# A study in the determination of quality/value relationships in rice (NRI Bulletin 55)

Natural Resources Institute

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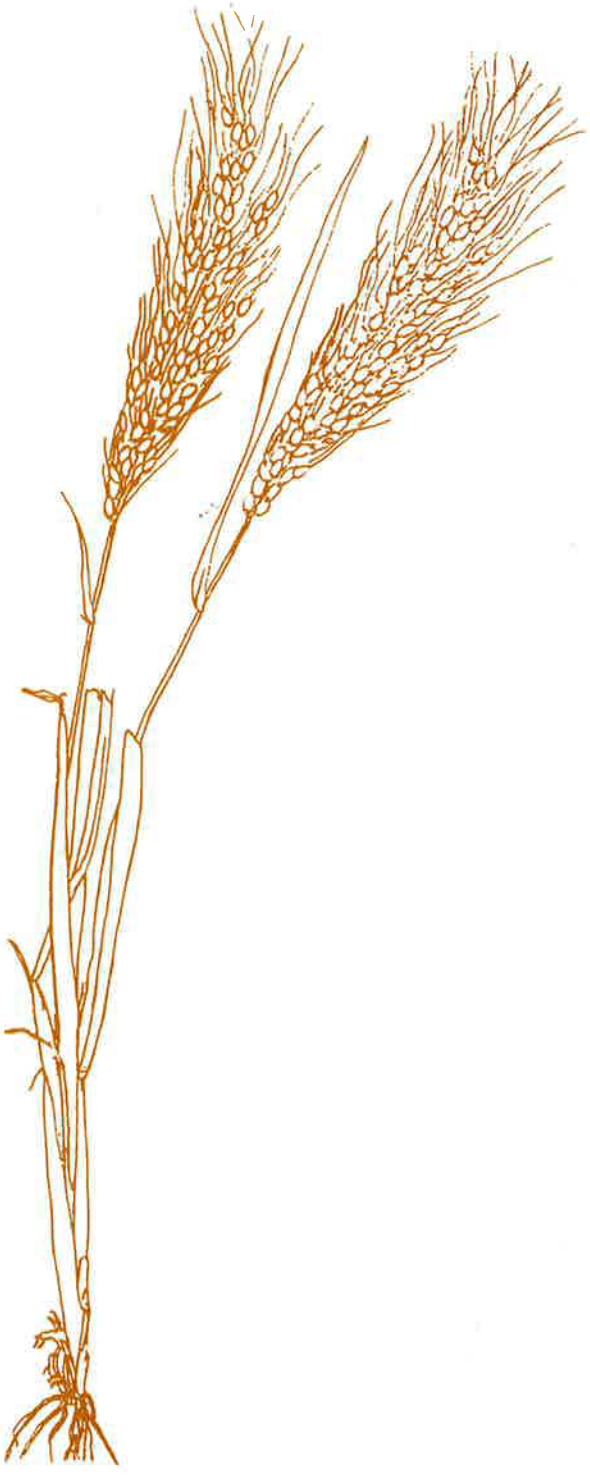
Bulletin 55



Overseas Development Administration

# A STUDY IN THE DETERMINATION OF QUALITY/VALUE RELATIONSHIPS IN RICE

J. A. Conway, P. F. Daplyn, P. A. Clarke
and D. R. Twiddy

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Natural Resources Institute

The scientific arm of the
Overseas Development Administration

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## SUMMARY

Econometric approaches to the valuation of a food product based on the implicit values of its individual quality attributes are a relatively recent development. Whilst such approaches have been used to explain and quantify consumer preferences at different market levels and in different countries, they offer considerable potential for storage enterprises. Armed with a knowledge of the financial significance of individual quality attribute changes over predicted storage periods, the enterprise can select a technology package which minimizes the most significant of those changes for a given commodity.

A methodology for such an approach, based on a Natural Resources Institute case study in Indonesia, is described.

## RESUME

Les optiques économétriques en ce qui concerne l'évaluation d'un produit alimentaire se basant sur les valeurs implicites de ses attributs individuels de qualité constituent un développement relativement récent. Tandis qu'il a été fait appel à de telles optiques pour expliquer et quantifier les préférences due consommateur à divers échelons du marché et dan différents pays, elles offrent un potentiel très important pour les entreprises de stockage. Celles-ci, grâce à une connaissance de la signification financière des changements individuels des attributs de qualité pendant les périodes de stockage prévues, sont en mesure de sélectionner un module global technologique minimisant le plus significatif de ces changements pour un produit donné.

Il est décrit une méthodologie applicable à une telle optique, se basant sur une étude individuelle du NRI, effectuée en Indonésie.

## RESUMEN

La aplicación de la econometría a la evaluación de un producto alimenticio, sobre la base del valor implícito de sus atributos cualitativos individuales, es un fenómeno relativamente reciente. Si bien estos planteamientos han sido utilizados para explicar y cuantificar as preferencias del consumidor en distintos países y niveles del mercado, ofrecen considerable potencial para empresas de almacenamiento. Sobre la base de conocimientos de la importancia financiera de cambios individuales en atributos de calidad sobre períodos de almacenamiento previstos, la empresa podrá seleccionar un conjunto tecnológico que reduzca al mínimo los cambios más significativos para un producto determinado de consumo. Se presenta una descripción de la metodología para dicho planteamiento, basada en un estudio de casos llevado a cabo por el NRI en Indonesia.

# A study in the determination of quality/value relationships in rice

## INTRODUCTION

### Concept

Many grain storage enterprises will have invested large sums of public or private money in purpose-built storage systems. Operational expenditure for intake quality assessment, for routine quality monitoring, and particularly for routine pest management operations may well be substantial.

In determining the cost-effectiveness of any storage system in relation to conservation of commodities passing through it, it would seem to be fundamental to be able to identify those quality characteristics of the commodity subject to change, to measure the rates at which they change, and to determine the financial significance of the changes.

Essential data for such a determination will focus on:

- the actual matrix of **quality attributes** in terms of quantified criteria as determined on intake of the commodity;
- the relationship between its **quality attributes** and those considered important on the commodity market;
- the actual **value** of the stock in relationship to its **quality attributes** and its intended offtake destination; and
- to what extent the **quality attributes** and hence the **value** of the stock have changed during storage.

**PROBLEM AREA**

GRAIN STOCKS DETERIORATE DURING STORAGE.

WHICH QUALITY ATTRIBUTES ARE MOST IMPORTANT TO CUSTOMERS?

AT WHAT RATE DO THESE ATTRIBUTES CHANGE OVER TIME DURING STORAGE?

WHAT ARE THE FINANCIAL IMPLICATIONS OF THESE CHANGES IN THE OFFTAKE MARKET?

WHICH STOCK PRESERVATION STRATEGIES MINIMIZE THE MOST IMPORTANT QUALITY CHANGES?

**FUNDAMENTAL QUESTION**

CAN WE PLACE A FINANCIAL VALUE ON QUALITY CHANGE IN THE GRAIN STORAGE SYSTEM?

### Background

A considerable body of literature exists both on physico-chemical properties of food grains and the extent to which these are influenced by different storage

regimes. In the case of milled rice, for example, much of this work is summarized by Juliano (1985) for results based on laboratory studies. Such studies have often incorporated simulated ageing in order to identify specific changes over time (Clarke *et al.*, 1987). Examination of those microclimatic factors which exercise a strong influence over changes in certain key quality attributes has also been conducted under field conditions for stored wheat, millet, and milled rice (Gough *et al.*, 1989).

Attempts to approach the financial valuation of grain quality attributes by adapting existing econometric models centred on the International Rice Research Institute (IRRI) in the mid-1980s. In an Association of South-East Asian Nations (ASEAN) survey of rice markets, using an adaptation of an economic model of consumer demand for goods characteristics, which describes the price of a good as a linear summation of the implicit values of its attributes, the workers concluded that laboratory measures of physical and chemical quality characteristics of rice could be regressed on rice price to explain observed differences in market prices (Unnevehr *et al.*, 1985).

Based on the methodology adapted for the limited ASEAN survey a more ambitious project, The Grain Quality Project, funded by the International Development Research Centre (IDRC) and implemented by IRRI was undertaken. A multi-country study of international and regional markets was undertaken in order to estimate the implicit value of milled rice characteristics using market price as a measure of average consumer preference subject to budget constraints (IRRI, 1989). This study had a multi-sectoral element in that consumers, retail markets, wholesale markets and rice mills were included in the surveys.

It will be noted that in the studies referred to above, the significance of quality/value relationships was established at a range of market outlets from producer through to consumer and related to a series of single transactions taking place at a specific point in time. Useful though such data obviously are to grain market participants, for the storage enterprise engaged in medium- or long-term stockholding the potential of the modelling approach is only partially tapped. The dynamic element of biodeterioration or quality change over time, and its financial relevance, is not captured by this 'snapshot' approach.

Using the Indonesian case study as an example (Clarke *et al.*, 1991), a methodology is described which addresses the legitimate concerns of the storage enterprise to place a realistic financial valuation on the elusive concept of quality change.

# METHODOLOGY

## Basic approach

For the determination of quality/value relationships at a single transaction level, for example a retail grain market, a cross-sectional sampling series will suffice. Consumers, having made their purchase, are asked to declare those quality attributes which influenced their purchase. Following this a sample of the grain is carefully analysed and the individual quality attributes thus quantified are regressed against the price paid in order to capture their individual contributions to that price.

However, where the primary interest is to relate quality change over time, as experienced by the grain storage enterprise, to its financial implications in the market place, a longitudinal or time-series sampling set will be required.

Baseline data, in the form of a quality attribute breakdown compiled at point of intake of the commodity into the storage system will be required. At periodic intervals, the same commodity will be re-sampled, subjected to the chosen range of quality analyses, market valuation of the samples conducted, and the hedonic regression of market price on quality attributes completed.

## The storage system

In order that the findings of a quality/value study can be taken to be generally applicable to the storage system as a whole, the selection of an appropriate sample frame requires some thought. In many tropical countries the system will be appropriately homogeneous with respect to commodity, storage container, type of storage structure, storage management regime, length of storage period, microclimatic factors, etc. In such cases the drawing-up of a sample frame of storage complexes and the selection of individual warehouses and stacks of commodity as sampling units will be straightforward. It may well be considered appropriate for pragmatic reasons to conduct the final selection on a purposive rather than a random basis in order to rationalize the demanding sampling programme which the study will require. A major consideration will be the requirement to 'block' the selected grain stacks for the chosen period of the study with no disturbances in the form of additions to or subtractions from the stacks. Ideally, of course, all normal forms of warehouse management, for example, pest management operations, routine cleaning, ventilation, etc., should continue.

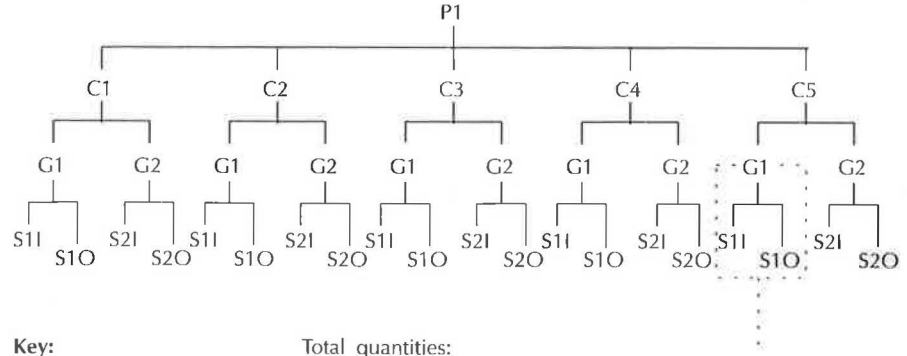
Whereas it may be tempting to attempt to simulate operational storage conditions at field stations or in operational warehouses using miniature study stacks, this is not recommended, as microclimatic conditions, and hence the quality attribute changes which these conditions influence, are known to be quite different in large, commercial-sized stacks.

In the Indonesian case study, the government-sector milled rice storage system consisting of 2.5 million tonnes of purpose-built flat bag godowns located at some 1400 sites throughout the country was used.

## Selection of sample units

Within each of the three operational provinces on Java, five storage centres were selected at random. At storage complexes two godown (warehouse) units were purposively identified on the basis of their intended use to store newly-procured new crop milled rice. On entry of new crop rice, one 250-450 tonne stack was randomly selected from the twelve stacks in each godown. These stacks were marked and blocked from any further non-study disturbance such as stack offtake, stack addition, re-stacking, etc. for the one-year study period.

