# Strategies to Maintain Grain Quality in the Humid Tropics

**Mulyo Sidik***

## Abstract

Indonesia like any other tropical countries, has experienced very high losses due to its inability to maintain grain quality. Various pests of stored products cause loss and damage to stored grain, and among those pests, insects and fungi contribute most significantly to the loss. In addition, the initial quality of grain prior to storage exerts a significant effect on the storability of the grain. Therefore, grain drying, processing and treatment carried out by farmers should be observed to ensure the initial quality of the grain.

To overcome the problems, a concept of integrated storage pest management has been implemented since the early eighties in the storages managed by the National Logistics Agency (BULOG), which enabled to minimize loss and maintain the grain quality successfully.

The concept basically integrates all measures to remove factors affecting grain quality deterioration from the stored grain. The strategy starts with the selection of grain quality during the procurement, maintenance of the hygiene and sanitation of storages throughout the storage period, inspection, application of various pest control measures and the implementation of controlled atmosphere storage technology for grain intended for long-term storage. The combination of measures which are applied in a fully integrated manner leads to a more efficient and cost-effective grain quality maintenance.

The management plays a key role in determining the successful adoption of such a strategy, since the decision on determining and selecting grain for storage will have a direct impact on the measures taken to maintain the grain quality.

## Introduction

It is generally recognized that tropical countries encounter serious problems in maintaining grain quality during storage due to among others, infestation of insect pests, fungal infection, and vertebrate pest invasion such as rodents and birds. Significant losses occurring annually bring about tremendous quantitative and qualitative losses of grain stored in various storages. Suitable climatic conditions for the development of insects and microorganisms coupled with improper postharvest processing of grain accelerate the deterioration process of grain during storage.

Furthermore, in addition to the highly conducive environment to the growth of insects and microorganisms, the physical characteristics of the grain itself accelerate the deterioration of quality. High-yielding varieties of rice for instance, basically are prone to shattering and the non-uniform maturity causing a high percentage of chalky grains, creates problems and

* Ministry of Food and Horticulture, Indonesia

difficulties in harvesting, threshing, milling and storage. As a result, rapid degradation of the grain quality occurs during storage.

Losses during storage actually offset the large amount of energy spent to increase grain production to ensure the availability of food for the people. Inability to preserve the quality of grain and prevent grain from insect and fungal infestations that cause deterioration and weight reduction, have hampered efforts in improving food availability as a strategy to strengthen food security in the country. Therefore it is obvious that greater benefit could be derived if grain protection and quality maintenance programs could be intensively conducted to minimize storage loss.

Although efforts to maintain grain quality have been made and various technologies have been developed and implemented, the problems still persist particularly in tropical developing countries, where in fact the availability of grain with good and safe quality is very much needed. Therefore, to overcome such problems, efforts should be geared towards the integration of various methods which have been found to be successful and cost-effective. The Integrated Storage Pest Management (ISPM) system which has been implented in BULOG storage complexes throughout Indonesia since the 1980s can be used as an example of strategy to overcome problems in maintaining grain quality during storage. However, it should be pointed out, that the BULOG system may not be applicable to other countries, since pest management is area-specific, and factors influencing the decisions made to implement certain measures to maintain grain quality have to be based on the conditions in that particular area.

## Factors influencing stored grain quality

The spatial distribution of stored commodities and the period during which they are stored are primarily determined by the needs of a supply system, which is generally related to the government policy on grain distribution. For cereal grains, in developing countries, a large proportion of grain is stored by the private sector, including farmers, grain traders, processors and only a small percentage is stored in government storage complexes. Storage and distribution patterns and duration of the storage period will certainly affect significantly the strategy and extent of pest management.

Storage period in BULOG godowns normally ranges from 3 to 6 months for short-term storage and up to 24 months or even longer for long-term storage, which very much depends on the supply of grain in the country. In the case of abundant harvest and large supply, a storage period of 2-3 years seems to be normal. The duration of the period of storage and the pattern of distribution will determine the method applied to maintain grain quality.

Generally several factors are taken into account in selecting the method used for preserving the quality of grain, which influence the process of quality deterioration in stored grain. These important factors are as follows:

### 1 Initial quality of grain prior to storage

The initial quality of grain entering the storage plays an important role in determining the fate of the grain itself throughout the storage period. Quality changes taking place in stored grain are apparently very much influenced by the treatment adopted at the farmers' level such

as cleaning, threshing, milling and other treatments carried out in the case of on-farm storage. The overall output of these treatments certainly determines the initial quality of grain entering the main storage facility and inevitably its effect will be further enhanced during the storage period (Sidik, 1997). It should be pointed out, however, that storage treatment will not be able to improve the quality of the stored grain unless the grain is reprocessed prior to distribution. Efforts to minimize pest infestation are primarily targeted to keep the grain quality which in turn maintains the high value of grain even after storage for a long period of time.

