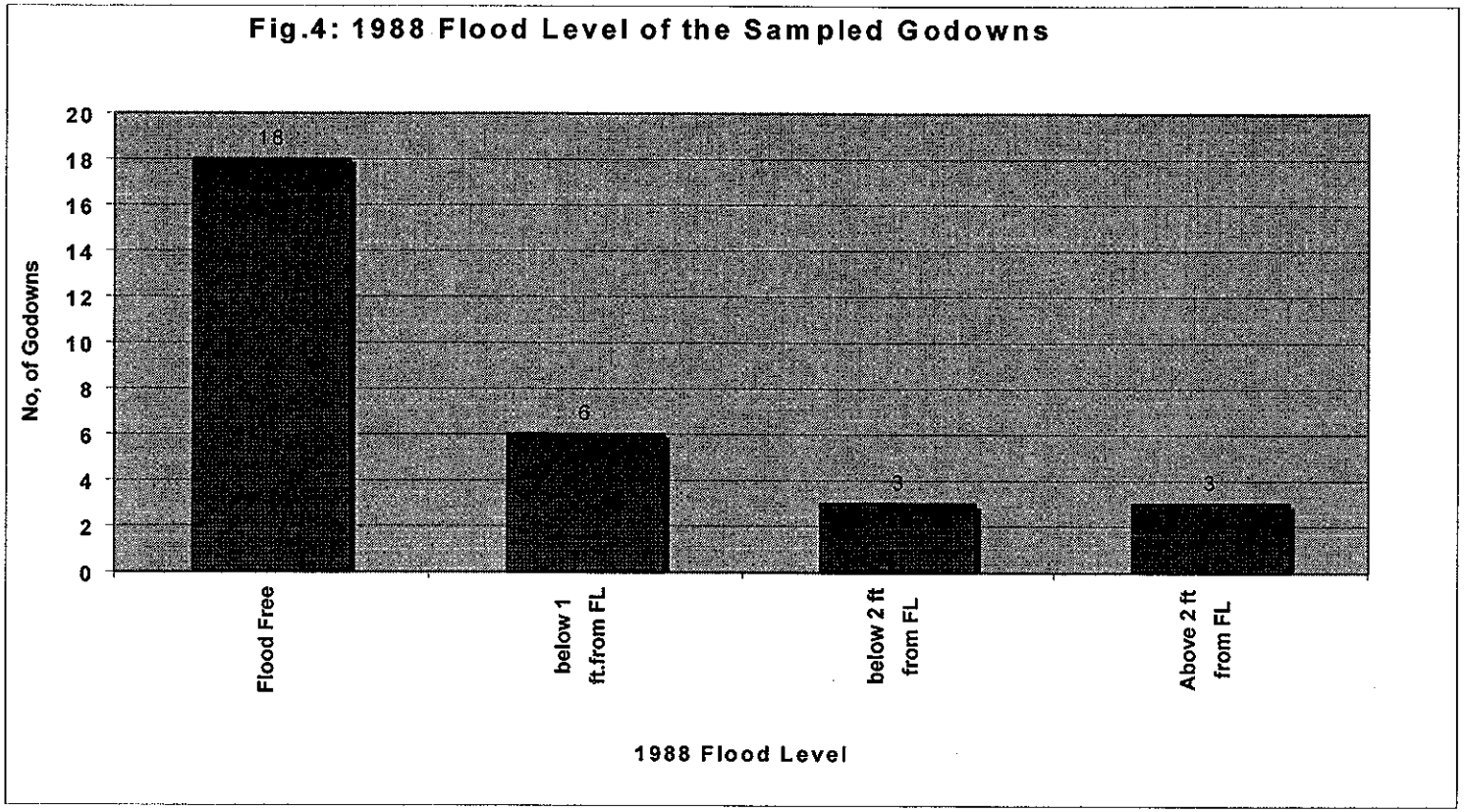
Year of Construction	# of Godowns	1988 Flood Level	# of Godowns
Before 1971	9	Flood Free	18
1971-1981	15	below 1 ft from FL*	6
1981-1991	5	below 2 ft from FL	3
1991-2000	1	Above 2 ft from FL	3

* Floor Level

Table 7 — Summary of the Changes of the Chemical Parameters Compared to the Age of the Grain in Storage

Parameter	Range	Average	SD	Correlation Coefficient [r]
Age of samples	7-180 days	101.90	43.06	
Moisture	11.01-14.66%	13.72	0.74	-0.08132
Fat	0.02-0.58%	0.26.	0.16	-0.05991
Acid value	4.4-7.9	6.39	1.10	0.83735
Peroxide value	10.1-17.39	14.15	2.26	0.83735
Reducing sugar	0.062-0.168	0.10	0.03	0.49748
Fungus	$1.0X10^2$- $33.3x10^4$	4.54×10^4	$9.64X10^4$	0.07084

Fig. 4: 1988 Flood Level of the Sampled Godowns



INFORMATION ABOUT THE PHYSICAL CONDITION OF THE GODOWNS

The godowns were constructed during the last part of the last century (Table 6). Some of them were renovated and structurally modified during the nineties. Most of the depots in the northwestern part of the country are located in flood free sites. The 1988 flood did not affect any godown but some of them were only marginally saved (Table 6, Fig. 4). Six godowns had damp walls. The floors of 9 godowns were fair and those of 5 were poor. The ceilings of 7 godowns were leaky. In summary, the physical condition of 5 godowns was bad. The door and ventilation system of all the godowns was good (Annexure 6).