Sample units (bags) were purposively selected to represent rice stock both from within the stack and in its outer layer (*see* Figures 1 and 2). Selected bags were marked to facilitate sampling at monthly intervals.




| Key: | | Total quantities: (for 3 provinces) |
|---|---|---|
| P | Province | 3 x 1 = 03 |
| C | Complex | 3 x 5 = 15 |
| G | Godown | 15 x 2 = 30 |
| SI | Stack, inner sample | 30 x 1 = 30 } = 60 samples |
| SO | Stack, outer sample | 30 x 1 = 30 } |

**Figure 1** Sampling schedule for one province

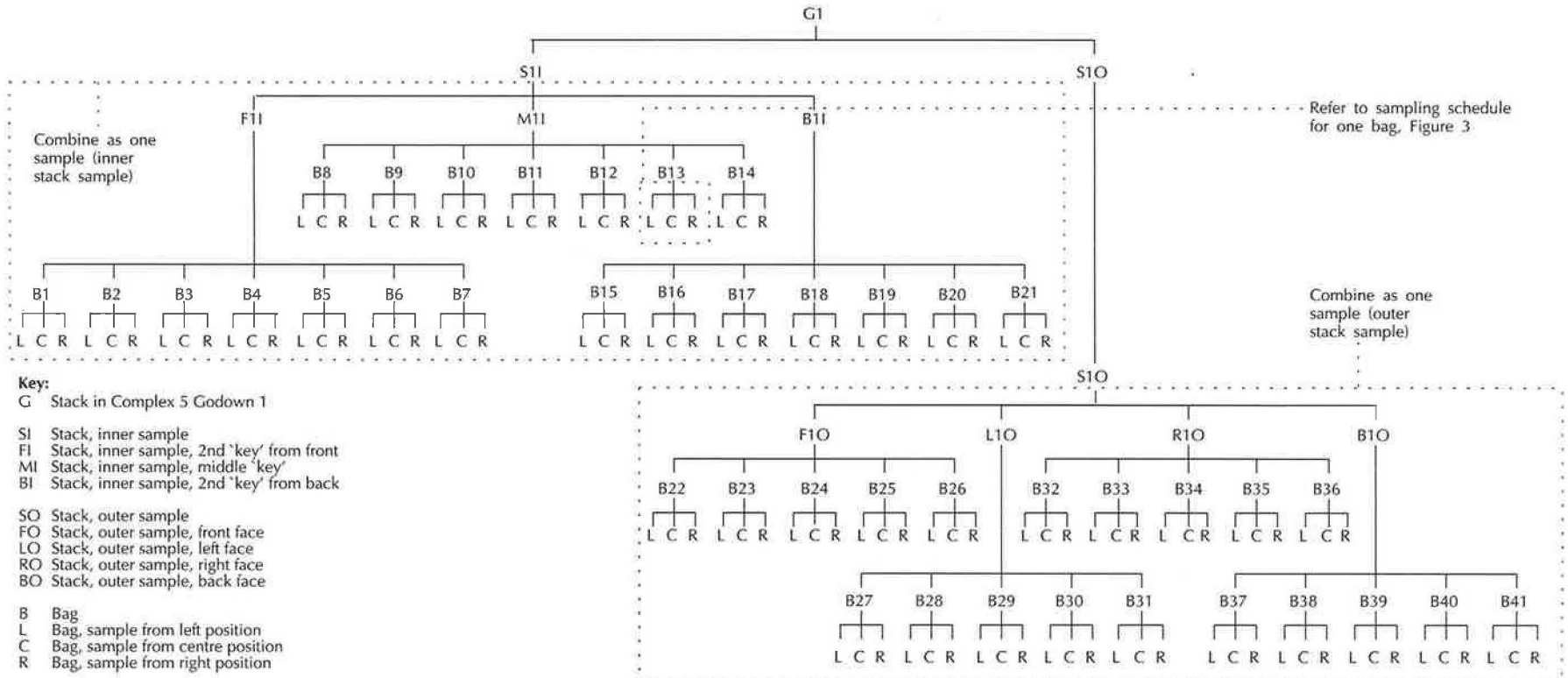



**Figure 2** Sampling schedule for one stack

## Within-stack variability in quality characteristics

For certain commodities and in certain procurement systems it may be considered that there is likely to be variability in quality characteristics between bags in the same stack, and that some information on the extent of this variability is necessary in the interpretation of results. This was the case in Indonesia and it was therefore decided to conduct a small preliminary study in order to assess the extent of within-stack variability. Three stacks were used, one from each of three storage complexes. From each stack, samples were taken from each of 60 bags, 20 on each of the long sides and 10 on each of the bottom 5 layers, 4 bags per layer on the long sides and 2 bags per layer on the short sides. The position of the selected bags in each layer was determined by random selection. The samples were sent to a central laboratory for analysis of the grain characteristics shown in Table 1.

**Table 1** Grain characteristics

| | |
|---|---|
| Moisture content | Variety |
| Milling degree | Large brokens |
| Small brokens | Chips |
| Actual yellows | Damaged grains |
| Chalky grains | Foreign matter |
| Minolta b colour | |

For 3 of the 10 characteristics considered, there proved upon examination to be insufficient variability to be worth conducting any further analysis.

For the remaining 7 variables, the overall variance within each stack was estimated together with the corresponding means and CVs.

For the statistical analysis, the large and small brokens were combined into a single total of all brokens.

It was found that most of the characteristics which could be expected to be affected by storage, the main focus of the study, were among the variables with reasonably small variability.

It was concluded that in most respects the planned sampling methodology for the study could be expected to provide appropriate measures of the variables of greatest interest.

## Sampling from bags

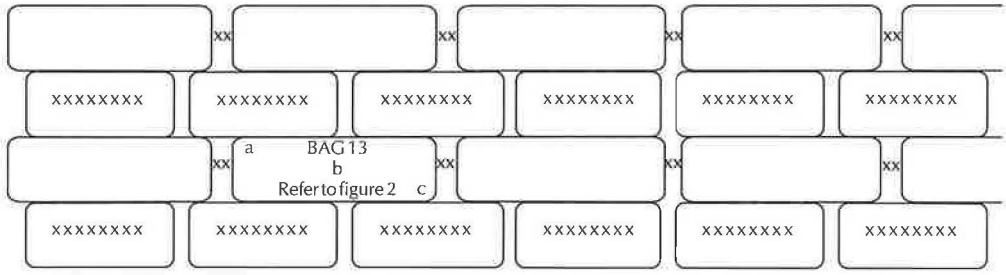
Great care needs to be taken to ensure that the sampling system chosen is tailored to the needs of the study, is physically feasible over the storage period, is capable of standardization across all sampling sites, is understood by and acceptable to the sampling teams, and has the approval of the manager of the complex. Sampling equipment must be standardized and available at all sites. Sufficient labour to assist with bag removal and replacement must be provided.

In the Indonesian study three samples of approximately 50 g were taken from each marked bag using a standardized sampling spear according to a set procedure (*see* Figure 3). Samples were combined to form composites of approximately 3 kg representative of both inner and outer regions of each stack. Prior to month 1 sampling, training exercises were conducted for godown staff at all 15 complexes to standardize on sampling procedure, removal/replacement of bags, sample labelling, etc.

## Sample management

If samples are to be broken down for submission of sub-samples to a number of laboratories for analysis and to a range of test marketing sites then careful co-ordination of this exercise is required. In Indonesia, composite samples from

all study sites were forwarded monthly by courier to the central laboratory. Samples were divided using standard laboratory equipment, labelled and re-routed according to the required schedule, shown in Figure 4. Sample destinations and analysis requirements are shown in Table 2.




**Key:**

| | | | | |
|---|---|---|---|---|
| a | Left position sampling point | Quantity ~ 50g | } | Total quantity required from one bag: ~ 150g |
| b | Centre position sampling point | Quantity ~ 50g | | |
| c | Right position sampling point | Quantity ~ 50g | | |

**Figure 3** Sampling schedule for one bag

## Sample numbering

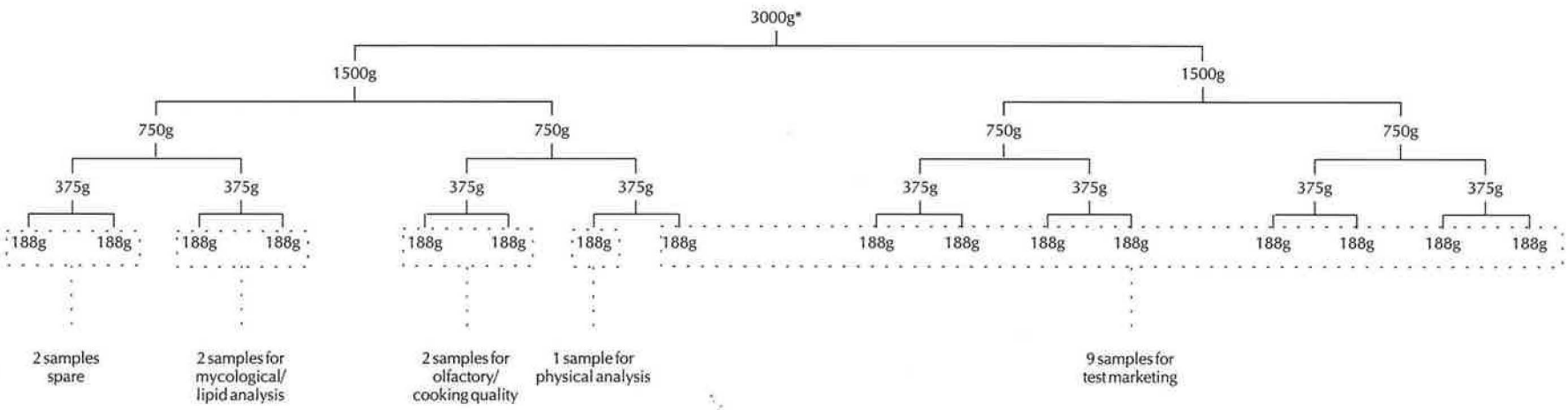
For samples submitted from sampling locations and being divided and re-routed for analysis or test marketing, it is essential to devise a sample numbering system which will not divulge information on province or godown complex of origin to the sample recipient. Master lists of sample numbers can be compiled using random tables to produce the first number of each of a number of columns. Each column represents a sampling operation (weekly/monthly/quarterly, etc.) and consists of **'n'** consecutive numbers in increasing order from 1 to n (n = the chosen number of sampling units).

Composite samples arriving from the field are labelled with an identification including:

- P (province) or other appropriate zoning;
- C (complex);
- S (stack) or other chosen sampling unit;
- I/O (inside/outside); and
- 1-12 (month) or other appropriate sampling frequency.

## Table 2 Samples analysis requirements and destinations

| Sample destination | Sample analysis requirement |
|---|---|
| Central R&D laboratory | Physical analyses |
| Food Testing laboratory | Olfactory/cooking quality tests |
| NRI (UK) | Mycological/lipids analyses |
| Medan (North Sumatra) | Test marketing |
| Jakarta (West Java) | Test marketing |
| Surabaya (East Java) | Test marketing |




* Sample bulked-up from:
4 faces x 5 bags x 3 bag samples x 50g = 3000g
An inner stack sample will bulk-up to:
3 locations x 7 bags x 3 bag samples x 50g = 3150g

**Figure 4** Boerner divider schedule for one outer stack sample

Prepared sub-samples going out for analysis or test marketing are labelled with an identification consisting of:

- destination (appropriately coded);
- 1-12 (month) or as appropriate;
- number (from master list); and
- replicate number.

Further details of the sampling procedures and sample numbering systems developed for the Indonesian study are given in Appendix 1.

## Quality analysis

A baseline inventory of key quality characteristics must be compiled for all initial samples. In the case of the milled rice used in the Indonesian study this consisted of physical attributes, physico-chemical composition, cooking quality, organoleptic properties, mycological and lipids analyses and yellow grains formation. A similarly comprehensive range of analyses must be completed at the end of the study period on the final samples submitted.

On intermediate samples taken between the initial and final samples, a more limited range of quality analyses is conducted. This will be based on a knowledge of those quality attributes which, for the chosen commodity, are known to change during storage. They may also include those quality characteristics which earlier market surveys have identified as preferred characteristics affecting consumer choice relative to pricing.

A typical set of comprehensive quality analysis requirements for milled rice for initial and final samples is shown in Table 3.

**Table 3** Milled rice quality characteristics

| | |
|---|---|
| **Physical quality** | |
| 1 Moisture content | 8 Damaged grains |
| 2 Colour | 9 Red grains |
| 3 Milling degree | 10 Broken grains |
| 4 Foreign matter | 11 Paddy grains |
| 5 Insects, live | 12 Size/shape |
| 6 Chips/points | 13 Potential yellows |
| 7 Yellow grains | |
| **Organoleptic/cooking quality** | |
| Uncooked rice | Cooked rice |
| 1 Odour | 5 Hardness |
| 2 Size/shape | 6 Stickiness |
| 3 Alkali spreading value | 7 Expansion ratio |
| 4 Cooking time | 8 Aroma/odour |
| **Physico-chemical analysis** | |
| 1 Surface lipids | 4 Yellows |
| 2 Free fatty acids (FFA) | 5 Potential yellows |
| 3 Colour | |
| **Mycological analysis** | |
| Total percentage infection levels of grain by fungi and individual species of fungi identified | |

Detailed sets of analysis requirements and procedures must be drawn up for all participating analytical laboratories and training arranged or conducted for study technicians. A sample of such documentation as produced for the Indonesian study is given in Appendix 2.

## Test marketing

### Choice of market

It will need to be established at the outset of the study the extent to which the prevailing quality/value relationships for the commodity of study may be destination-dependent. In other words, certain areas of the country, or certain types or levels of market, or certain groups of consumers may have different perceptions of quality and hence apply different pricing criteria. The actual and potential marketing outlets serviced by the grain storage enterprise will need to be appraised and earlier work on differential consumer preferences with possible spatial implications reviewed.

### Identification of traders/respondents

In each of the selected markets, wholesale or retail traders who would be normal buyers of the study commodity will be chosen for the duration of the study. These traders may or may not be selected at random, but it is necessary to check that they are not traders specializing in distant markets or in special varieties/grades of food grains, but sell a broad range of grain commodities to local purchasers.

At the beginning of the study, the study enumerator in charge of the test marketing exercise at each market, will explain the purpose of the study to the selected traders, and will make it clear that what is wanted is the trader's true opinion of the price he would pay for grain of the quality of each sample, if presented to him in normal trading quantities.

### Identification of staff for test marketing

From the various options which may be available it is probable that staff from the local office of the storage/marketing organization for which the study is being conducted will be the most appropriate choice for use as enumerators to do the test marketing. These staff are often accustomed to price data collection, and will be known to the traders.

To assist in maintaining consistency between markets, co-ordination staff from the head office from which the study is being conducted should visit each market and observe the test marketing periodically, during the course of the study.

Various other possibilities for conducting test-marketing, including the use of college students, etc., may be considered, but careful attention to minimization of non-sampling errors must be a major criterion in these deliberations.

### Organization of samples

For the Indonesian study, operating on a monthly sampling frequency, the person in charge at each market received 3 duplicates of each of 15 samples each month. Each duplicate set of 15 samples was assigned to 3 of the chosen traders, and the 15 samples divided into 3 sets of 5 randomly.

In order to provide a check on possible biases in the pricing, and to give information on general price trends, each trader was given, in addition to the 5 samples as already described, a 'dummy' sample of a standard quality of rice for that market, comparable with the study rice quality. The most suitable standard quality was identified for each market, in the light of local conditions. Each month, the person in charge of test marketing at a market bought 2 kg of the chosen standard rice, and divided it into 9 samples labelled in accordance with the sample recording and labelling scheme as follows:

Market code/Month No./16/Sample No. 1-9
MJ/1/16/1, MJ/1/16/2 --------- MJ/1/16/9.

One of these samples was then added to each set of 5 samples presented to one trader. It was considered possible that the traders, knowing that the samples came from the national grain stockpile, might assume that the prices of all the

samples would be low, and differences between them negligible. In order to draw their attention to the possibility of differentials in value, it was decided to add a second dummy sample, of a standard but higher quality rice. This was done in a similar way to that described above for the first set of dummy samples. The standard, higher quality rice was identified and recorded for each market. The samples were labelled and one of these samples was added to the set of 5 samples plus one dummy sample presented to each trader, so that finally each trader was presented with 7 samples to price each month.

## Presentation of samples

In order that the trader will be aware that there is a range of qualities in the samples presented to him, the whole set should first be placed before him. Then, each sample should be presented in turn, in random order. The ordering is done in the same way as the random assignment of samples to traders.

With each sample given to the trader, a Test Marketing Form should also be given, with the identification data already completed by the enumerator, and the trader asked to give the information on price, and on the characteristics of the sample influencing the price. (*See* Form 5 in Appendix 2).