Several methods are used to classify the "original" quality of grain, such as moisture content of the grain, milling degree, percentage of broken kernels, foreign materials, percentage of chalky kernels, number of insects, occurrence of mold, etc. All of those factors are normally set-out in the quality standards based on a certain grade as determined by the consumers' preference reflected in the market or by the owner of the storage complex.

## 2 Physical structure of the storage

The pattern of storage including location, storage period and physical structure of the storage obviously exerts a significant influence on the grain quality maintenance programs. Ideally physical structure of storage should be suited to the type of commodity to be stored, type of pest control treatment applied to reduce insect infestation and the duration of the storage period. An airtight storage for example, certainly increases the efficiency of fumigation or application of controlled atmosphere storage system or surface spraying with contact insecticides.

In developing tropical countries, however, such ideal conditions are not always realized. Instead it is commonly observed that grain is stored in storages which are not suitable for storing grain due to the shortage of good storages, particularly during a bumper harvest. Poor storage conditions certainly affect the process of quality deterioration during the storage period where changes in the physiological and chemical properties of grain such as changes in appearance, taste and palatability, cooking quality, and reduction in nutrient contents commonly occur (Unnevehr *et al.*, 1992 ; Damardjati and Oka,1992).

## 3 Pest status in the storage

Various pests are commonly found in storage complexes in tropical areas, but the level of infestation varies from area to area. Fluctuation of insect pest population is very much influenced by factors such as climatic conditions, type of commodity stored and storage sanitation level. Severe pest infestation will bring about significant qualitative and quantitative losses of grain stored in the godowns. It has been observed that the association of various species of insect pests may have synergetic effects which exacerbate the process of quality degradation of the grain (Sidik and Pranata, 1988). Therefore monitoring of pest populations should be carried out routinely as an integral part of pest management.

## 4 Treatments during the storage period

The magnitude of the treatments applied during the storage period aims at ensuring that the process of quality deterioration can be slowed-down by using various measures. The treatments include efforts to ensure sanitation and hygienic conditions of storage, application

of chemical and non-chemical methods, such as grain cooling, aeration and controlled atmosphere storage technology. The concept of maintaining the store hygiene as a prerequisite of storage management is sometimes questionable, particularly in tropical areas where insect infestation is practically difficult to avoid and intensive cleanliness may not be economically justifiable. But orderliness and hygienic conditions will undoubtedly contribute to preventing rodents from staying in the storage, and to the easy detection of insect infestation. Such conditions will have a positive impact on the overall strategy of pest management.

In the application of non-chemical treatment, a good storage structure may have a synergic effect since it can provide a physical barrier to bag stack storage which in turn gives a good protection from insect infestation, reduces humidity and enables the application of controlled atmosphere system. It is expected that as a result of the treatments applied during the storage period, quality can be preserved and the grain value can be retained and finally that the consumers will be satisfied.

The interrelationship of the above-mentioned factors in the case of on-farm storage, including initial condition of the grain and large-scale storage complex and the output of overall treatment is depicted in Figs. 1 and 2.

## Problems and constraints in grain quality maintenance

Quality maintenance principally should be pursued thoroughly in the postharvest system, starting with the production, processing, storage until the grain is ready for consumption, since in each component of the system it is always possible that the quality of the grain may