PARAMETERS OF CHEMICAL CHANGES

Parameters of chemical changes of the grain samples collected during the 1st round have been determined (Table 7) (Annexure 7). The results were correlated with the time gap between the stock entry and the dates of sample drawn (age of the sample). The age of the sample varies between 7 to 180 days with an average of 101.90 days, having a SD of 43.06. It may be noted that all the samples were harvested during the summer season of 2000. So the net age of the sample appears to be almost identical. But for the sake of following the changes in the chemical parameters of the grain in the stores, the date of stock entry was considered as the starting date and the results were correlated accordingly. The moisture level of the grain samples ranged between 11.01- 14.66 % with the average of 13.72% having SD 0.74. It appears from the correlation coefficient (r) that the moisture level of the grains showed a decrease trend with age. It may also be noted that the moisture content of the grains naturally decreases with age, but the rate of decrease depends on a number of variables. Some of those factors are: initial moisture level, level milling, physical condition of the store, ventilation facilities in the store, container, temperature, humidity etc. (Bala, 1997, Pingale, 1978, Hall, 1980). In Bangladesh government stores, there is no system to control the variable except a ventilation system near the ceiling. Further, the temperature and humidity of the country

as a whole show a decreasing trend after the summer months, and reaches the lowest during the winter. These changes may leave some effect and influence the moisture level in the grains stored in the government stores.

Fat content of the grains normally depends on the degree of milling. Parboiled and milled polished rice contain almost similar amounts of fat that decrease with the age of the grains. (Rao. et al. 1954, Houston et al 1954) The acid value of the grain samples ranged between 10.1-17.39. The acid value of the samples is positively correlated with the age of the samples. The peroxide value of the analysed samples ranged between 10.1 to 18.8 wht the average of 14.15, having a standard deviation of 2.26304 and shows similar co-relation with age. A similar increase in peroxide values was also reported by Yasumatsu et al. (1966a; 1966b) and Tsuzuki et al. (1981). The change in the reducing sugar was negligible and the results are in agreement with Rao et al. (1954) and Sreenivasan (1939). The fungal load of the grains varied widely which may be due to the unhygienic handling of the grains during processing, milling and packaging. Teunissson (1954) reported almost similar fungal load in various rice samples having varying amounts of moisture.

It may be noted that only one sample of imported wheat was collected from a local silo. The origin and age of the sample could not be ascertained. Results obtained with wheat also vary with those of rice samples and no attempt was made to correlate the results with those of rice samples.

9. PRELIMINARY OBSERVATIONS AND CONCLUSIONS

The preliminary results of analysis conducted on the sampled grains indicate decreasing percentage of moisture, and increasing acid and peroxide values with increased age (time period between stock entry and sampling date). The fungal load of the sampled grains varies widely between samples taken from various government storage units. This variation is most probably attributable to the extent of contamination imparted to the grains during post harvest handling, processing, and storage.

Samples of rice and wheat were chemically analysed and parameters of change with subsequent samples will be recorded over a period of 6 months. These changes will be corroborated with age of the food grains as well as the physical conditions of storage.

The preliminary results reported here are only indicative of the chemical changes in food grains stored in government godowns by the first round of samples and analysis thereof. Conclusions may be drawn and appropriate recommendations may be made only after completion of the 4th round of analysis covering 6 months of storage life.

REFERENCES

AOAC, 1984. Official Methods of Analysis. Centennial Ed. Association of Official Analytical Chemists, Inc. Virginia. USA. P- 252.

AOCS Method Cd 8-53.

Bala, B.K. 1997. Drying and Storage of Cereal Grains. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, P-200.

BANSDOC, 1997. Directory of Bangladesh R & D Organizations and Their Current Scientific and Technological Research Projects. Bangladesh National Scientific & Technical Documentation Centre (BANSDOC), Dhaka.

Barre, H. J. 1954. Storage of cereal grains and their products. American Association of Cereal Chemist, Vol. II.

Bautista, G.M., Lugay, J.G., Lourdes, J.C. and Juliano, B.O. 1964. Glutamic acid decarboxylase activity as a viability index of artificially dried and stored rice. Cereal Chemistry 41 : 188.

Bull. Cent. Fd technol. Res. Inst., Mysore, 1955-56, 5, 50.

Chrastil, J. 1994. Effect of storage on the physicochemical properties and quality factors of rice. Rice Science and Technology, W.E. Marshall and J.I. Wadsworth, eds. Marcel-Dekker; New York, P 49-81.

Daftary,R.D. and Pomeranz,Y. 1965. Changes in lipid composition in wheat during storage deterioration. J. Agr. Food Chem. 13: 442.

Desikachar, H.S.R. 1956. Changes leading to improved culinary properties of rice on storage. Cereal Chemistry 33: 324.

Desikachar et al. Res. & Ind. 1957,2, 150.

Encyclopaedia Britannica, 1978. The Encyclopaedia Britannica, Macropaedia Vol.3, 15th Ed. P 1157-72.

FAO nutr. Stud., No. 1, 1954, 22-24

GOB, 1988. Food Policy, Government of Bangladesh.

Ghose, R.L.M., Ghatge, M.B. and Subrahmanyan, V. (1960). Rice in India. Indian Council of Agricultural Research, New Delhi, 2nd edn. -51).

Golumbic, C. and Laudani, H. 1966. Protecting our food. Yb. Agric. U.S. Dep. Agric.

Grist, G.H. Rice. Longmans, Green & Co., Ltd., London, 3rd ed., 1959, P-131.

Hall, D.W. 1980. Handling and Storage of Food Grains in Tropical and Subtropical Areas. Food and Agriculture Organization of the United Nations, Rome.p-47.

Hamaker, B.R., Siebenmorgen, T.J. and Dilday, R.H. 1993. Aging of rice in the first 6 months after harvest. Ark. Farm Res. 42(1): 8.

Houston,D.F., Hunter, I.R. McComb, E.A.and Kester, E.B. 1954. Deteriorative changes in the oil fraction of stored parboiled rice. Agricutural and Food Chemistry 2: 1185.