Each trader should be asked to do the pricing individually on his own premises, not at a gathering of the whole panel of traders.

## Collection of routine price data

In order to use the information relating to the dummy samples in considering general price trends and possible trader biases, it is necessary to obtain, at regular intervals, the normal wholesale prices for the standard qualities of grain used for any dummy samples, as routinely collected by the local marketing office. These prices will be selling prices rather than buying prices, but this can be allowed for in the analysis. A note of the procedure used for the collection of these data should be made at the beginning of the study, and attached to the first month's data.

## Data assembly

In the Indonesian example one study team member was given responsibility for all data entry. A series of databases were constructed using Lotus 1-2-3 spreadsheets which incorporated password entry, protected cells, storage macros, and automated sequential entries to ensure secure and accurate data recording. The spreadsheet formats followed closely the hard-copy proformas being used for manual entry of raw data at the respective analysis/marketing points.

## Price/quality modelling approaches

### *Consumer goods characteristics model (CGCM)*

The conceptual basis for estimating implicit prices for grain quality is Lancaster's (1966) model of consumption which regards the properties of the goods and not the goods themselves as the direct object of utility. Based on this concept, Ladd and Suvannunt (1976) developed the Consumer Goods Characteristics Model (CGCM) which describes the price of a good as the linear summation of the implicit values of its attributes. Product demand is a measure of the utility provided by the goods which is a function of the characteristics of the product. The history of attempts to incorporate quality into demand models and the adoption of hedonic pricing curves for studies of food demand is exhaustively reviewed by Tabor (1988). For a food grain the CGCM can be expressed mathematically as:

$$P_r = \sum_{j=1}^{n} X_{rj} P_{rj}$$

The above equation states that price paid by the consumer equals the sum of the marginal values of individual product characteristics.

If the characteristics that define grain quality can be measured, then the impact value of these characteristics can be estimated. An ordinary least square regression of price on measures of quality provides such estimates.

The estimating equation is:

$$P_r = \Sigma X_{rj} b_{rj} + u$$

where:
$P_r$ – price of grain
$X_{rj}$ – quantity of characteristic j
$b_{rj}$ – parameter estimates
u – error term

The dependent variable, $P_r$, will vary for different grades/qualities of grain. The independent variables, $X_{rj}$, should explain the variance in the price of grain. The parameter estimates, $b_{rj}$, give the implicit prices of the characteristics.

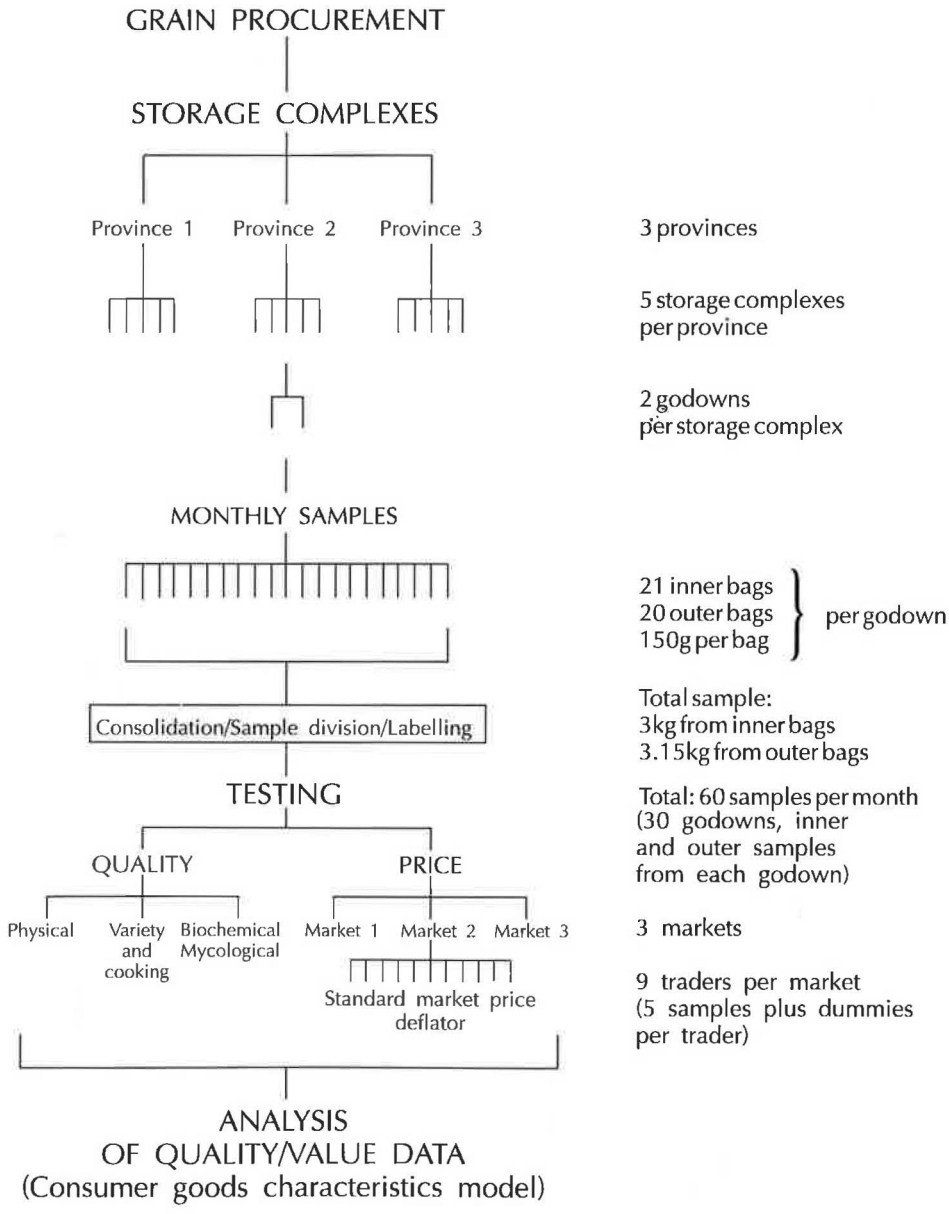



**Figure 5** Diagrammatic representation of sampling and analysis framework

## Study methodology framework

A graphical summary of the survey and analysis framework is shown in Figure 5.

# DATA ANALYSIS AND INTERPRETATION

## Grain quality

### Baseline intake quality

Data from the initial sample set are compiled and summarized for the chosen quality attributes using appropriate measures of central tendency. If it has been decided to segregate data from different geographical areas for purposes of comparison then data may be presented in aggregated and disaggregated forms.

Typical aggregated data for the attributes of intake physical quality, grain colour, and mycological infection are shown in Tables 4, 5 and 6, as examples, together with typical graphical presentations of disaggregated data for the attributes of moisture content, broken grains and surface lipids, in Figures 6, 7 and 8.

**Table 4** Intake quality – physical attributes – aggregate data

| Physical attributes | Mean value | Interquartile range |
|---|---|---|
| Moisture content %w.b. | 13.9 | 0.7 |
| Degree of milling % | 90 | 0 |
| Foreign matter % | 0.02 | 0.02 |
| Yellows potential % | 0.81 | 0.45 |
| actual % | 0.42 | 0.27 |
| Damaged % | 2.19 | 1.0 |
| Chips % | 0.42 | 0.24 |
| Brokens % | 31.1 | 8.32 |
| Red % | 0 | 0 |
| Paddy: no./kg | 9.7 | 20.0 |
| Insects: live no./kg | 2 | 0 |
| dead no./kg | 3 | 0 |

**Table 5** Intake quality – colour values – aggregate data

| Colour value | Mean | Minimum value | Maximum value | Coefficient of variation % |
|---|---|---|---|---|
| Unground samples | | | | |
| L* | 88.5 | 83.6 | 97.1 | 3 |
| a* | 1.16 | 0.78 | 1.45 | 11 |
| b* | 16.4 | 15.3 | 18.2 | 4 |
| Ground samples | | | | |
| L* | 55.7 | 54.4 | 56.7 | 1 |
| a* | −0.38 | −0.43 | −0.30 | 8 |
| b* | 4.56 | 4.19 | 4.89 | 4 |

### Quality changes during storage

Data from the intermediate sample sets are plotted against storage time and summarized as described above with disaggregation added if appropriate.

Given the considered possibility of differential quality changes between internal and external parts of grain stacks which can be captured by segregating both 'inside' and 'outside' stack samples, it may be considered useful to collect

**Table 6** Intake quality – mycological infection – aggregate data

| Fungus | % infection of milled rice |
|---|---|
| *Aspergillus flavus* | 17 |
| *Aspergillus niger* | 5 |
| *Aspergillus candidus* | 32 |
| *Aspergillus fumigatus* | 12 |
| *Aspergillus glaucus* group | 6 |
| *Aspergillus versicolor* | 1 |
| *Aspergillus ochraceus* | 1 |
| Other *Aspergilli (terreus/wentii)* | 1 |
| *Penicillium islandicum* | 16 |
| *Penicillium* spp. | 5 |
| Field fungi | 2 |
| *Rhizopus/Mucor* | 17 |
| Others | 1 |

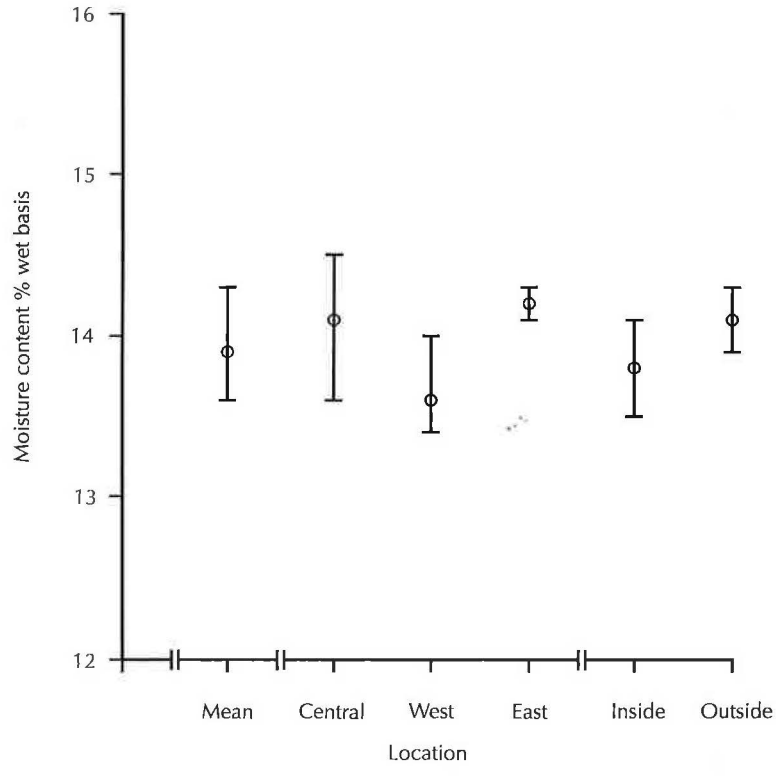



**Figure 6** Intake quality – moisture content – disaggregated data – mean values

supplementary data on microclimatic changes occurring within the storage structure. Whereas limited data can be collected using a thermohygrograph, the extra time and effort needed to place sensory equipment within study stacks will produce data specifically relevant to the chosen bag sampling points. The use of sensors and thermistors in stacks for the routine logging of moisture content and temperature data is described by Gough (1980).

Typical graphical presentations of aggregate data on moisture content, insect contamination, and colour values are shown in Figures 9, 10 and 11.