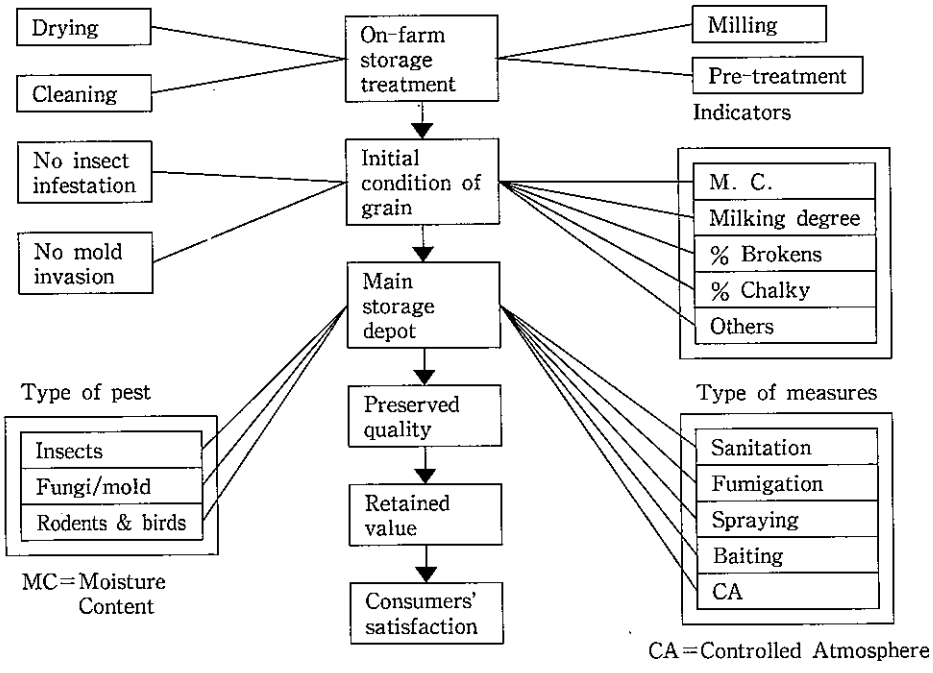


**Fig.1 Relationship of factors influencing grain quality**

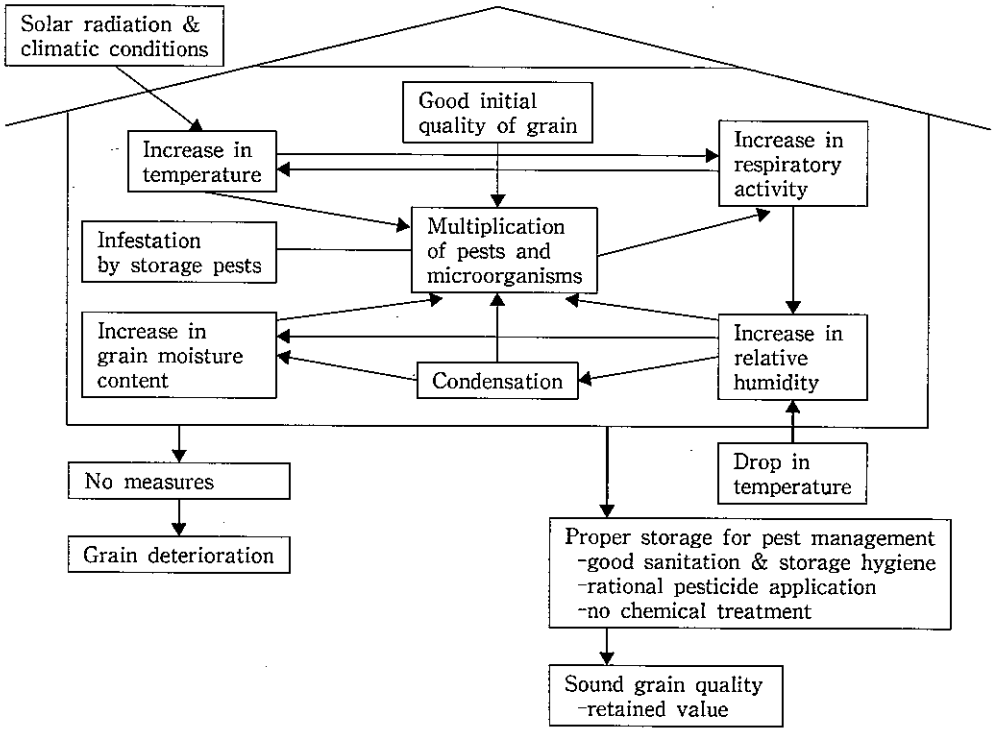


**Fig.2 Interrelationship of factors in storage system**

deteriorate. And we all know that such a process involving either physiological or chemical changes can not be stopped completely but that the process can be retarded by various methods.

Storage as an integral part of the postharvest system is generally considered to be the most vulnerable period for grain deterioration in humid tropical areas. Hot and humid conditions throughout the year provide a suitable environment for the development of pests and micro-organisms and as a result, the quality of grain cannot be maintained. Therefore efforts to minimize the impact of various factors influencing grain quality degradation should be made at the early stage (Sidik, 1997).