Houston,D.F., Hunter, I.R. and Kester, E.B. 1956. Storage changes in parboiled rice. Agricutural and Food Chemistry, 4: 964.

Houston,D.F., Ferrel,R.E., Hunter, I.R. and Kester, E.B. 1959. Preservation of rough rice by cold storage. Cereal Chemistry, 36: 103.

Houston,D.F., Hill, B.E., Garrett,V.H. and Kester,E.B. 1963. Organic acids of rice and some other cereal seeds. Agricultural and Food Chemistry, 11: 512.

Indudhara Swamy, Sowbhagya, C.M.and Bhattacharya, K.R. 1978. Changes in the physicochemical properties of rice with aging. J.Sci.Food Agric. 29 : 627.

Iwasaki, T. and Tani, T. 1967. Effect of oxygen concentration on deteriorative mechanisms of rice during storage. Cereal Chemistry 44: 233

JAOAC, 1969, 52: 235, 394

J Am Oil Chem. Soc., 1949, 26: 345

Joarder, G.K., Huq, M.S.,Khatun,M. and Huq, A.K.F. 1980. Studies on the incidence of fungul flora and determination of aflatoxin in rice in Bangladesh. A BCSIR-IDS Collaborative Research Project. Post-production workshop on Food Grains, December 12-14, 1980, BCSIR-Ford Foundation. Dhaka.

Karon, M.L. and Adams, M.E. 1949. Hygroscopic equilibrium of rice and rice frations. Cereal Chemistry. XXVI : 1.

Lee,T.C., Wu, W.T. and Williams,V.R. 1965. The effect of storage time on the compositional patterns of rice fatty acids. Cereal Chemistry. 42: 498.

Perdon, A.A., Marks,B.P., Siebenmorgen,T.J. and Reid, N.B. 1997. Effects of rough rice storage condition on the amylograph and cooking properties of medium-grain rice cv. Bengal. Cereal Chemistry 74: 864.

Pingale, S.V. 1961. Bulk Storage of Foodgrains. Rev. Fd. Technol. 3.

Pingale, S.V. 1978. Handling and Storage of Food grains. Indian Council of Agricultural Research, New Delhi, p74-118.

Pingale, S.V., Kadkol, S.B., Rao, M.N., Swaminathan, M. and Subrahmanyan, V. 1957. Effect of insect infections on stored grain. II. Studies on husked hand-ponded and milled raw rice, and parboiled milled rice. J.Sci.Food Afri. 8: 512.

Prado, F.A.D. and Christensen, C.M. 1952.Grain storage studies. XII. The fungus flora of stored rice seed. Cereal Chemistry 29: 456.

Rao, M.N., Viswanatha,T, Mathur, P.B., Swaminathan,M. and Subrahmanyan, V. 1954. Effect of storage on the chemical composition of husked, undermilled and milled rice. J.Sci.Food Agric. 5: 405.

Sabularse,V.C., Liuzzo,J.A., Rao, R.M. and Grodner,R.M. 1991. Cooking quality of brown rice as influenced by gamma irradiation variety and storage. J. Food Sci. 56:96.

Sharf, J.M. 1966. Recommended Methods for the Microbiological Examination of food (2nd Ed.). American Public Health Association Inc. New York, P-180.

Singh, D. and Chaudhary, F.S. 1986. Theory and Analysis of Sample Survey Designs. New Age Int. Ltd. New Delhi p-20.

Somogy, M. 1952. J. Biol. Chem. 195: 19.

Spiegel, M.R. 1972. Theory and Problems of Statistics. SI (metric) Ed. McGraw-Hill Book Co. Ltd. New York. P- 349.

Stahl, B.M. 1950. Grain Bin requirement. US Dept. agric. Circ. 835.

Subbia Pillai, 1958. Cultural Trials and practices of Rice in India. Indian Council of Agricultural Research, New Delhi, 80-82.

Subrahmanyan et al, J. Sci. Industr. Res., 1955, 14 A, 110;

Teunisson, D.J. 1954. Influence of storage without aeration on the microbial populations of rough rice. Cereal Chemistry 31. 462.

Villareal, R.M., Resurreccion, A.P., Suzuki, L.B. and Juliano, B.O. 1976. Changes in the physicochemical properties of rice during storage. Starch/Staerke, 28 : 88.

Wimberly, J.E., Technical Handbook for the Paddy Rice Postharvest Industry in Developing Countries. International Rice Research Institute, Philippines, 1983.

Yasumatsu, K., Moritaka,S. and Wada,S. 1966a. Volatile carbonyl compound of cooked rice. Agric. Biol.. Chem. 30:478.

Yasumatsu, K., Moritaka,S. and Wada,S. 1966b. Stale flavor of stored rice. Agric. Biol.. Chem. 30:483Tsuzuku,E., Tanaka,K. and Shida,S. 1981. Effect of storage condition on some fatty acids composition and flavor components in rice grains. Bull.Fac. Agr. Miyazaki Univ. 28 : 31.