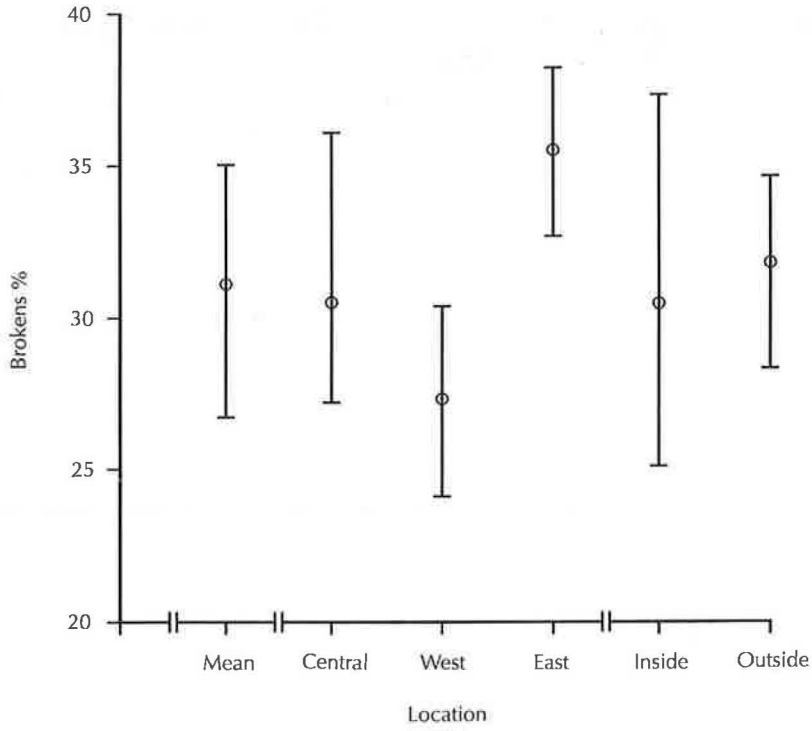



**Figure 7** Intake quality – broken grains – disaggregated data – mean values

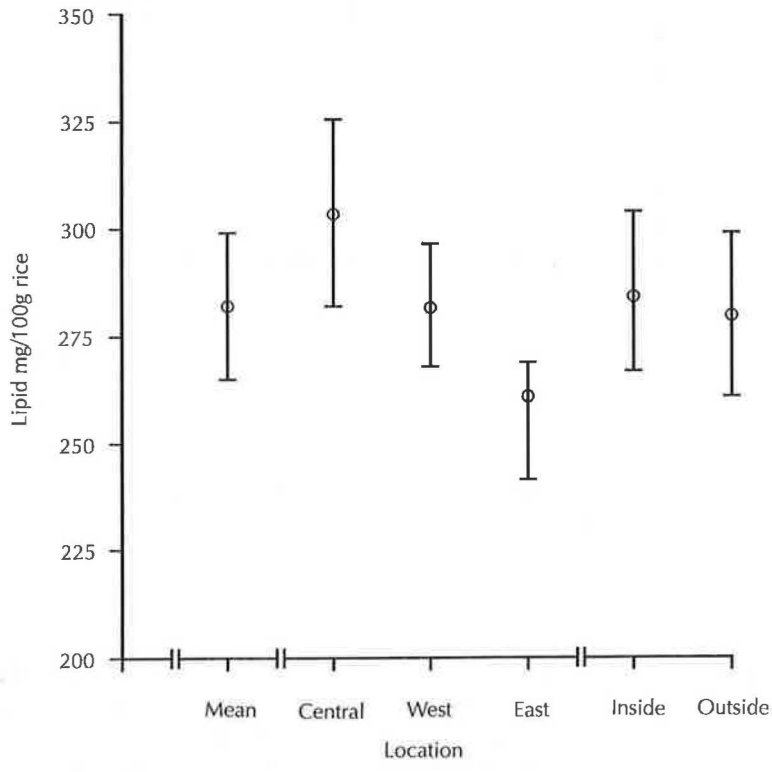



**Figure 8** Intake quality – surface lipids – disaggregated data – mean values

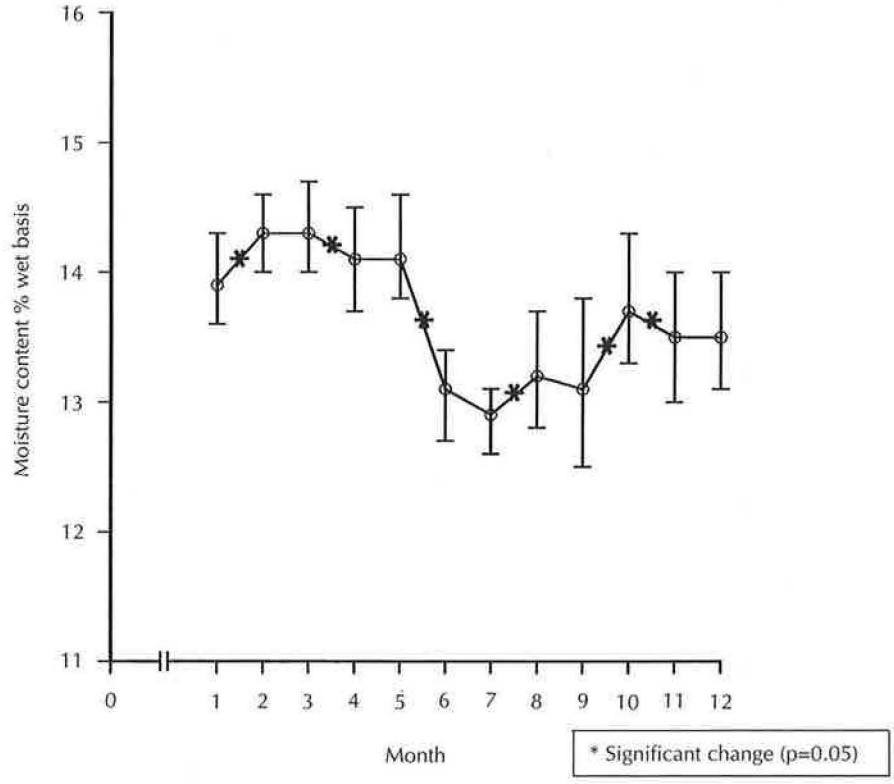



**Figure 9** Quality change over time – moisture content – aggregate data – mean values

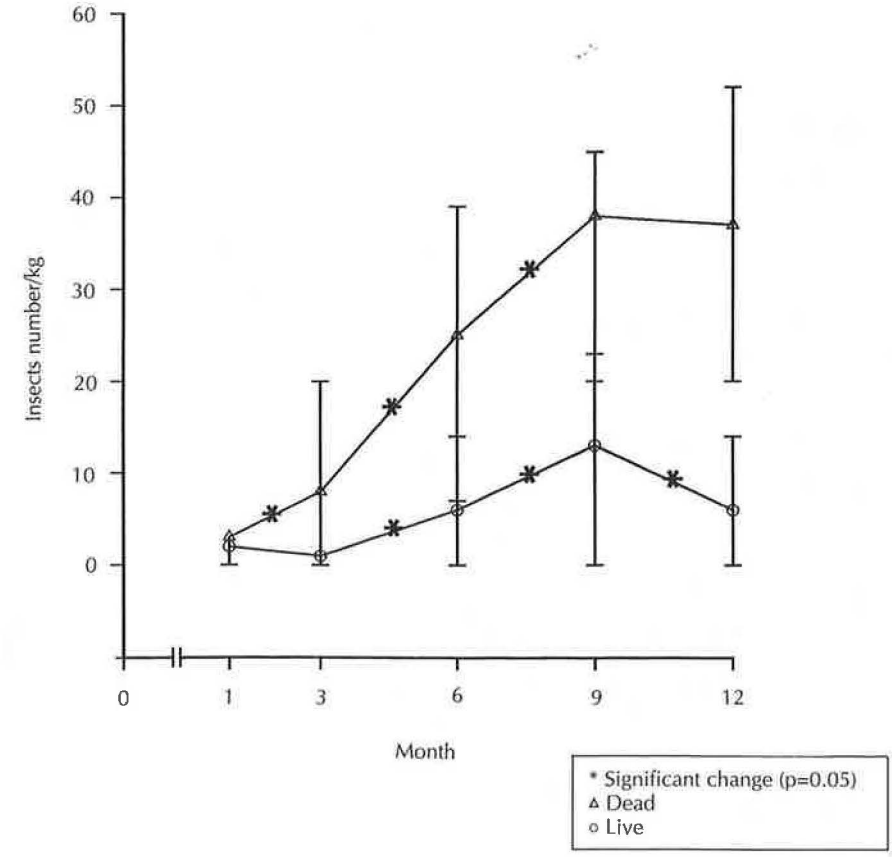



**Figure 10** Quality change over time – insect contamination – aggregate data – mean values

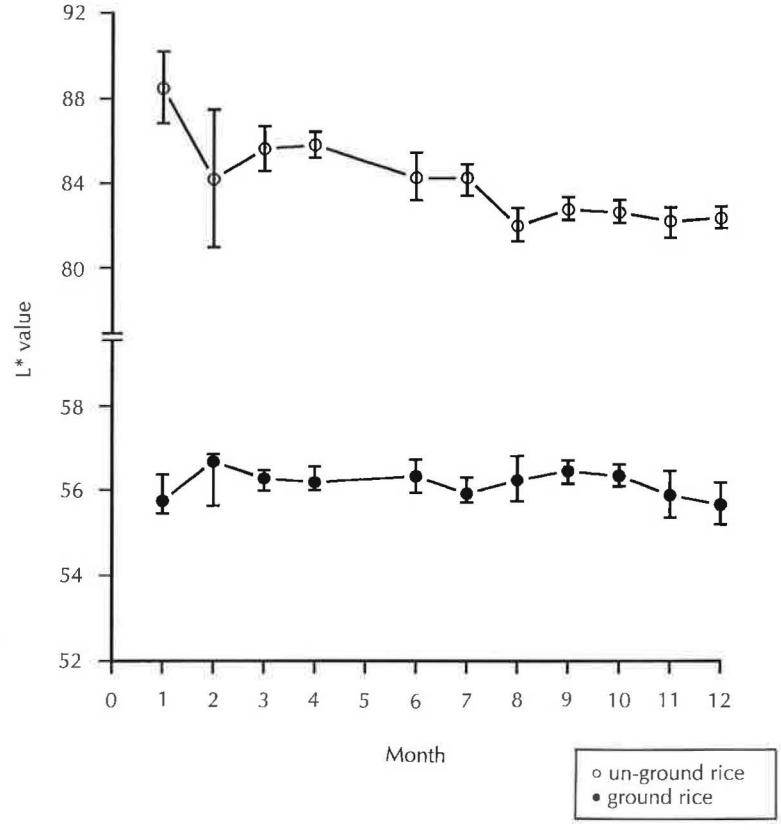



**Figure 11** Quality change over time – colour values – aggregate data – mean values

## Test marketing price data

### Adjustments for non-quality effects

It was noted in the presentation of a suggested methodology above that the prices estimated by traders during a test marketing operation can be expected to be affected by factors other than quality, particularly seasonal demand and supply effects. In order to enable adjustments to be made to compensate for these effects one or more complementary approaches may be adopted.

Firstly, in addition to the study samples, traders may be presented with a dummy sample of newly-purchased grain of a standard comparable with the study samples, so that on each test marketing day each trader will estimate a price for a consistent, standard sample of grain.

Secondly, for each of the markets in the study, data on prices for various standard qualities of grain should be routinely collected by the local marketing office. From these price lists the prices for the quality of grain most closely comparable with the study samples may be extracted.

A typical graphical presentation of the plotted price series and their relationships is shown in Figure 12. The study sample prices need to be deflated by a standard price series. This is done for month 't' by calculating a deflation factor as the value of the standard price in month 't' divided by the corresponding price in month 1; then, for each study sample, the mean of the estimated prices in month 't' from the group of traders is divided by the calculated deflation factor. In case of inconsistencies between the two standard series described above, the study sample prices may be deflated by both series and by an average in order to establish which series gives the most satisfactory result.

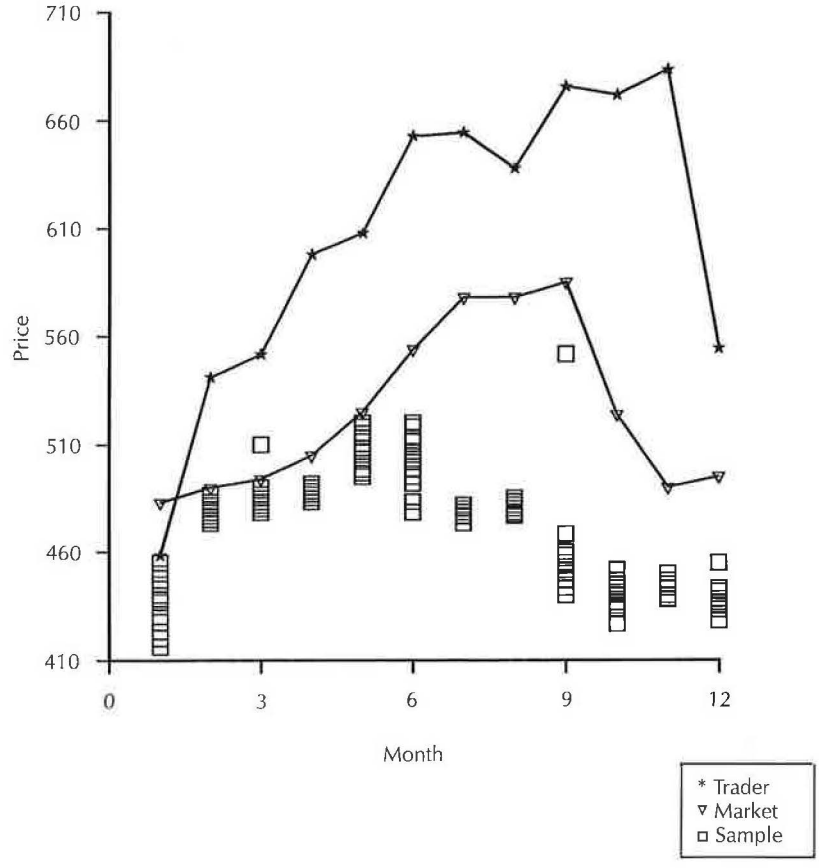



**Figure 12** Comparative price series for study samples, dummy samples, and standard market indices

### Trader bias

An additional reason for incorporating dummy samples in the test marketing is to assess whether there is any effect of bias in the estimation of prices by individual traders. For each market, the coefficient of variation (CV) of the estimated prices for each study sample can be calculated, and this figure compared with the CV of the prices when adjusted by each trader's estimated price for the dummy sample in order to compensate for any trader biases.

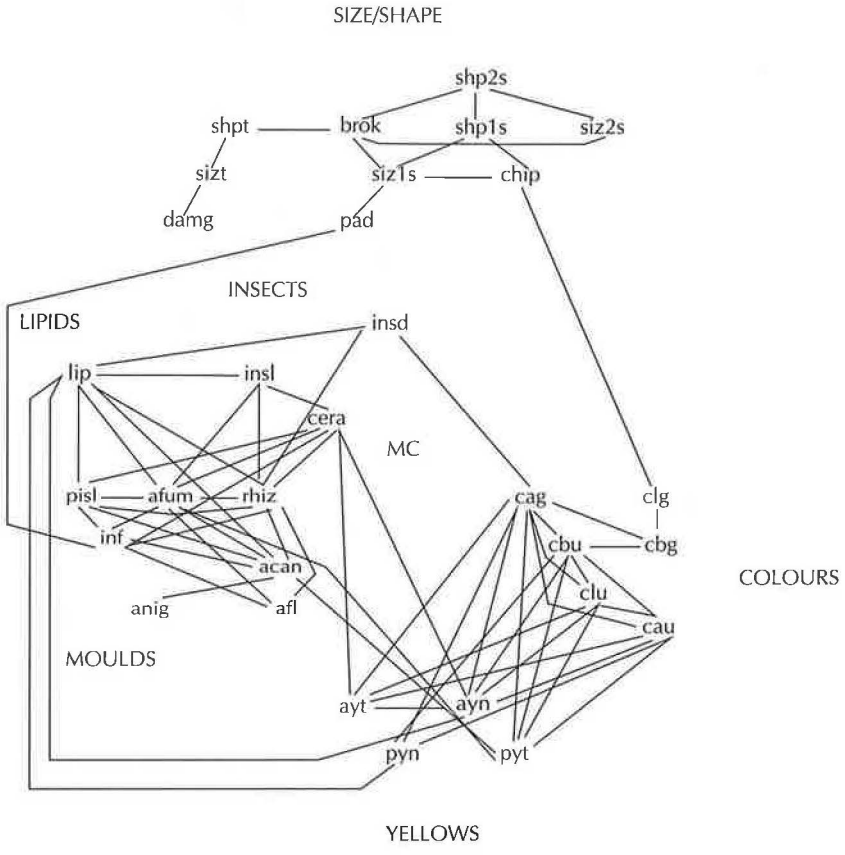
Once markets have been identified where trader bias appears to be operative, a further deflated set of prices may be derived in which each estimated price is deflated by the individual trader's dummy sample price.

## Quality/price relationships

### Quality variables

The list of quality variables should include all those for which reliable and adequate data have been produced. Thus, not only those variables which may be expected to change over time, but also variables which may be expected to remain unchanged throughout the study period and which are thought to have some influence on price determination, should be incorporated in the pricing models. For these variables, attribute values established on the initial study samples may be used throughout.

Many of the quality variables can be expected to be correlated with each other and it may be convenient, in examining the pattern of correlations, to construct a diagram by means of lines joining the pairs of variables, in order to show which pairs of variables had a correlation coefficient greater than, or equal to, a pre-specified threshold, say 0.30. The diagram constructed for the Indonesian study is shown at Figure 13.