The adoption and implementation of pest management basically aim at reducing the process of deterioration which occurs during the storage period. In this regard, the ability to identify the key problems and find the best solution are the most important steps to be taken by decision-makers. There are problems and constraints in maintaining the grain quality in the storage and these problems are not only technical but also socio-economic, among others:

## 1 Lack of national grades and standards for grain

Grades and standards are used to facilitate grain trading, particularly to evaluate the quality and safety aspects of a commodity. The lack of a proper grading system results in the identification of grades based on subjective judgement made by the trader or grain processors, and price manipulation is commonly practiced at the expense of farmers. Therefore it is obvious that farmers are not eager to produce good quality grain since there is no incentive for them to produce better quality product, which is basically an important factor in determining

the quality of grain prior to storage. This situation apparently is commonly found in the ASEAN region, such as the Philippines and Malaysia (Sison and Valdez, 1992).

## 2 Lack of postharvest facilities

Grains such as paddy are normally threshed, dried, stored and then milled before being ready for further processing or consumption. In tropical areas where solar drying is still predominantly practiced by farmers, traditional methods including the use of concrete floors or even public roads are applied. Sun-drying is certainly cheap as compared to mechanical drying, but it contributes to grain quality deterioration, and losses during the drying process are excessively high. Mechanical drying is not popular due to economic and technical reasons, and farmers still prefer to use sun-drying.

Storage and milling facilities are not always readily available or adequate for processing of grain during the harvest season. At the farm level, storage is very simple, consisting of structures using bamboo, wood and does not meet hygienic standards. It is not surprising, therefore that grain stored under such conditions shows an inferior quality, and becomes a source of problems in large-scale storages like main godowns owned by the government.

Inadequate milling facilities in the village area have required the utilization of old inefficient milling units such as Engelberg type rice mill units. As a result, such milling units lead to a high percentage of brokens, low percentage of head rice, low milling recovery, etc., which basically cannot give maximum benefits to farmers since the price of this rice is lower than that of high quality rice.

## 3 Lack of knowledge in pest management

Since most of the farmers are not getting enough education, they do not really understand the basic principles of storage entomology, management and other types of knowledge which are important tools in maintaining grain quality. Knowledge of how to operate a processing unit, mechanical dryer or other postharvest facilities is needed in order to produce better quality products. Problems in this aspect are even more serious if there is an inadequate supply of spare-parts of equipment, which brings about inefficient operation of the equipment and creates dependency on the supplier of these machines.

In addition, farmers are not really aware of the importance of pest control measures to eliminate pests which cause tremendous quantitative and qualitative losses during storage. The lack of availability of pest control equipment and pesticides suitable for controlling various species of pests certainly creates another problem in maintaining the quality. Another factor that hinders the application of pest control measures is the inadequate financial support from the government through provision of special credit line with low interest, tax exemption for imported postharvest equipment, or special arrangement on non-collateral credit particularly for purchasing postproduction machinery.

## 4 Absence of strong linkages in research and extension

Research in various fields to promote the reduction in quality degradation has been carried out at research institutions, universities and ministries responsible for this aspect. Although significant results have been reported, there are no strong linkages between research and

extension to actually apply the output of the research to action programs. It is commonly observed that the developed and tested technology is not properly disseminated to target groups (i.e. farmers, millers or grain processors) and most of the findings just laid idle on the shelf at research institutions. In addition, the seemingly untapped or under-utilized developed technology by users is due to the lack of monitoring and evaluation of the application of the new technologies. Grain processors may not be aware about the available new technology to improve the performance of their postharvest facilities. Therefore an institution responsible for compiling and monitoring research findings and developed technology, and also bridging the gap between researchers and end-users may enable to overcome these problems.

## Integrated Storage Pest Management: a strategy to maintain grain quality

Basic strategy to maintain grain quality is how to manage the major factors of grain deterioration to a level which only causes a minimal negative impact on the grain, with the most cost-effective ways and negligible impact on the environment. This strategy can then be translated into the implementation of good storage management practices. All the preventive measures, either pest control, adherence to quality standards in purchasing grain or improving storage sanitation must aim at achieving the ultimate objectives.

BULOG Integrated Storage Pest Management (ISPM) principally adopts that strategy, which covers the following aspects:

### 1 Ensuring storage sanitation and hygiene

It is mandatory that prior to receiving rice, the storage has to be cleaned thoroughly, including walls, floor inside and outside. Cracks, crevices, leakage on the roof should be plastered and fixed to avoid the penetration of insects, in that area, which may become a source of infestation. In this case an inspection program to check the physical structure of the storage is set-up to support the overall sanitation program. The storage then should be sprayed with contact insecticides as a preventive measure to minimize insect populations. Maintenance of storage hygiene and sanitation is carried out routinely, whereas regular spraying and fumigation are performed whenever population built-up has reached a certain level. Spraying of surface fabrics is also performed prior to fumigation of the stored commodity, which is normally conducted at three-month intervals and sometimes surface spraying is also conducted on a monthly basis depending on the occurrence of insect pests.