ANNEXURES

Annexure 1 — Food Grain Storage Capacity and Stock Position in Sampled Depots

				Present Stock			
Sample Serial No.	Name of LSD/CSD/SILO	Total Storage Capacity (MT)	No of Godowns	Rice (MT)	Paddy (MT)	Wheat (MT)	Oil (MT)
4	Debigonj LSD	1000	2	1241.000	0.000	216.000	0.000
13	Pirgonj LSD	4500	6	3352.000	287.000	573.000	0.000
22	Chilahati LSD	1000	2	608.000	190.000	227.000	0.000
34	Birol LSD	2500	3	446.000	894.000	649.000	0.000
46	Monmothpur LSD	1500	3	1103.000	0.000	140.000	0.000
56	Rangpur LSD	5500	9	4632.000	0.000	583.000	0.000
65	Kurigram LSD	8000	11	4589.000	0.000	800.000	0.000
82	Kamdia LSD	2000	2	1226.000	0.000	62.000	0.000
86	Akkelpur LSD	2500	5	2330.000	0.000	27.000	0.000
97	Nozipur LSD	1250	2	538.000	0.000	4.000	0.000
112	Rohanpur LSD	6250	11	2780.429	851.124	332.270	0.000
129	Mirzapur LSD	1500	3	1619.280	0.000	105.395	0.000
136	Rajshahi LSD	5000	9	2742.797	0.000	473.778	84.545
157	Bagabari LSD	7000	7	3196.000	113.000	26.000	0.000
176	Nakla LSD	1500	3	681.969	0.000	424.064	0.000
199	Phulpur LSD	3500	6	1932.905	0.000	566.405	0.000
221	Bhairab LSD	4500	9	3128.085	0.000	437.014	0.000
245	Gopalpur LSD	2000	4	1216.915	19.690	467.204	0.000
266	Raipur Lsd	2000	3	999.504	0.000	1083.420	0.000
294	Gopalgonj LSD	2000	4	1493.057	0.000	457.639	6.837
329	Shailakupa LSD	2000	4	373.160	47.850	395.866	0.000
359	Parulia LSD	1000	1	233.000	70.000	205.000	0.000
404	Jhalokathi LSD	5125	10	2163.434	0.000	587.537	0.000
458	Chatak LSD	3400	7	1449.794	49.840	433.972	0.000
493	Saistagonj LSD	4000	5	3513.999	0.000	840.778	0.000
512	Dharmapur LSD	6500	11	2032.000	0	1771.000	181.000
536	Raipur LSD	1500	3	1290.000	0.000	151.000	0.000
576	Jurachari LSD	500	1	175.539	0.000	59.730	0.000
5	Tejgaon CSD	32500	38	20914.000	0.000	2.000	360.000
4	Ashugonj SILO	50000	84	0.000	0.000	15586.000	0.000

Annexure 2 — Storage Capacity and Present Stock of the Sampled Godown

Sample Serial No.	Name of the LSD/CSD/SILO	Storage capacity of the sampled godown(MT)	Present stock in the sampled godown(MT)	Present stock in the sampled stack(MT)	Date of entry of sampled stack
4	Debigonj LSD	500	690.000	136.000	16.8.2000
13	Pirgonj LSD	500	485.644	115.200	4.7.2000
22	Chilahati LSD	500	278.248	69.768	9.7.2000
34	Birol LSD	1000	518.960	105.600	29.7.2000
46	Monmothpur LSD	500	643.212	108.000	6.6.2000
56	Rangpur LSD	500	671.143	108.990	18.9.2000
65	Kurigram LSD	500	547.579	124.840	22.7.2000
82	Kamdia LSD	1000	702.400	104.355	31.7.2000
86	Akkelpur LSD	500	702.120	117.120	11.6.2000
97	Nozipur LSD	500	537.827	15.120	4.7.2000
112	Rohanpur LSD	750	856.800	95.200	31.5.2000
129	Mirzapur LSD	500	458.080	111.360	16.6.2000
136	Rajshahi LSD	500	478.877	110.000	10.6.2000
157	Bagabari LSD	1000	992.196	112.377	15.10.2000
176	Nakla LSD	500	277.299	35.360	30.8.2000
199	Phulpur LSD	500	470.000	130.000	29.6.2000
221	Bhairab LSD	500	600.000	100.000	19.6.2000
245	Gopalpur LSD	500	496.510	100.000	11.7.2000
266	Raipur Lsd	500	372.631	8.424	30.6.2000
294	Gopalgonj LSD	500	442.010	100.000	14.5.2000
329	Shailakupa LSD	500	373.160	99.896	30.6.2000
359	Parulia LSD	1000	233.225	31.652	1.11.2000
404	Jhalokathi LSD	500	525.692	89.004	23.9.2000
458	Chatak LSD	500	507.864	50.000	29.6.2000
493	Saistagonj LSD	500	645.268	102.800	28.6.2000
512	Dharmapur LSD	500	213.000	128.000	30.10.2000
536	Raipur LSD	500	580.320	33.960	25/8.2000
576	Jurachari LSD	500	415.668	57.224	7.8.2000
5	Tejgaon CSD	1000	532.000	93.705	10.9.2000
4	Ashugonj SILO*	500*	456.46*	456.46*	4.7.2000