**Notes:** Lines link variables with correlation coefficient >=0.3
Table 7 interprets the variables codes

**Figure 13** Correlations between quality variables in price data set

A decision will have to be taken on whether to include in the modelling those variables which cannot be considered to be objective measurements of attributes which are perceptible to the senses. Attributes such as moisture content, foreign matter, and broken grains clearly are perceptible, but fungal infection levels, and lipid composition equally clearly are not.

However, as all of these variables may possibly be related to other attributes which are perceptible, for example, the association between lipids and rancidity, one approach may be to run both full and reduced models in order to capture these relationships.

## Regression modelling

Given the potentially large number of correlations which may be established between quality variables it could be quite misleading to perform regression analyses of price on all the variables, as the effects of correlated variables could be confounded with each other. In this situation a stepwise approach is recommended, in which at each step the variable which provides the greatest addition to the explanatory capacity of the regression model is added.

However, correlations between quality variables still give reason for caution in performing such regression analyses, since it is likely that various possible

models, of similar explanatory capacity, but incorporating different quality variables, could be devised for a particular price variable. In this situation, the selection of an appropriate model, and its interpretation, may become ambiguous.

In order to assist with this potential problem, each stepwise regression is performed both forwards and backwards. Where the models produced by the two approaches are identical, more confidence is given as to the robustness of the model. Also, during the process of each stepwise regression, the stability of the regression coefficients as each new variable is added is examined, and greater stability is regarded as suggesting greater robustness of the model. It may also be helpful to start one stepwise regression with the 'best' variable, and a second regression with the second best variable, and use the results of this also to assess the robustness of the models.

When considering the functional form of the model, two general options appear equally plausible. A quality characteristic might have an additive effect on value, with a unit change in quality leading to a unit change added to the value, or it might have a multiplicative effect, with a unit change in quality leading to the value being changed by a fixed proportion.

For the Indonesian study, two model types were used: an additive model, with price determined as a sum of quality variables each multiplied by an implicit price coefficient; and a multiplicative model, with price determined as a product of quality variables each raised to a power determined by the implicit price. In practice, the latter was represented by an additive model with logarithmic transformations of all the variables, both price and quality. It may be noted that for all the models considered, the residuals were examined to check for appropriateness of the model; both types of model were found to be satisfactory in all cases.

**Table 7** Variables in the hedonic price analysis

| Abbreviation | Definition of variable |
|---|---|
| cera | Moisture content measured by Cera meter |
| clu | Colour L* value, unground sample |
| cau | Colour a* value, unground sample |
| cbu | Colour b* value, unground sample |
| clg | Colour L* value, ground sample |
| cag | Colour a* value, ground sample |
| cbg | Colour b* value, ground sample |
| chip | Percentage of chips |
| damg | Percentage of damaged grain |
| pad | Number per kg of paddy grain |
| brok | Percentage of broken grain |
| fm | Percentage of foreign matter |
| insd | Number per kg of dead insects |
| insl | Number per kg of live insects |
| ayt | Actual yellows, measured at R&D lab. |
| pyt | Potential yellows, measured at R&D lab. |
| sizt | Size (length) of grain, measured at R&D lab. |
| shpt | Shape of grain, measured at R&D lab. |
| ayn | Actual yellows, measured at NRI |
| pyn | Potential yellows, measured at NRI |
| inf | Percentage of total infection by fungi |
| afl | Percentage of infection by *A. flavus* |
| anig | Percentage of infection by *A. niger* |
| acan | Percentage of infection by *A. candidus* |
| afum | Percentage of infection by *A. fumigatus* |
| agl | Percentage of infection by *A. glaucus* group |
| pisl | Percentage of infection by *P. islandicum* |
| pen | Percentage of infection by *Penicillium* sp. |
| rhiz | Percentage of infection by *Rhizopus/Mucor* spp. |
| lip | Total lipids |
| ffpc | Percentage of lipids as free fatty acids |
| nvrs | Number of varieties, measured at Food lab. |
| siz1s | Size of grain, predominant variety, measured at Food lab. |
| shp1s | Shape of grain, predominant variety, measured at Food lab. |
| siz2s | Size of grain, second variety, measured at Food lab. |
| shp2s | Shape of grain, second variety, measured at Food lab. |

**Table 8** Final regressions – multiplicative models

| Variable | Coefficient for market | | |
|---|---|---|---|
| | Jakarta | Medan | Surabaya |
| Colour | | | |
| L unground | 0.937 | 0.229 | –0.558 |
| L ground | –2.520 | | |
| a unground | –0.087 | –0.051 | –0.091 |
| a ground | | –0.010 | |
| b unground | | | 0.470 |
| b ground | | | –0.480 |
| Yellow grains | –0.042 | –0.007 | –0.028 |
| Moisture content | 0.342 | | 0.130 |
| Insects (dead) | –0.005 | | |
| Brokens | | | 0.023 |
| Lipids | | 0.047 | |
| Free fatty acids | | –0.036 | 0.045 |
| **Coefficient of variation** | **.80** | **.89** | **.67** |

## Interpretation of regression results

At this stage, therefore, various types of models will have been tried, incorporating differing variables, and differing coefficients for the same variables. For each market, there may be models using different deflators, different pools of variables for selection, additive or multiplicative models, and models obtained by forward or backward stepping. It is now necessary to assess, for each market, which models are most appropriate.

A number of criteria are relevant to this assessment. The magnitude of the coefficient of variation indicates how much of the variability in price is accounted for by the model. Examination of the residuals from the model gives an indication of whether the functional form of the model is appropriate. The degree of consistency of the variables selected by forward and backward stepping, and the stability of their coefficients during the stepwise regression process, indicate how stable the model is. It may also be relevant to consider the degree of consistency of the different models themselves – whether the same deflator (if several have been tried) gives consistently the best results for different model forms, or whether the same variables are consistently important in different models.

In the Indonesian study, there were good levels of the coefficient of determination, the highest values for the three markets being .90, .95, and .73 respectively. Examination of the residuals suggested that all the models considered were satisfactory as regards functional form. For most of the variables appearing in the models there was good consistency for both directions of the stepwise regressions, and good stability of the coefficients during the stepwise process. Those variables where there was less consistency tended to be those appearing late in the stepwise procedure, and of marginal importance in the model. For the different model types for each market, there was good consistency in the variables appearing in the models, and also in which deflator gave the best results. For each market, the variables appearing consistently in the best models of each type largely coincided with the variables selected from the reduced set, and the final regression models were therefore obtained by restricting the analysis to these variables. (It may be noted however that this last step may only be worthwhile where there are small numbers of missing values for a large number of variables, and the affected cases do not coincide). The final models are given in Table 8.

Having thus arrived at a final set of parsimonious, consistent, robust and well-fitting models, there are still some issues which need to be borne in mind in interpreting and using these models. First of all, there are still likely to be some correlations between variables in the same model. This will make interpretation of the coefficients of these variables difficult, since each one may incorporate effects which could also be attributed to the other. There is also the possibility

that the coefficients may be unstable, and it may be useful to examine this by applying ridge regression.

Secondly, there may be variables which do not appear in the models because the focus of the study is on a restricted range of some characteristics of the commodity of interest, but which might well appear if a wider range of the commodity were studied. In the Indonesian study, for example, the variety of rice did not appear in the models since the samples studied did not vary much in this respect, but other studies covering a wider range of this characteristic have found it to be of considerable importance. Thus, characteristics which do not appear in a model which relates to a restricted range of a commodity may still be of importance in a more general context, and this needs to be borne in mind in interpreting the model. A further implication is that the model may be affected by specification bias, so that the coefficients of other variables in the model might change significantly if other characteristics were incorporated in the model. In interpreting the models, therefore, particular care needs to be taken in interpreting the magnitudes of coefficients.

Considering the models from the Indonesian study given in Table 8, it has already been noted that there was found to be good consistency and stability of the variables and their coefficients. There are also high values of the coefficient of variation. There are some correlations between the variables in the models (*see* Figure 13), but mainly between the colour variables. Interpretation of these models should not, therefore, be too severely affected by the issues noted above, but it is necessary to bear in mind that the different colour variables are correlated with each other.

The most striking point arising from these models is the importance of colour. Colour variables appear consistently across the three markets, and although detailed interpretation of the individual colour variables is inappropriate in view of the correlations between them, the overall effect appears to be of an association of higher prices with rice which is more white, and tending more towards a green shade than a red one. Also of consistent importance is the level of yellow grains, where a higher price is consistently associated with a lower incidence of yellows. Other variables appearing in the models for some but not all markets are moisture content, insects, brokens, and lipids and free fatty acids.

## Traders' perceptions of quality variables

In the Indonesian study, traders were asked, in addition to estimating prices, to list those characteristics which had influenced their pricing. The factors listed were categorized and coded for two sample sets presented at the beginning and near the end of the study in order to capture the full range of quality variables for comparative analysis. The frequencies of characteristics listed for each market and for each sample set were recorded and compared with the objectively measured corresponding variables as determined for the identical sample sets at the analytical laboratories. In all such cases examined, the correlation coefficients were not significantly different from zero.

This lack of a relationship between the price, and the factors declared by the traders to be important in determining it, may well be due to the relatively small range of some quality variables in the Indonesian study samples. The level of, for example, broken grains in a sample may be important to a trader in differentiating it in price from the generality of other qualities of grain in the market, but may not be of much relevance in distinguishing it from other study samples which have similar levels of broken grains.

## Financial implications of regression results

The range of quality changes identified and the price relationships which can be determined will be a function of:

**Commodity**
**Intake quality**
**Storage system**
**Storage management regime**
**Marketing system**
**Consumer preference***

* Trader/wholesaler/retailer, etc.

The storage enterprise will wish to isolate those price-related changes of greatest financial significance and to examine its operational strategy in order to determine in which areas the potential for cost-effective modifications exist. The aim of the quality/value study will be to set out for senior management the estimated effects on price of quality change over time. This may be expressed in terms of currency per unit volume of grain, for example, cents per pound, rupiah per kilogram, etc., and will relate to specific periods of time, for example, a typical storage period, change per month stored, etc. The data can be listed in order of financial significance by quality variable and by offtake market where appropriate.

In the Indonesian study, the mean quality changes over the one year period of storage observed were calculated, and the price changes associated with these quality changes were estimated using the models of Table 8.

Figure 14 shows the contributions of the various major elements of quality change to the price changes for the different markets.

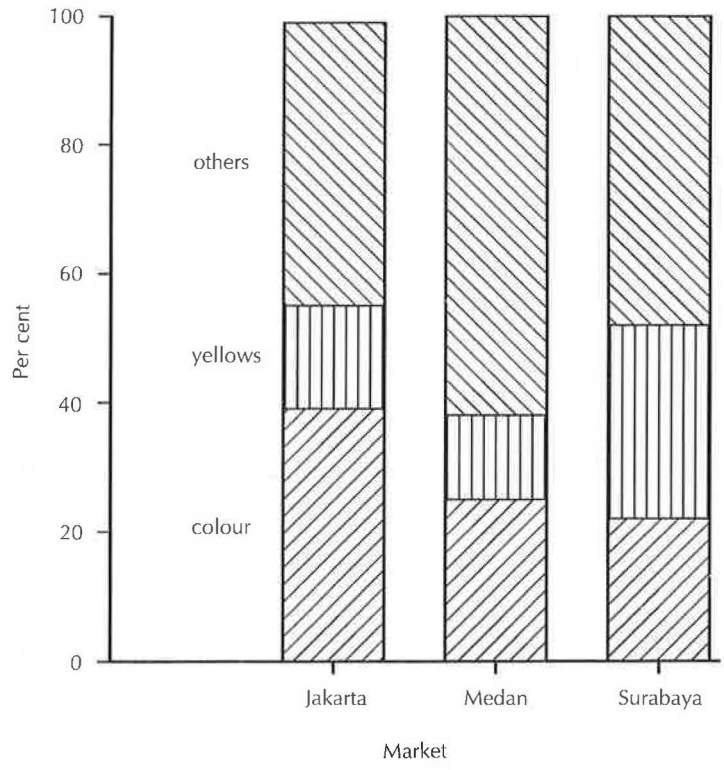



**Figure 14** Estimated contributions of quality variables to price changes

## CONCLUSIONS

The methodology described in this bulletin is concerned with the application of general models of consumer goods characteristics to the estimation of implicit prices for quality attributes of stored grain. This approach offers exciting possibilities for grain storage enterprises to evaluate the cost-effectiveness of their operations, and to approach, possibly for the first time, the elusive concept of financial valuation of quality change.

Based on a case study and the experience derived therein, a set of methodologies is proposed which requires the minimum of enterprise-specific modification. These methodologies cover the assembly and interpretation of data to provide a basis for the selection of storage technology packages.

An encouraging example of this is the identification of the quality variables of colour as having greatest price significance in the Indonesian case study on milled rice. Techniques which effectively minimize colour change in milled rice are available to the national storage agency and can now be considered for further adoption; other age-related problems require further study.

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# Appendices

## APPENDIX 1 STUDY METHODOLOGY – SAMPLING PROCEDURES

### Sampling

#### Sampling of stacks

Three provinces are selected purposively.

In each province, 5 lowland storage centres (referred to in subsequent notes as complexes) are selected purposively according to logistical convenience and to give a broad range of conditions.

In each complex, 2 godowns are selected purposively according to administrative and logistical convenience. In each godown, 1 full-size stack is selected purposively according to administrative and logistical convenience, and if possible, of a single grain variety. From each stack, 1 inner and 1 outer sample are collected.

Figures 1 and 2 show the overall sampling schedule.

#### Selection of bags

The method of stack construction will affect the detailed method of selection of bags. In general, the 5-key unit method of construction is used – three bags are laid side by side and at one end, two bags are laid end to end. Figure 15 shows one such layer.

The next layer is then added, rotated through 180°. Stacks consist of a number of these units, usually 20 layers high, four units wide across the front face and 7, 8 or 9 units deep along the side face. It follows then, that the depth of the stack determines its size.

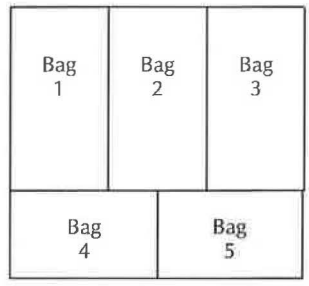



**Figure 15** The 5-key unit of stack construction

#### General principles for selection

All bags are to be sampled through their long sides, not through their short ends.

Each bag will be marked with coloured string, to facilitate its resampling at monthly intervals.