### 2 Adherence to quality standard during procurement

Quality standard is set-out as a basic guideline to determine the quality of rice purchased by BULOG, during the procurement season. With sound conditions of the grain upon reception, the function of storage management is only to prevent the grain from insect infestation, fungal infection and to slow down the deterioration process by using various methods including controlled atmosphere storage system.

## 3 Rational use of pesticides

The use of chemicals to protect grain from insect infestation is still predominant throughout the world, but excessive use of pesticides causes problems of pesticide residues, insect resistance and pollution of the environment. Therefore, to optimize the application of this method, monitoring of insect populations by using bait bag traps or other types of insect traps, is recommended. Carrying out treatment just based on calendar may induce excessive use of pesticides which may not be economical. In addition, implementation of proper procedures of pesticide application, such as improving sealing technique of fumigation, applying low concentration of fumigants, etc. will certainly enhance the efficiency and rationalize the use of pesticides.

## 4 Monitoring of insect resistance

The development of insect resistance to insecticides is apparently very much influenced by various factors such as a severe selection pressure. Underdosage application or improper use of pesticides may lead to "under-treated" insects which, if associated with untreated ones, could result in the development of resistant strains. Therefore, efforts to minimize selection pressure on the pest population to a level equivalent to other selection pressures may offset any trend toward resistance. This can be achieved by, among others, avoiding all but absolutely necessary treatments and utilizing as many alternative control procedures as possible, so that full dependence on chemical treatment can be avoided. Monitoring and evaluation programs to check the level of pesticide resistance in major storage pests are indeed very important, not only to confirm the efficacy of a particular pesticide but also to prevent the development of resistance.

## 5 Encourage the use of non-chemical treatment

The increasing demand on the part of consumers for residue-free grain has resulted in minimal application of pesticides to maintain grain quality. Among the alternatives to pesticide use, sealed storage, controlled atmosphere storage system, the combination of cooling and aeration and physical barriers to prevent grain from insect reinfestation are widely recommended. The retention of a plastic enclosure after fumigation is an example of application of a physical barrier, which is widely used. BULOG uses carbon dioxide as fumigant in the controlled atmosphere storage for maintaining the quality of grain stored for more than 12 months.

## 6 Strong support and commitment on the part of the management

The failure of most integrated pest management programs to maintain grain quality is very much influenced by the decision made by the management. A good program without strong commitment from the line manager is likely to end up with failure. Therefore, the person responsible for the implementation of ISPM has to convince the decision-makers that the program must be implemented consistently, otherwise grain quality cannot be maintained, resulting in financial loss and loss of trust of the consumers.

To obtain the support and commitment of the decision-makers, relevant information on various aspects of storage management including pest status, pest control measures, etc. should

be clearly conveyed to the line managers. Based on the information and data obtained, the decision-maker can select the best measure for a particular condition in implementing the ISPM.

## Conclusion

Stored grain will always experience quality degradation, but such a process can be slowed-down by various measures, among others by integrating all preventive measures, pest control and management of procurement. Initial condition of the grain plays an important role in avoiding the acceleration of quality deterioration of stored grain. The deterioration process will be accelerated by the presence of insect pests and fungi.

Chemical treatments still play a predominant role in keeping the quality of grain, either by application as surface fabrics spraying or fumigation. With the increasing awareness on the use of pesticides, improvement in the application procedures and stringent control, together with the application of non-chemical treatments as alternatives measures are deemed necessary.

Integrated Storage Pest Management as a strategy to solve problems of maintenance of grain quality during storage which has been implemented by BULOG, principally requires a multi-disciplinary approach. The basic framework is to adhere to quality standards during procurement to ensure sound initial grain quality, provide a good physical storage structure, maintain maximum levels of storage hygiene and sanitation, apply pesticides in the most cost-effective and efficient manner, promote the application of non-chemical measures and generate strong commitment on the part of the management. Efforts to reduce the process of quality deterioration of stored grain, particularly in the humid tropics, should be directed toward the integration of all the measures, both preventive and control treatments, to achieve the ultimate objective of maintaining grain quality, minimizing losses, ensuring the safety of the grain in the most cost-effective ways while at the same time minimizing the negative impact on the environment.

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