* Wheat

Annexure 3 — Planned Dates of Drawing Samples

Sample Serial No.	Name of the LSD/CSD/SILO	1st Round	2nd Round	3rd Round	4th Round
4	Debigonj LSD	09/11/00	09/01/01	09/03/01	09/04/01
13	Pirgonj LSD	07/11/00	07/01/01	07/03/01	07/04/01
22	Chilahati LSD	10/11/00	10/01/01	10/03/01	10/04/01
34	Birol LSD	08/11/00	08/01/01	08/03/01	08/04/01
46	Monmothpur LSD	06/11/00	06/01/01	06/03/01	06/04/01
56	Rangpur LSD	11/11/00	11/01/01	11/03/01	11/04/01
65	Kurigram LSD	13/11/00	13/01/01	13/03/01	13/04/01
82	Kamdia LSD	05/11/00	05/01/01	05/03/01	05/04/01
86	Akkelpur LSD	04/11/00	04/01/01	04/03/01	04/04/01
97	Nozipur LSD	04/11/00	04/01/01	04/03/01	04/04/01
112	Rohanpur LSD	04/11/00	04/01/01	04/03/01	04/04/01
129	Mirzapur LSD	01/11/00	01/01/01	01/03/01	01/04/01
136	Rajshahi LSD	05/11/00	05/01/01	05/03/01	05/04/01
157	Bagabari LSD	01/11/00	01/01/01	01/03/01	01/04/01
176	Nakla LSD	08/11/00	01/01/01	01/03/01	01/04/01
199	Phulpur LSD	08/11/00	08/01/01	08/03/01	08/04/01
221	Bhairab LSD	07/11/00	07/01/01	07/03/01	07/04/01
245	Gopalpur LSD	09/11/00	09/01/01	09/03/01	09/04/01
266	Raipur LSD	10/11/00*	10/01/01	10/03/01	10/04/01
294	Gopalgonj LSD	09/11/00	09/01/01	09/03/01	09/04/01
329	Shailakupa LSD	07/11/00	07/01/01	07/03/01	07/04/01
359	Parulia LSD	08/11/00	08/01/01	08/03/01	08/04/01
404	Jhalokathi LSD	12/11/00	12/01/01	12/03/01	12/04/01
458	Chatak LSD	06/11/00	06/01/01	06/03/01	06/04/01
493	Saistagonj LSD	05/11/00	05/01/01	05/03/01	05/04/01
512	Dharmapur LSD	27/11/00	27/01/01	27/03/01	27/04/01
536	Raipur LSD	26/11/00	26/01/01	26/03/01	26/04/01
576	Jurachari LSD	04/11/00	04/01/01	04/03/01	04/04/01
5	Tejgaon CSD	26/10/00	26/12/00	26/02/01	26/03/01
4	Ashugonj SILO	26/11/00	26/01/01	26/03/01	26/04/01

Annexure 4 — Questionaire on Basic Information about Government Storage

BASIC INFORMATION ABOUT GOVERNMENT STORAGE

1. Sampling Code No. of the LSD/CSD/SILO----------
2. Name of the LSD/CSD/SILO----------
3. Address of the LSD/CSD/SILO : P.S.----------

   Dist.---------- Region----------
4. No. of godowns in the LSD/CSD/SILO----------
5. No. of Sampled godown ----------
6. Storage capacity of the sampled godown----------
7. Date of construction of the LSD/CSD/SILO (Sampled godown)----------
8. Date of last structural modification work done(Sampled godown)----------
9. Total Storage Capacity of the LSD/CSD/SILO----------
10. Names of grains normally stored. **Rice/Paddy/Wheat/----------**
11. Present stock : Paddy---------- Rice----------Wheat----------Others ---------
12. Stack position of the rice (Sample Godown):

SL. No	Stack No.*	Date of entry	Amount entered	Present stock	Comments
Total					

*----------

13. Information about the stack selected for sampling:

a) Stack selected for sampling : Stack No.----------

b) Domestic rice : season : Boro/Amon

c) Imported rice: Date of Import ----------

d) Marking on the stack/bags ----------

14. Physical condition of the LSD/CSD/SILO.

a) Wall : Brick/Concrete (Damp/Dry)

b) Floor : i) Good : (No cracks, no chips, dry);
ii) Fair : (Some cracks, holes, depression, damp/dry)
iii) Poor : (Large cracks, holes, depressions, damp/dry)

c) Ceiling : Dry/Leaky

d) Doors : Shutter/ Sliding (Damp/dry)

e) Ventilator : i) Upper : Yes/No. II) Lower : Yes/No

e) Remarks.----------

15. Use of insecticides ;

a) How many times insecticides were sprayed in the last six months-------

b) Date of last spray----------

c) Planned date of next spray ----------

d) Name(s) of the insecticides used ----------

16. Water level in 1988 flood : ---------- ft below the godown floor.

17. Any other information : ----------

Information provided by	**Information collected by**
Name----------	Name----------
Signature ----------	Signature ----------
Date----------	Date----------

Annexure 5 — Time Gap Between Stack Entry and Sample Drawn

Sample Serial No.	Name of the LSD/CSD/SILO	Date of entry of sampled stack	Date of sample drawn	Time between stack entry & sample drawn
4	Debigonj LSD	16.8.2000	9.11.2000	2months 23days
13	Pirgonj LSD	4.7.2000	7.11.2000	4months 3days
22	Chilahati LSD	9.7.2000	10.11.2000	4months 1 days
34	Birol LSD	29.7.2000	8.11.2000	3months 9days
46	Monmothpur LSD	6.6.2000	6.11.2000	5months
56	Rangpur LSD	18.9.2000	11.11.2000	1month 23days
65	Kurigram LSD	22.7.2000	13.11.2000	3months 21days
82	Kamdia LSD	31.7.2000	5.11.2000	3months 4days
86	Akkelpur LSD	11.6.2000	4.11.2000	4months 12days
97	Nozipur LSD	4.7.2000	4.11.2000	4months
112	Rohanpur LSD	31.5.2000	4.11.2000	5months 3days
129	Mirzapur LSD	16.6.2000	1.11.2000	4months 15days
136	Rajshahi LSD	10.6.2000	5.11.2000	4months 25days
157	Bagabari LSD	15.10.2000	1.11.2000	16days
176	Nakla LSD	30.8.2000	8.11.2000	2months 8days
199	Phulpur LSD	29.6.2000	8.11.2000	4months 12days
221	Bhairab LSD	19.6.2000	7.11.2000	4months 18days
245	Gopalpur LSD	11.7.2000	9.11.2000	3months 28days
266	Raipur Lsd	30.6.2000	10.10.2000	3months 10days
294	Gopalgonj LSD	14.5.2000	9.11.2000	5months 25days
329	Shailakupa LSD	30.6.2000	7.11.2000	4months 7days
359	Parulia LSD	1.11.2000	8.11.2000	7days
404	Jhalokathi LSD	23.9.2000	12.11.2000	1month 19days
458	Chatak LSD	29.6.2000	6.11.2000	4months 7days
493	Saistagonj LSD	28.6.2000	5.11.2000	4months 7days
512	Dharmapur LSD	30.10.2000	27.11.2000	27 days
536	Raipur LSD	25.8.2000	26.11.2000	3 months 1 day
576	Jurachari LSD	7.8.2000	4.11.2000	2months 28days
5	Tejgaon CSD	10.9.2000	26.10.2000	1month 16days
4	Ashugonj SILO	4.7.2000	26.11.200	4months 22days