### *Outside sample*

*Front and back faces* In each 5-key unit at the corner of the stack, count 5 layers up from the floor and 5 layers down from the top. If on this layer the second bag in from the corner presents its long side, use this bag; if not, the bag to select will be in the sixth layer. Four bags will be sampled in this way. The fifth sample will be taken from either of the two inner 5-key units, tenth or eleventh row up. Choose the bag which is next to the central seam of the stack.

*Left and right faces* This time ignore the two outermost 5-key units, choosing the bag in the fifth or sixth layer which is next to the outermost seam of the stack. The remaining sample will be taken from the central unit if the stack is an odd number of units deep, or from one of the two central units if not, tenth or eleventh row up.

### *Inside sample*

*Front and back samples* Climb onto the top of the stack and ignoring the first row of four 5-key units which constitute the front and back faces of the stack choose the two inner units of the next row. Remove the top two layers of these units to expose the third layer which consists of ten bags. Choose any seven of these bags and mark with coloured string, then taking care not to disturb the contents unduly gently lift out the chosen bags and draw samples through their long sides (*see* below). Gently replace all bags and cover with layers 2 and 1.

*Middle sample* If the stack consists of an odd number of rows of units, choose the middle row; if not choose one of the central two. Uncover the two inner units and proceed to select, mark and sample bags as above.

Each outside stack sample will consist of 5 bags from each of 4 faces = 20 bags.

Each inside stack sample will consist of 7 bags from each of 3 locations = 21 bags.

## Sampling of bags

The sample-drawing method has been devised to provide a sample of sufficient quantity to meet the needs of analysis and evaluation, yet to minimize the reduction in bag volume and stack stability. It is important precisely to follow the procedure given below.

### *The spear*

It is most important to standardize on one model of sampling spear at all study sites. A specification which has been found to be appropriate is given below.

Two-piece tubular, closable single-compartment sampling spear, the inner tube secured by a bayonet catch, and equipped with a T-bar handle and chamfered point to facilitate sack penetration.

Outer tube: 16 mm outside diameter, 14 mm inside diameter, length 645 mm.
Inner tube: 12.5 mm o.d., 10 mm i.d.
Combined overall length when fitted 750 mm.
Eight sampling apertures, round-ended slots 30 × 7 mm, 16 mm apart to a single internal compartment.
External tube chamfered to a point by a single cross cut extending back 80 mm to a plug in the tube.

### *Sampling procedure*

Refer to Figure 3 which shows the sampling positions on the long side of the bag: namely, top left, centre, bottom right.

If the bag is part of the outside sample it should be sampled *in situ*; if part of the inside sample it should be lifted carefully and laid flat; so that in both cases the spear can be inserted parallel to the bottom seam of the bag.

1 Close the spear and with the closed apertures uppermost insert vigorously at point 'a' so that all the apertures are within the bag. The spear must penetrate parallel to the bag's bottom seam.

2 Ensuring that the outer tube remains static, rotate the inner tube to open the apertures and tap the spear gently to encourage grain to fill the inner compartment.

3 Ensuring that the outer tube remains static, withdraw the inner tube and collect its contents in a secure container.

4 Tap the outer tube gently, withdraw it and add its contents to the secure container.

5 Repeat the procedure at points 'b' and 'c' of the bag.

The above procedure thus produces six sub-samples from any given bag. These should be collected together into one sample and added to the samples from the other bags in the same series, that is Inside Stack Sample and Outside Stack Sample.

The samples therefore will consist of:

Inside Sample – 6 sub-samples from each of 21 bags;
Outside Sample – 6 sub-samples from each of 20 bags.

## Sample division

For each outer or inner stack sample, the individual spear samples from the selected bags are to be combined, giving a total quantity of minimum 3000 g. This quantity is then to be divided by Boerner divider into 16 equal samples, to be used for various purposes, as indicated in Figure 4.

# Master list of sample numbers

When the samples of rice coming from the stacks are sent for analysis or test marketing, any unconscious effects of knowing which area or store they come from, or what the previous results from the same stack were must be avoided. For this purpose, the samples need to be given identification numbers which do not identify their origin, or associate them with other samples from the same stack.

The two master lists, one for analysis samples and one for test marketing samples, give suitable test identification numbers (TID) and are shown as Figures 16 and 17. It is a complex matter to ensure that the correct numbers are given to the samples, and the results of analysis or marketing recorded correctly, and it is therefore important that a senior study team member be directly in charge of the labelling of the samples, as well as the eventual recording of the results. To maintain the necessary confidentiality of the numbering system, it is important that only this team member and the study co-ordinator be familiar with the master lists of sample numbers.

## Numbering systems

The identification data that will be needed for the statistical analysis and interpretation of the results are those which show whence the sample originated. This information, following the same numbering system as in Figure 1, is given on the left hand side of the master lists, and consists of:

| Sample ID | | | | OD (NRI, mycological/lipids) | | | | | | | | | | | | SK (Sukamandi, olfactory/cooking quality) | | | | | | | | | | | | TB (Tambun, physical analysis) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | C | SI/O | Mth | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 1 | 1 | I | 1 | 5 | 41 | 28 | 22 | 40 | 17 | 37 | 41 | 18 | 13 | 10 | 17 | 43 | 19 | 6 | 52 | 42 | 19 | 39 | 20 | 27 | 20 | 19 | 57 | 23 | 59 | 46 | 11 | 1 | 39 | 60 | 40 | 47 | 40 | 38 |
| 1 | 1 | 1 | O | 2 | 6 | 42 | 29 | 24 | 42 | 19 | 39 | 43 | 20 | 15 | 12 | 18 | 44 | 20 | 7 | 54 | 44 | 22 | 41 | 22 | 29 | 22 | 21 | 58 | 24 | 60 | 47 | 13 | 3 | 41 | 2 | 42 | 49 | 42 | 41 |
| 1 | 1 | 2 | I | 3 | 7 | 43 | 30 | 26 | 44 | 22 | 41 | 45 | 22 | 1 | 14 | 19 | 45 | 21 | 8 | 56 | 46 | 24 | 43 | 24 | 31 | 24 | 23 | 59 | 25 | 1 | 48 | 15 | 5 | 43 | 4 | 44 | 51 | 44 | 43 |
| 1 | 1 | 2 | O | 4 | 8 | 44 | 31 | 28 | 46 | 24 | 43 | 47 | 24 | 19 | 16 | 20 | 46 | 22 | 9 | 58 | 48 | 26 | 45 | 26 | 33 | 26 | 25 | 60 | 26 | 2 | 49 | 17 | 7 | 45 | 6 | 46 | 53 | 46 | 45 |
| 1 | 2 | 1 | I | 5 | 9 | 45 | 32 | 30 | 48 | 26 | 45 | 49 | 26 | 21 | 18 | 21 | 47 | 23 | 10 | 60 | 50 | 28 | 47 | 28 | 35 | 28 | 27 | 1 | 27 | 3 | 50 | 19 | 9 | 47 | 8 | 48 | 55 | 48 | 47 |
| 1 | 2 | 1 | O | 6 | 10 | 46 | 33 | 32 | 50 | 28 | 47 | 51 | 28 | 23 | 20 | 22 | 48 | 24 | 11 | 2 | 52 | 30 | 49 | 30 | 37 | 30 | 29 | 2 | 28 | 4 | 51 | 22 | 11 | 49 | 10 | 50 | 57 | 50 | 49 |
| 1 | 2 | 2 | I | 7 | 11 | 47 | 34 | 34 | 52 | 30 | 49 | 53 | 30 | 25 | 22 | 23 | 49 | 25 | 12 | 4 | 54 | 32 | 51 | 32 | 39 | 32 | 31 | 3 | 29 | 5 | 52 | 24 | 13 | 51 | 12 | 52 | 59 | 52 | 51 |
| 1 | 2 | 2 | O | 8 | 12 | 48 | 35 | 36 | 54 | 32 | 51 | 55 | 32 | 27 | 24 | 24 | 50 | 26 | 13 | 6 | 56 | 34 | 53 | 34 | 40 | 34 | 33 | 4 | 30 | 6 | 53 | 26 | 15 | 53 | 14 | 54 | 1 | 54 | 53 |
| 1 | 3 | 1 | I | 9 | 13 | 49 | 36 | 38 | 56 | 34 | 53 | 57 | 34 | 29 | 26 | 25 | 51 | 27 | 14 | 8 | 58 | 36 | 55 | 36 | 42 | 36 | 35 | 5 | 31 | 7 | 54 | 28 | 17 | 55 | 16 | 56 | 3 | 56 | 55 |
| 1 | 3 | 1 | O | 10 | 14 | 50 | 37 | 40 | 58 | 36 | 55 | 59 | 36 | 31 | 28 | 26 | 52 | 28 | 15 | 10 | 60 | 38 | 57 | 38 | 44 | 38 | 37 | 6 | 32 | 8 | 55 | 30 | 19 | 57 | 18 | 58 | 5 | 58 | 57 |
| 1 | 3 | 2 | I | 11 | 15 | 51 | 38 | 42 | 60 | 38 | 57 | 1 | 38 | 33 | 30 | 27 | 53 | 29 | 16 | 12 | 2 | 40 | 59 | 41 | 46 | 41 | 39 | 7 | 33 | 9 | 56 | 32 | 22 | 59 | 20 | 60 | 7 | 60 | 59 |
| 1 | 3 | 2 | O | 12 | 16 | 52 | 39 | 44 | 2 | 40 | 59 | 3 | 41 | 35 | 32 | 28 | 54 | 30 | 17 | 14 | 4 | 42 | 1 | 43 | 48 | 43 | 40 | 8 | 34 | 10 | 57 | 34 | 24 | 1 | 21 | 2 | 9 | 2 | 1 |
| 1 | 4 | 1 | I | 13 | 17 | 53 | 40 | 46 | 4 | 42 | 1 | 5 | 43 | 37 | 34 | 29 | 55 | 31 | 18 | 16 | 6 | 44 | 3 | 45 | 50 | 45 | 42 | 9 | 35 | 11 | 58 | 36 | 26 | 3 | 23 | 4 | 11 | 4 | 3 |
| 1 | 4 | 1 | O | 14 | 18 | 54 | 41 | 48 | 6 | 44 | 3 | 7 | 45 | 39 | 36 | 30 | 56 | 32 | 19 | 18 | 8 | 46 | 5 | 47 | 52 | 47 | 44 | 10 | 36 | 12 | 59 | 38 | 28 | 5 | 25 | 6 | 13 | 6 | 5 |
| 1 | 4 | 2 | I | 15 | 19 | 55 | 42 | 50 | 8 | 46 | 5 | 9 | 47 | 40 | 38 | 31 | 57 | 33 | 20 | 20 | 10 | 48 | 7 | 49 | 54 | 49 | 46 | 11 | 37 | 13 | 60 | 40 | 30 | 7 | 27 | 8 | 15 | 8 | 7 |
| 1 | 4 | 2 | O | 16 | 20 | 56 | 43 | 52 | 10 | 48 | 7 | 11 | 49 | 42 | 41 | 32 | 58 | 34 | 21 | 21 | 12 | 50 | 9 | 51 | 56 | 51 | 48 | 12 | 38 | 14 | 1 | 42 | 32 | 9 | 29 | 10 | 17 | 10 | 9 |
| 1 | 5 | 1 | I | 17 | 21 | 57 | 44 | 54 | 12 | 50 | 9 | 13 | 51 | 44 | 43 | 33 | 59 | 35 | 22 | 23 | 14 | 52 | 11 | 53 | 58 | 53 | 50 | 13 | 39 | 15 | 2 | 44 | 34 | 11 | 31 | 12 | 19 | 12 | 11 |
| 1 | 5 | 1 | O | 18 | 22 | 58 | 45 | 56 | 14 | 52 | 11 | 15 | 53 | 46 | 45 | 34 | 60 | 36 | 23 | 25 | 16 | 54 | 13 | 55 | 60 | 55 | 52 | 14 | 40 | 16 | 3 | 46 | 36 | 13 | 33 | 14 | 21 | 14 | 13 |
| 1 | 5 | 2 | I | 19 | 23 | 59 | 46 | 58 | 16 | 54 | 13 | 17 | 55 | 48 | 47 | 35 | 1 | 37 | 24 | 27 | 18 | 56 | 15 | 57 | 2 | 57 | 54 | 15 | 41 | 17 | 4 | 48 | 38 | 15 | 35 | 16 | 23 | 16 | 15 |
| 1 | 5 | 2 | O | 20 | 24 | 60 | 47 | 60 | 18 | 56 | 15 | 19 | 57 | 50 | 49 | 36 | 2 | 38 | 25 | 29 | 20 | 58 | 17 | 59 | 4 | 59 | 56 | 16 | 42 | 18 | 5 | 50 | 40 | 17 | 37 | 18 | 25 | 18 | 17 |
| 2 | 1 | 1 | I | 21 | 25 | 1 | 48 | 2 | 20 | 58 | 17 | 21 | 59 | 52 | 51 | 37 | 3 | 39 | 26 | 31 | 21 | 60 | 19 | 1 | 6 | 1 | 58 | 17 | 43 | 19 | 6 | 52 | 42 | 19 | 39 | 20 | 27 | 20 | 19 |
| 2 | 1 | 1 | O | 22 | 26 | 2 | 49 | 4 | 21 | 60 | 19 | 23 | 1 | 54 | 53 | 38 | 4 | 40 | 27 | 33 | 23 | 2 | 22 | 3 | 8 | 3 | 60 | 18 | 44 | 20 | 7 | 54 | 44 | 22 | 41 | 22 | 29 | 22 | 21 |
| 2 | 1 | 2 | I | 23 | 27 | 3 | 50 | 6 | 23 | 2 | 22 | 25 | 3 | 56 | 55 | 39 | 5 | 41 | 28 | 35 | 25 | 4 | 24 | 5 | 10 | 5 | 2 | 19 | 45 | 21 | 8 | 56 | 46 | 24 | 43 | 24 | 31 | 24 | 23 |
| 2 | 1 | 2 | O | 24 | 28 | 4 | 51 | 8 | 25 | 4 | 24 | 27 | 5 | 58 | 57 | 40 | 6 | 42 | 29 | 37 | 27 | 6 | 26 | 7 | 12 | 7 | 4 | 20 | 46 | 22 | 9 | 58 | 48 | 26 | 45 | 26 | 33 | 26 | 25 |
| 2 | 2 | 1 | I | 25 | 29 | 5 | 52 | 10 | 27 | 6 | 26 | 29 | 7 | 60 | 59 | 41 | 7 | 43 | 30 | 39 | 29 | 8 | 28 | 9 | 14 | 9 | 6 | 21 | 47 | 23 | 10 | 60 | 50 | 28 | 47 | 28 | 35 | 28 | 27 |
| 2 | 2 | 1 | O | 26 | 30 | 6 | 53 | 12 | 29 | 8 | 28 | 31 | 9 | 2 | 1 | 42 | 8 | 44 | 31 | 41 | 31 | 10 | 30 | 11 | 16 | 11 | 8 | 22 | 48 | 24 | 11 | 2 | 52 | 30 | 49 | 30 | 37 | 30 | 29 |
| 2 | 2 | 2 | I | 27 | 31 | 7 | 54 | 14 | 31 | 10 | 30 | 33 | 11 | 4 | 3 | 43 | 9 | 45 | 32 | 43 | 33 | 12 | 32 | 13 | 18 | 13 | 10 | 23 | 49 | 25 | 12 | 4 | 54 | 32 | 51 | 32 | 39 | 32 | 31 |
| 2 | 2 | 2 | O | 28 | 32 | 8 | 55 | 16 | 33 | 12 | 32 | 35 | 13 | 6 | 5 | 44 | 10 | 46 | 33 | 45 | 35 | 14 | 34 | 15 | 20 | 15 | 12 | 24 | 50 | 26 | 13 | 6 | 56 | 34 | 53 | 34 | 40 | 34 | 33 |
| 2 | 3 | 1 | I | 29 | 33 | 9 | 56 | 18 | 35 | 14 | 34 | 37 | 15 | 8 | 7 | 45 | 11 | 47 | 34 | 47 | 37 | 16 | 36 | 17 | 22 | 17 | 14 | 25 | 51 | 27 | 14 | 8 | 58 | 36 | 55 | 36 | 42 | 36 | 35 |
| 2 | 3 | 1 | O | 30 | 34 | 10 | 57 | 20 | 37 | 16 | 36 | 39 | 17 | 10 | 9 | 46 | 12 | 48 | 35 | 49 | 39 | 18 | 38 | 19 | 24 | 19 | 16 | 26 | 52 | 28 | 15 | 10 | 60 | 38 | 57 | 38 | 44 | 38 | 37 |
| 2 | 3 | 2 | I | 31 | 35 | 11 | 58 | 21 | 39 | 18 | 38 | 40 | 19 | 12 | 11 | 47 | 13 | 49 | 36 | 51 | 41 | 20 | 40 | 21 | 26 | 21 | 18 | 27 | 53 | 29 | 16 | 12 | 2 | 40 | 59 | 41 | 46 | 41 | 39 |
| 2 | 3 | 2 | O | 32 | 36 | 12 | 59 | 23 | 41 | 20 | 40 | 42 | 21 | 14 | 13 | 48 | 14 | 50 | 37 | 53 | 43 | 21 | 42 | 23 | 28 | 23 | 20 | 28 | 54 | 30 | 17 | 14 | 4 | 42 | 1 | 43 | 48 | 43 | 40 |
| 2 | 4 | 1 | I | 33 | 37 | 13 | 60 | 25 | 43 | 21 | 42 | 44 | 23 | 16 | 15 | 49 | 15 | 51 | 38 | 55 | 45 | 23 | 44 | 25 | 30 | 25 | 22 | 29 | 55 | 31 | 18 | 16 | 6 | 44 | 3 | 45 | 50 | 45 | 42 |
| 2 | 4 | 1 | O | 34 | 38 | 14 | 1 | 27 | 45 | 23 | 44 | 46 | 25 | 18 | 17 | 50 | 16 | 52 | 39 | 57 | 47 | 25 | 46 | 27 | 32 | 27 | 24 | 30 | 56 | 32 | 19 | 18 | 8 | 46 | 5 | 47 | 52 | 47 | 44 |
| 2 | 4 | 2 | I | 35 | 39 | 15 | 2 | 29 | 47 | 25 | 46 | 48 | 27 | 20 | 19 | 51 | 17 | 53 | 40 | 59 | 49 | 27 | 48 | 29 | 34 | 29 | 26 | 31 | 57 | 33 | 20 | 20 | 10 | 48 | 7 | 49 | 54 | 49 | 46 |
| 2 | 4 | 2 | O | 36 | 40 | 16 | 3 | 31 | 49 | 27 | 48 | 50 | 29 | 22 | 21 | 52 | 18 | 54 | 41 | 1 | 51 | 29 | 50 | 31 | 36 | 31 | 28 | 32 | 58 | 34 | 21 | 21 | 12 | 50 | 9 | 51 | 56 | 51 | 48 |
| 2 | 5 | 1 | I | 37 | 41 | 17 | 4 | 33 | 51 | 29 | 50 | 52 | 31 | 24 | 23 | 53 | 19 | 55 | 42 | 3 | 53 | 31 | 52 | 33 | 38 | 33 | 30 | 33 | 59 | 35 | 22 | 23 | 14 | 52 | 11 | 53 | 58 | 53 | 50 |
| 2 | 5 | 1 | O | 38 | 42 | 18 | 5 | 35 | 53 | 31 | 52 | 54 | 33 | 26 | 25 | 54 | 20 | 56 | 43 | 5 | 55 | 33 | 54 | 35 | 41 | 35 | 32 | 34 | 60 | 36 | 23 | 25 | 16 | 54 | 13 | 55 | 60 | 55 | 52 |
| 2 | 5 | 2 | I | 39 | 43 | 19 | 6 | 37 | 55 | 33 | 54 | 56 | 35 | 28 | 27 | 55 | 21 | 57 | 44 | 7 | 57 | 35 | 56 | 37 | 43 | 37 | 34 | 35 | 1 | 37 | 24 | 27 | 18 | 56 | 15 | 57 | 2 | 57 | 54 |
| 2 | 5 | 2 | O | 40 | 44 | 20 | 7 | 39 | 57 | 35 | 56 | 58 | 37 | 30 | 29 | 56 | 22 | 58 | 45 | 9 | 59 | 37 | 58 | 39 | 45 | 39 | 36 | 36 | 2 | 38 | 25 | 29 | 20 | 58 | 17 | 59 | 4 | 59 | 56 |
| 3 | 1 | 1 | I | 41 | 45 | 21 | 8 | 41 | 59 | 37 | 58 | 60 | 39 | 32 | 31 | 57 | 23 | 59 | 46 | 11 | 1 | 39 | 60 | 40 | 47 | 40 | 38 | 37 | 3 | 39 | 26 | 31 | 21 | 60 | 19 | 1 | 6 | 1 | 58 |
| 3 | 1 | 1 | O | 42 | 46 | 22 | 9 | 43 | 1 | 39 | 60 | 2 | 40 | 34 | 33 | 58 | 24 | 60 | 47 | 13 | 3 | 41 | 2 | 42 | 49 | 42 | 41 | 38 | 4 | 40 | 27 | 33 | 23 | 2 | 22 | 3 | 8 | 3 | 60 |
| 3 | 1 | 2 | I | 43 | 47 | 23 | 10 | 45 | 3 | 41 | 2 | 4 | 42 | 36 | 35 | 59 | 25 | 1 | 48 | 15 | 5 | 43 | 4 | 44 | 51 | 44 | 43 | 39 | 5 | 41 | 28 | 35 | 25 | 4 | 24 | 5 | 10 | 5 | 2 |
| 3 | 1 | 2 | O | 44 | 48 | 24 | 11 | 47 | 5 | 43 | 4 | 6 | 44 | 38 | 37 | 60 | 26 | 2 | 49 | 17 | 7 | 45 | 6 | 46 | 53 | 46 | 45 | 40 | 6 | 42 | 29 | 37 | 27 | 6 | 26 | 7 | 12 | 7 | 4 |
| 3 | 2 | 1 | I | 45 | 49 | 25 | 12 | 49 | 7 | 45 | 6 | 8 | 46 | 41 | 39 | 1 | 27 | 3 | 50 | 19 | 9 | 47 | 8 | 48 | 55 | 48 | 47 | 41 | 7 | 43 | 30 | 39 | 29 | 8 | 28 | 9 | 14 | 9 | 6 |
| 3 | 2 | 1 | O | 46 | 50 | 26 | 13 | 51 | 9 | 47 | 8 | 10 | 48 | 43 | 40 | 2 | 28 | 4 | 51 | 22 | 11 | 49 | 10 | 50 | 57 | 50 | 49 | 42 | 8 | 44 | 31 | 41 | 31 | 10 | 30 | 11 | 16 | 11 | 8 |
| 3 | 2 | 2 | I | 47 | 51 | 27 | 14 | 53 | 11 | 49 | 10 | 12 | 50 | 45 | 42 | 3 | 29 | 5 | 52 | 24 | 13 | 51 | 12 | 52 | 59 | 52 | 51 | 43 | 9 | 45 | 32 | 43 | 33 | 12 | 32 | 13 | 18 | 13 | 10 |
| 3 | 2 | 2 | O | 48 | 52 | 28 | 15 | 55 | 13 | 51 | 12 | 14 | 52 | 47 | 44 | 4 | 30 | 6 | 53 | 26 | 15 | 53 | 14 | 54 | 1 | 54 | 53 | 44 | 10 | 46 | 33 | 45 | 35 | 14 | 34 | 15 | 20 | 15 | 12 |
| 3 | 3 | 1 | I | 49 | 53 | 29 | 16 | 57 | 15 | 53 | 14 | 16 | 54 | 49 | 46 | 5 | 31 | 7 | 54 | 28 | 17 | 55 | 16 | 56 | 3 | 56 | 55 | 45 | 11 | 47 | 34 | 47 | 37 | 16 | 36 | 17 | 22 | 17 | 14 |
| 3 | 3 | 1 | O | 50 | 54 | 30 | 17 | 59 | 17 | 55 | 16 | 18 | 56 | 51 | 48 | 6 | 32 | 8 | 55 | 30 | 19 | 57 | 18 | 58 | 5 | 58 | 57 | 46 | 12 | 48 | 35 | 49 | 39 | 18 | 38 | 19 | 24 | 19 | 16 |
| 3 | 3 | 2 | I | 51 | 55 | 31 | 18 | 1 | 19 | 57 | 18 | 20 | 58 | 53 | 50 | 7 | 33 | 9 | 56 | 32 | 22 | 59 | 20 | 60 | 7 | 60 | 59 | 47 | 13 | 49 | 36 | 51 | 41 | 20 | 40 | 21 | 26 | 21 | 18 |
| 3 | 3 | 2 | O | 52 | 56 | 32 | 19 | 3 | 22 | 59 | 20 | 22 | 60 | 55 | 52 | 8 | 34 | 10 | 57 | 34 | 24 | 1 | 21 | 2 | 9 | 2 | 1 | 48 | 14 | 50 | 37 | 53 | 43 | 21 | 42 | 23 | 28 | 23 | 20 |
| 3 | 4 | 1 | I | 53 | 57 | 33 | 20 | 5 | 24 | 1 | 21 | 24 | 2 | 57 | 54 | 9 | 35 | 11 | 58 | 36 | 26 | 3 | 23 | 4 | 11 | 4 | 3 | 49 | 15 | 51 | 38 | 55 | 45 | 23 | 44 | 25 | 30 | 25 | 22 |
| 3 | 4 | 1 | O | 54 | 58 | 34 | 21 | 7 | 26 | 3 | 23 | 26 | 4 | 59 | 56 | 10 | 36 | 12 | 59 | 38 | 28 | 5 | 25 | 6 | 13 | 6 | 5 | 50 | 16 | 52 | 39 | 57 | 47 | 25 | 46 | 27 | 32 | 27 | 24 |
| 3 | 4 | 2 | I | 55 | 59 | 35 | 22 | 9 | 28 | 5 | 25 | 28 | 6 | 1 | 58 | 11 | 37 | 13 | 60 | 40 | 30 | 7 | 27 | 8 | 15 | 8 | 7 | 51 | 17 | 53 | 40 | 59 | 49 | 27 | 48 | 29 | 34 | 29 | 26 |
| 3 | 4 | 2 | O | 56 | 60 | 36 | 23 | 11 | 30 | 7 | 27 | 30 | 8 | 3 | 60 | 12 | 38 | 14 | 1 | 42 | 32 | 9 | 29 | 10 | 17 | 10 | 9 | 52 | 18 | 54 | 41 | 1 | 51 | 29 | 50 | 31 | 36 | 31 | 28 |
| 3 | 5 | 1 | I | 57 | 1 | 37 | 24 | 13 | 32 | 9 | 29 | 32 | 10 | 5 | 2 | 13 | 39 | 15 | 2 | 44 | 34 | 11 | 31 | 12 | 19 | 12 | 11 | 53 | 19 | 55 | 42 | 3 | 53 | 31 | 52 | 33 | 38 | 33 | 30 |
| 3 | 5 | 1 | O | 58 | 2 | 38 | 25 | 15 | 34 | 11 | 31 | 34 | 12 | 7 | 4 | 14 | 40 | 16 | 3 | 46 | 36 | 13 | 33 | 14 | 21 | 14 | 13 | 54 | 20 | 56 | 43 | 5 | 55 | 33 | 54 | 35 | 41 | 35 | 32 |
| 3 | 5 | 2 | I | 59 | 3 | 39 | 26 | 17 | 36 | 13 | 33 | 36 | 14 | 9 | 6 | 15 | 41 | 17 | 4 | 48 | 38 | 15 | 35 | 16 | 23 | 16 | 15 | 55 | 21 | 57 | 44 | 7 | 57 | 35 | 56 | 37 | 43 | 37 | 34 |
| 3 | 5 | 2 | O | 60 | 4 | 40 | 27 | 19 | 38 | 15 | 35 | 38 | 16 | 11 | 8 | 16 | 42 | 18 | 5 | 50 | 40 | 17 | 37 | 18 | 25 | 18 | 17 | 56 | 22 | 58 | 45 | 9 | 59 | 37 | 58 | 39 | 45 | 39 | 36 |