Annexure 7 — Use of Insecticides in Sampled Godowns

Sample Serial No.	Name of the LSD/CSD/SILO	Times insecticides sprayed during last 6 months	Date of last spray	Proposed date of planned spray	Name of the insecticide used
4	Debigonj LSD	6	10.10.2000	10.11.2000	Actelic 50 EC(liquid)
13	Pirgonj LSD	6	23.10.2000	23.11.2000	Actelic 50 EC(liquid)
22	Chilahati LSD	6	12.10.2000	12.11.2000	Actelic 50 EC(liquid)
34	Birol LSD	3	31.8.2000	No expected date	Actelic 50 EC(liquid)
46	Monmothpur LSD	4	20.10.2000	20.11.2000	Actelic 50 EC(liquid)
56	Rangpur LSD	6	22.10.2000	22.11.2000	Actelic 50 EC(liquid)
65	Kurigram LSD	6	23.10.2000	23.11.2000	Actelic 50 EC(liquid)
82	Kamdia LSD	4	24.9.2000	6.11.2000	Actelic 50 EC(liquid)
86	Akkelpur LSD	2	18.10.2000	18.11.2000	Actelic 50 EC(liquid)
97	Nozipur LSD	5	2.11.2000	2.12.2000	Actelic 50 EC(liquid)
112	Rohanpur LSD	2	10.10.2000	10.12.2000	Actelic 50 EC(liquid)
129	Mirzapur LSD	3	19.10.2000	20.11.2000	Actelic 50 EC(liquid)
136	Rajshahi LSD	2	11.10.2000	10.12.2000	Actelic 50 EC(liquid)
157	Bagabari LSD	0	Not Yet	No expected date	N/A
176	Nakla LSD	3	1.11.2000	1.12.2000	Actelic(liquid) & Agriphos(solid tablet)
199	Phulpur LSD	6	29.9.2000	100.11.2000	Actelic(liquid) & Agriphos(solid tablet)
221	Bhairab LSD	3	26.9.2000	25.11.2000	Actelic 50 EC(liquid)
245	Gopalpur LSD	2	24.10.2000	25.11.2000	Actelic(liquid) & Agriphos(solid tablet)
266	Raipur LSD	Unknown	15.9.2000	No expected date	Actelic 50 EC(liquid)
294	Gopalgonj LSD	3	10.10.2000	15.11.2000	Actelic 50 EC(liquid)
329	Shailakupa LSD	Unknown	Not Yet	16.11.2000	Falithion
359	Parulia LSD	Unknown	Not Yet	No expected date	N/A
404	Jhalokathi LSD	1	9.10.2000	7.12.2000	Fenitri-Thion
458	Chatak LSD	3	5.10.2000	10.12.2000	Actelic(liquid) & Agriphos(solid tablet)
493	Saistagonj LSD	2	5.10.2000	7.11.2000	Actelic(liquid) & Methail Bromide(solid)
512	Dharmapur LSD	6	19.10.2000	No expected date	Actelic & Aluminum phosphate Fum.
536	Raipur LSD	3	2.11.2000	No expected date	Actelic and Agro. Phos.
576	Jurachari LSD	1	8.8.2000	10.11.2000	Actelic 50 EC(liquid)
5	Tejgaon CSD	1	6.9.2000		Actelic 50 EC(liquid)
4	Ashugonj SILO	No	Not Yet	N/A	N/A

Annexure 6 — Year of Construction & Physical Condition of the Sampled Godown

					Physical Condition				
Sample Serial No.	Name of the LSD/CSD/SILO	Year of construction of the godown	Year of last structural modification	Water level in 1988 flood	Wall	Floor	Celling	Door	Ventilator
4	Debigonj LSD	1980	1998	Flood Free	Dry	Fair	Dry	Sliding	Upper
13	Pirgonj LSD	1977	Not Yet	Flood Free	Dry	Fair	Dry	Shutter	Upper
22	Chilahati LSD	1984	1996	Flood Free	Dry	Fair	Dry	Sliding	Upper
34	Birol LSD	15.12.80	Not Yet	Flood Free	Dry	Fair	Dry	Sliding	Upper
46	Monmothpur LSD	1976	Not Yet	Flood Free	Dry	Poor	Leaky	Sliding	Upper
56	Rangpur LSD	1984	Not Yet	Flood Free	Dry	Poor	Dry	Shutter	Upper
65	Kurigram LSD	1981	Not Yet	Flood Free	Damp	Poor	Leaky	Shutter	Upper
82	Kamdia LSD	1981	Not Yet	Flood Free	Dry	Good	Dry	Sliding	Upper
86	Akkelpur LSD	19.8.95	Not Yet	Flood Free	Dry	Good	Dry	Sliding	Upper
97	Nozipur LSD	1977	1989	2 ft Below the Floor	Dry	Good	Leaky	Sliding	Upper
112	Rohanpur LSD	1977	1994	12 ft Below the Floor	Dry	Good	Dry	Sliding	Upper
129	Mirzapur LSD	1964	Not Yet	3 ft Below the Floor	Damp	Poor	Dry	Sliding	Upper
136	Rajshahi LSD	10.2.90	Not Yet	Flood Free	Dry	Good	Dry	Sliding	Upper
157	Bagabari LSD	1985	1999	5 ft Below the Floor	Dry	Good	Dry	Sliding	Upper
176	Nakla LSD	1974	Not Yet	0.25 ft Below the Floor	Dry	Good	Dry	Sliding	Upper
199	Phulpur LSD	1978	Not Yet	4 ft Below the Floor	Damp	Fair	Leaky	Shutter & Sliding	Upper
221	Bhairab LSD	1967	1993	2 ft Below the Floor	Dry	Fair	Dry	Shutter & Sliding	Upper
245	Gopalpur LSD	1958	Jun-00	0.5 ft Below the Floor	Dry	Good	Dry	Shutter & Sliding	Upper
266	Raipur Lsd	1980	1995-96	2 ft Below the Floor	Damp	Fair	Dry	Sliding	Upper
294	Gopalgonj LSD	1958	1991	1 ft Below the Floor	Dry	Good	Dry	Sliding	Upper
329	Shailakupa LSD	1978	1994	8 ft Below the Floor	Dry	Fair	Dry	Sliding	Upper
359	Parulia LSD	1982	Not Yet	7 ft Below the Floor	Dry	Good	Dry	Sliding	Upper
404	Jhalokathi LSD	1978	Not Yet	1 ft Below the Floor	Dry	Fair	Leaky	Sliding	Upper

Annexure 6 — Year of Construction & Physical Condition of the Sampled Godown (con't.)

					Physical Condition				
Sample Serial No.	Name of the LSD/CSD/SILO	Year of construction of the godown	Year of last structural modification	Water level in 1988 flood	Wall	Floor	Celling	Door	Ventilator
458	Chatak LSD	1964	1995	0.5 ft Below the Floor	Dry	Good	Dry	Shutter & Sliding	Upper
493	Saistagonj LSD	1981	1995	1 ft Below the Floor	Dry	Good	Dry	Shutter & Sliding	Upper
512	Dharmapur LSD	1963	Not yet done	Flood free	Damp	Poor	Leaky	Sliding	Upper
536	Raipur LSD	1969	1994	Flood Free	Dry	Good	Dry	Sliding	Upper
576	Jurachari LSD	1981	Not Yet	10 ft Below the Floor	Damp	Good	Leaky	Shutter	Upper
5	Tejgaon CSD	1958	1999-2000	Flood Free	Dry	Good	Dry	Sliding	Upper
4	Ashugonj SILO	1971	Not yet	Flood free	Dry	N/A	N/A	No	No

Annexure 7 — Use of Insecticides in Sampled Godowns

Sample Serial No.	Name of the LSD/CSD/SILO	Times insecticides sprayed during last 6 months	Date of last spray	Proposed date of planned spray	Name of the insecticide used
4	Debigonj LSD	6	10.10.2000	10.11.2000	Actelic 50 EC(liquid)
13	Pirgonj LSD	6	23.10.2000	23.11.2000	Actelic 50 EC(liquid)
22	Chilahati LSD	6	12.10.2000	12.11.2000	Actelic 50 EC(liquid)
34	Birol LSD	3	31.8.2000	No expected date	Actelic 50 EC(liquid)
46	Monmothpur LSD	4	20.10.2000	20.11.2000	Actelic 50 EC(liquid)
56	Rangpur LSD	6	22.10.2000	22.11.2000	Actelic 50 EC(liquid)
65	Kurigram LSD	6	23.10.2000	23.11.2000	Actelic 50 EC(liquid)
82	Kamdia LSD	4	24.9.2000	6.11.2000	Actelic 50 EC(liquid)
86	Akkelpur LSD	2	18.10.2000	18.11.2000	Actelic 50 EC(liquid)
97	Nozipur LSD	5	2.11.2000	2.12.2000	Actelic 50 EC(liquid)
112	Rohanpur LSD	2	10.10.2000	10.12.2000	Actelic 50 EC(liquid)
129	Mirzapur LSD	3	19.10.2000	20.11.2000	Actelic 50 EC(liquid)
136	Rajshahi LSD	2	11.10.2000	10.12.2000	Actelic 50 EC(liquid)
157	Bagabari LSD	0	Not Yet	No expected date	N/A
176	Nakla LSD	3	1.11.2000	1.12.2000	Actelic(liquid) & Agriphos(solid tablet)
199	Phulpur LSD	6	29.9.2000	100.11.2000	Actelic(liquid) & Agriphos(solid tablet)
221	Bhairab LSD	3	26.9.2000	25.11.2000	Actelic 50 EC(liquid)
245	Gopalpur LSD	2	24.10.2000	25.11.2000	Actelic(liquid) & Agriphos(solid tablet)
266	Raipur LSD	Unknown	15.9.2000	No expected date	Actelic 50 EC(liquid)
294	Gopalgonj LSD	3	10.10.2000	15.11.2000	Actelic 50 EC(liquid)
329	Shailakupa LSD	Unknown	Not Yet	16.11.2000	Falithion
359	Parulia LSD	Unknown	Not Yet	No expected date	N/A
404	Jhalokathi LSD	1	9.10.2000	7.12.2000	Fenitri-Thion
458	Chatak LSD	3	5.10.2000	10.12.2000	Actelic(liquid) & Agriphos(solid tablet)
493	Saistagonj LSD	2	5.10.2000	7.11.2000	Actelic(liquid) & Methail Bromide(solid)
512	Dharmapur LSD	6	19.10.2000	No expected date	Actelic & Aluminum phosphate Fum.
536	Raipur LSD	3	2.11.2000	No expected date	Actelic and Agro. Phos.
576	Jurachari LSD	1	8.8.2000	10.11.2000	Actelic 50 EC(liquid)
5	Tejgaon CSD	1	6.9.2000		Actelic 50 EC(liquid)
4	Ashugonj SILO	No	Not Yet	N/A	N/A

Annexure 8 — Analysis of First Round Rice Samples

Sample Serial No.	Name of the LSD/CSD/SILO	Date of sample drawn	Days between stack entry & sample drawn	Moistur%	Fat%	Acid Value	Peroxide value	Reducing sugar	Fungus	Fungus
4	Debigonj LSD	9.11.2000	83	14.68	0.15	4.4	12.4	0.093	$33.2x10^4$	332000
13	Pirgonj LSD	7.11.2000	123	14.14	0.21	7.3	13.9	0.093	$14.0x10^2$	1400
22	Chilahati LSD	10.11.2000	121	13.61	0.12	6.9	12	0.092	$26.0x10^4$	260000
34	Birol LSD	8.11.2000	99	13.97	0.28	7	12.5	0.128	$1.0x10^2$	100
46	Monmothpur LSD	6.11.2000	150	13.66	0.21	7.5	16	0.097	$26.0x10^2$	2600
56	Rangpur LSD	11.11.2000	53	13.92	0.55	6	10.1	0.062	$2.0x10^2$	200
65	Kurigram LSD	13.11.2000	111	13.80	0.21	7.1	12.3	0.075	$13.0x10^2$	1300
82	Kamdia LSD	5.11.2000	94	13.92	0.01	6.2	11.6	0.083	$12.2x10^4$	122000
86	Akkelpur LSD	4.11.2000	132	13.48	0.29	7.1	12.9	0.106	$5.0x10^2$	500
97	Nozipur LSD	4.11.2000	120	12.65	0.39	5.8	12.6	0.075	$10.9x10^4$	109000
112	Rohanpur LSD	4.11.2000	153	14.02	0.39	7.9	17.36	0.097	$70.0x10^2$	7000
129	Mirzapur LSD	1.11.2000	135	12.62	0.31	7.1	17.39	0.119	$60.0x10^2$	6000
136	Rajshahi LSD	5.11.2000	145	14.62	0.27	7.3	16.9	0.107	$56.0x10^2$	5600
157	Bagabari LSD	1.11.2000	16	13.00	0.32	5	12	0.105	$13.2x10^2$	1320
176	Nakla LSD	8.11.2000	68	13.90	0.3	5.8	11	0.105	$10.0x10^2$	1000
199	Phulpur LSD	8.11.2000	132	14.02	0.58	7.1	14	0.150	$33.3x10^4$	333000
221	Bhairab LSD	7.11.2000	138	13.92	0.36	7.3	15.2	0.098	$7.0x10^2$	700
245	Gopalpur LSD	9.11.2000	118	13.69	0.5	6.8	14.5	0.107	$61.0x10^2$	6100
266	Raipur Lsd	10.10.2000	100	11.01	0.46	7	13.9	0.168	$3.5x10^2$	350
294	Gopalgonj LSD	9.11.2000	175	14.36	0.12	7.2	18.8	0.054	$12.1x10^3$	12100
329	Shailakupa LSD	7.11.2000	127	13.12	0.01	6.1	17.38	0.086	$15.0x10^2$	1500
359	Parulia LSD	8.11.2000	7	14.23	0.31	4.8	17.21	0.125	$1.0x10^2$	100
404	Jhalokathi LSD	12.11.2000	49	14.68	0.02	5	12.6	0.127	$1.0x10^2$	100

Annexure 8 — Analysis of First Round Rice Samples (con't)

Sample Serial No.	Name of the LSD/CSD/SILO	Date of sample drawn	Days between stack entry & sample drawn	Moistur%	Fat%	Acid Value	Peroxide value	Reducing sugar	Fungus	Fungus
458	Chatak LSD	6.11.2000	127	13.56	0.11	7.5	13.9	0.128	$25.0x10^3$	25000
493	Saistagonj LSD	5.11.2000	127	13.31	0.09	7.1	17.01	0.085	$25.0x10^3$	25000
512	Dharmapur LSD	27.11.2000	27	14.03	0.08	5	12.6	0.085	$59.0x10^3$	59000
536	Raipur LSD	26.11.2000	91	14.41	0.28	5.4	14	0.129	$1.0x10^2$	100
576	Jurachari LSD	4.11.2000	88	13.88	0.14	5.4	14.6	0.110	$20.0x10^2$	2000
5	Tejgaon CSD	26.10.2000	46	13.72	0.54	5.1	13.6	0.075	$26.3x10^2$	2630
4	Ashugonj SILO	26.11.200	142	11.79	1.62	17.1	37.46	0.243	$7.10x10^2$	710
Average			**101.8965517**	**13.72**	**0.26241379**	**6.39**	**14.15**	**0.102**		**45437.93103**
Standard Deviation			**43.05672739**	**0.740260905**	**0.16450478**	**1.008083**	**2.26303727**	**0.025315692**		**96485.1358**
Correlation				**-0.081320895**	**-0.0599156**	**0.837349**	**0.83734944**	**0.497479724**		**0.070839216**

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FMRSP Bangladesh

Food Management & Research Support Project
Ministry of Food, Government of the People's Republic of Bangladesh

International Food Policy Research Institute

The FMRSP is a 3.5 year Project of the Ministry of Food, Government of the People's Republic of Bangladesh, providing advisory services, training and research, related to food policy. The FMRSP is funded by the USAID and is being implemented by the International Food Policy Research Institute (IFPRI) in collaboration with the Food Planning and Monitoring Unit (FPMU) of the Ministry of Food, the Bangladesh Institute of Development Studies (BIDS), the University of Minnesota and International Science & Technology Institute (ISTI).

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