**Figure 16** Master list of sample numbers – laboratory analysis

| Sample ID | | | | MJ (Test marketing Jakarta) | | | | | | | | | | | | MM (Test marketing Medan) | | | | | | | | | | | | MS (Test marketing Surabaya) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | C | SI/O | Mth | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 1 | 1 | I | 1 | | | | | | | 15 | | | 1 | | 9 | | | | | | | 7 | | | 2 | | 3 | | | | | | 13 | | | 5 | | |
| 1 | 1 | 1 | O | | 1 | | | | | 15 | | | | | 1 | | 9 | | | | | 7 | | | | | 2 | | 3 | | | | 13 | | | | | 5 |
| 1 | 1 | 2 | I | | | 1 | | | 15 | | | 1 | | | | | | 9 | | | | 7 | | | 2 | | | | | 3 | | | 13 | | | 5 | | |
| 1 | 1 | 2 | O | | | | 1 | 15 | | | | | 1 | | | | | | 9 | 7 | | | | | 2 | | | | | 3 | 13 | | | | 5 | | |
| 1 | 2 | 1 | I | | | | 2 | 14 | | | | | 3 | | | | | | 10 | 6 | | | | | 4 | | | | | 4 | 12 | | | | 7 | | |
| 1 | 2 | 1 | O | | | 2 | | | 14 | | | 3 | | | | | | 10 | | | 6 | | | | 4 | | | | | 4 | | | 12 | | | 7 | | |
| 1 | 2 | 2 | I | | 2 | | | | | 14 | | | | | 3 | | 10 | | | | | 6 | | | | | 4 | | 4 | | | | 12 | | | | | 7 |
| 1 | 2 | 2 | O | 2 | | | | | | | 14 | | | 3 | | 10 | | | | | | | 6 | | | 4 | | 4 | | | | | 12 | | | 7 | | |
| 1 | 3 | 1 | I | 3 | | | | | | | 13 | | | 5 | | 11 | | | | | | | 5 | | | 6 | | 5 | | | | | 11 | | | 9 | | |
| 1 | 3 | 1 | O | | 3 | | | | | 13 | | | | | 5 | | 11 | | | | | 5 | | | | | 6 | | 5 | | | | 11 | | | | | 9 |
| 1 | 3 | 2 | I | | | 3 | | | 13 | | | 5 | | | | | | 11 | | | 5 | | | 6 | | | | | 5 | | | 11 | | | 9 | | |
| 1 | 3 | 2 | O | | | | 3 | 13 | | | | | 5 | | | | | | 11 | 5 | | | | | 6 | | | | | 5 | 11 | | | | 9 | | |
| 1 | 4 | 1 | I | | | | 4 | 12 | | | | | 7 | | | | | | 12 | 4 | | | | | 8 | | | | | 6 | 10 | | | | 11 | | |
| 1 | 4 | 1 | O | | | 4 | | | 12 | | | 7 | | | | | | 12 | | | 4 | | | | 8 | | | | | 6 | | | 10 | | | 11 | | |
| 1 | 4 | 2 | I | | 4 | | | | | 12 | | | | | 7 | | 12 | | | | | 4 | | | | | 8 | | 6 | | | | 10 | | | | | 11 |
| 1 | 4 | 2 | O | 4 | | | | | | | 12 | | | 7 | | 12 | | | | | | | 4 | | | 8 | | 6 | | | | | 10 | | | 11 | | |
| 1 | 5 | 1 | I | 5 | | | | | | | 11 | | | 9 | | 13 | | | | | | | 3 | | | 10 | | 7 | | | | | 9 | | | 13 | | |
| 1 | 5 | 1 | O | | 5 | | | | | 11 | | | | | 9 | | 13 | | | | | 3 | | | | | 10 | | 7 | | | | 9 | | | | | 13 |
| 1 | 5 | 2 | I | | | 5 | | | 11 | | | 9 | | | | | | 13 | | | 3 | | | 10 | | | | | 7 | | | 9 | | | 13 | | |
| 1 | 5 | 2 | O | | | | 5 | 11 | | | | | 9 | | | | | | 13 | 3 | | | | | 10 | | | | | 7 | 9 | | | | 13 | | |
| 2 | 1 | 1 | I | | | | 6 | 10 | | | | | 11 | | | | | | 14 | 2 | | | | | 12 | | | | | 8 | 8 | | | | 15 | | |
| 2 | 1 | 1 | O | | | 6 | | | 10 | | | 11 | | | | | | 14 | | | 2 | | | | 12 | | | | | 8 | | | 8 | | | 15 | | |
| 2 | 1 | 2 | I | | 6 | | | | | 10 | | | | | 11 | | 14 | | | | | 2 | | | | | 12 | | 8 | | | | 8 | | | | | 15 |
| 2 | 1 | 2 | O | 6 | | | | | | | 10 | | | 11 | | 14 | | | | | | | 2 | | | 12 | | 8 | | | | | 8 | | | 15 | | |
| 2 | 2 | 1 | I | 7 | | | | | | | 9 | | | 13 | | 15 | | | | | | | 1 | | | 14 | | 9 | | | | | 7 | | | 2 | | |
| 2 | 2 | 1 | O | | 7 | | | | | 9 | | | | | 13 | | 15 | | | | | 1 | | | | | 14 | | 9 | | | | 7 | | | | | 2 |
| 2 | 2 | 2 | I | | | 7 | | | 9 | | | 13 | | | | | | 15 | | | 1 | | | 14 | | | | | 9 | | | 7 | | | 2 | | |
| 2 | 2 | 2 | O | | | | 7 | 9 | | | | | 13 | | | | | | 15 | 1 | | | | | 14 | | | | | 9 | 7 | | | | 2 | | |
| 2 | 3 | 1 | I | | | | 8 | 8 | | | | | 15 | | | | | | 1 | 15 | | | | | 1 | | | | | 10 | 6 | | | | 4 | | |
| 2 | 3 | 1 | O | | | 8 | | | 8 | | | 15 | | | | | | 1 | | | 15 | | | 1 | | | | | 10 | | | 6 | | | 4 | | |
| 2 | 3 | 2 | I | | 8 | | | | | 8 | | | | | 15 | | 1 | | | | | 15 | | | | | 1 | | 10 | | | | 6 | | | | | 4 |
| 2 | 3 | 2 | O | 8 | | | | | | | 8 | | | 15 | | 1 | | | | | | | 15 | | | 1 | | 10 | | | | | 6 | | | 4 | | |
| 2 | 4 | 1 | I | 9 | | | | | | | 7 | | | 2 | | 2 | | | | | | | 14 | | | 3 | | 11 | | | | | 5 | | | 6 | | |
| 2 | 4 | 1 | O | | 9 | | | | | 7 | | | | | 2 | | 2 | | | | | 14 | | | | | 3 | | 11 | | | | 5 | | | | | 6 |
| 2 | 4 | 2 | I | | | 9 | | | 7 | | | 2 | | | | | | 2 | | | 14 | | | 3 | | | | | 11 | | | 5 | | | 6 | | |
| 2 | 4 | 2 | O | | | | 9 | 7 | | | | | 2 | | | | | | 2 | 14 | | | | | 3 | | | | | 11 | 5 | | | | 6 | | |
| 2 | 5 | 1 | I | | | | 10 | 6 | | | | | 4 | | | | | | 3 | 13 | | | | | 5 | | | | | 12 | 4 | | | | 8 | | |
| 2 | 5 | 1 | O | | | 10 | | | 6 | | | 4 | | | | | | 3 | | | 13 | | | 5 | | | | | 12 | | | 4 | | | 8 | | |
| 2 | 5 | 2 | I | | 10 | | | | | 6 | | | | | 4 | | 3 | | | | | 13 | | | | | 5 | | 12 | | | | 4 | | | | | 8 |
| 2 | 5 | 2 | O | 10 | | | | | | | 6 | | | 4 | | 3 | | | | | | | 13 | | | 5 | | 12 | | | | | 4 | | | 8 | | |
| 3 | 1 | 1 | I | 11 | | | | | | | 5 | | | 6 | | 4 | | | | | | | 12 | | | 7 | | 13 | | | | | 3 | | | 10 | | |
| 3 | 1 | 1 | O | | 11 | | | | | 5 | | | | | 6 | | 4 | | | | | 12 | | | | | 7 | | 13 | | | | 3 | | | | | 10 |
| 3 | 1 | 2 | I | | | 11 | | | 5 | | | 6 | | | | | | 4 | | | 12 | | | 7 | | | | | 13 | | | 3 | | | 10 | | |
| 3 | 1 | 2 | O | | | | 11 | 5 | | | | | 6 | | | | | | 4 | 12 | | | | | 7 | | | | | 13 | 3 | | | | 10 | | |
| 3 | 2 | 1 | I | | | | 12 | 4 | | | | | 8 | | | | | | 5 | 11 | | | | | 9 | | | | | 14 | 2 | | | | 12 | | |
| 3 | 2 | 1 | O | | | 12 | | | 4 | | | 8 | | | | | | 5 | | | 11 | | | | 9 | | | | | 14 | | | 2 | | | 12 | | |
| 3 | 2 | 2 | I | | 12 | | | | | 4 | | | | | 8 | | 5 | | | | | 11 | | | | | 9 | | 14 | | | | 2 | | | | | 12 |
| 3 | 2 | 2 | O | 12 | | | | | | | 4 | | | 8 | | 5 | | | | | | | 11 | | | 9 | | 14 | | | | | 2 | | | 12 | | |
| 3 | 3 | 1 | I | 13 | | | | | | | 3 | | | 10 | | 6 | | | | | | | 10 | | | 11 | | 15 | | | | | 1 | | | 14 | | |
| 3 | 3 | 1 | O | | 13 | | | | | 3 | | | | | 10 | 6 | | | | | | 10 | | | | | 11 | 15 | | | | | 1 | | | 14 | | |
| 3 | 3 | 2 | I | | | 13 | | | 3 | | | 10 | | | | | 6 | | | | 10 | | | 11 | | | | | 15 | | | 1 | | | 14 | | |
| 3 | 3 | 2 | O | | | | 13 | 3 | | | | | 10 | | | | | 6 | 10 | | | | | 11 | | | | | 15 | 1 | | | | 14 | | |
| 3 | 4 | 1 | I | | | | 14 | 2 | | | | | 12 | | | | | 7 | 9 | | | | | 13 | | | | | 1 | 15 | | | | 1 | | |
| 3 | 4 | 1 | O | | | 14 | | | 2 | | | 12 | | | | | 7 | | | | 9 | | | 13 | | | | 1 | | | 15 | | | 1 | | | |
| 3 | 4 | 2 | I | | 14 | | | | | 2 | | | | | 12 | | 7 | | | | | 9 | | | | | 13 | | 1 | | | | 15 | | | | | 1 |
| 3 | 4 | 2 | O | 14 | | | | | | | 2 | | | 12 | | 7 | | | | | | | 9 | | | 13 | | 1 | | | | | 15 | | | 1 | | |
| 3 | 5 | 1 | I | 15 | | | | | | | 1 | | | 14 | | 8 | | | | | | | 8 | | | 15 | | 2 | | | | | 14 | | | 3 | | |
| 3 | 5 | 1 | O | | 15 | | | | | 1 | | | | | 14 | | 8 | | | | | 8 | | | | | 15 | | 2 | | | | 14 | | | | | 3 |
| 3 | 5 | 2 | I | | | 15 | | | 1 | | | 14 | | | | | | 8 | | | 8 | | | 15 | | | | | | 2 | | | 14 | | | 3 | | |
| 3 | 5 | 2 | O | | | | 15 | 1 | | | | | 14 | | | | | | 8 | 8 | | | | | 15 | | | | | 2 | 14 | | | | 3 | | |

**Figure 17** Master list of sample numbers – test marketing

- P (province)
- C (complex)
- S (stack)
- I or O (inside or outside)

The month is also a vital piece of information throughout, but does not need to be concealed, and can be retained as part of the TID.
The elements of the TID are:

- destination
- month
- number (from master list)
- number of individual sample.

The destination codes are given on the master lists, and will refer to sample analysis and test marketing destinations.

The month is to be given as a number from 1 to 12.

The number is taken from the master list, according to the source of the sample, the destination, and the month.

Since in most cases there are to be several similar samples sent to each destination, there will need to be a final element in the TID to distinguish the different samples. This is most conveniently numbers 1, 2 or 3.

The complete TID of the form is therefore: destination/month/master list number/replicate

## *Example*

Consider the sample coming from province 1, complex 1, stack 1, inner part, in the first month. This sample is divided into 16 parts.

For the samples from province 1, complex 1, stack 1, inner part, the TID is given in the first row of the master lists. For the samples for analysis at NRI, we need to look at the left-hand portion of the master list for analysis, Figure 16. For month 1, the TID is 1. Thus the 2 samples for NRI are to be labelled:

OD/1/1/1 and OD/1/1/2.

For the samples for Sukamandi, we need the central part of that master list, and for month 1 the TID is 17. Thus the 2 samples for Sukamandi are to be labelled:

SK/1/17/1 and SK/1/17/2.

For the sample for Tambun, we need the right-hand part of the master list, and for month 1 the TID is 57, so the sample for Tambun is to be labelled:

TB/1/57/1.

For the test marketing sample, we need the test marketing master list, Figure 17. Only a sub-sample of the samples are to be test marketed each month, so many of the spaces in this list are blank, indicating that the relevant sample is not due for test marketing in that month.

Considering still the sample from province 1, complex 1, stack 1, inner part, which is again in the first row, we see that for month 1 there are entries for the three markets. For Jakarta, on the left-hand side, the TID is 1, so the 3 samples for test marketing in Jakarta are to be labelled:

MJ/1/1/1 and MJ1/1/2 and MJ/1/1/3.

For marketing in Medan, we need the central part of the list, and the TID is 9, so the 3 samples are to be labelled:

MM/1/9/1 and MM/1/9/2 and MM/1/9/3.

For the test marketing in Surabaya, we look at the right hand part of the list, and the TID here is 3, so the 3 samples are to be labelled:

MS/1/3/1 and MS/1/3/2 and MS/1/3/3.

# APPENDIX 2 STUDY METHODOLOGY – ANALYSIS METHODS

## Physical analysis

### Initial and final samples

1 Divide the stack sample into 16 approximately equal portions using a Boerner divider. Do not adjust the weights of any of the samples. Label clearly each of the samples.

Perform the following analysis on the physical analysis laboratory sample:

*Moisture content by Cera meter*

Pass 100 g of the sample through the Cera meter and record the dial reading (%) of moisture content and note the correction factor for the temperature at which the sample was measured. Re-combine with the remainder of the sample.

2 Divide the laboratory sample to obtain two sub-samples (of approximately 94 g each).

Using one of the two sub-samples determine **moisture content** (oven method) and **colour** and **degree of milling** after removing obvious foreign matter and paddy grains.

*Moisture content by oven method*

Grind approximately 5 g of sample.

For each sample to be measured place two clean weighing dishes (with lids) into a fan-assisted oven maintained at 135°C and dry for two hours. Remove dishes from oven using clean tongs, and place dishes in a desiccator to cool. When dishes have cooled to room temperature accurately weigh and record to four decimal places.

In duplicate, place approximately 2 g of sample into the pre-weighed weighing dishes. Accurately weigh the dishes and contents and record to four decimal places.

Place the weighing dishes and contents into the drying oven and dry the sample at 135°C for 2 hours.

Remove the dishes from the oven and transfer to a desiccator. When dishes have cooled to room temperature, weigh accurately and record to four decimal places.

*Degree of milling (DOM)*

By visual comparison with the standard blister pack determine the degree of milling. Express the results as a percentage.

*Colour*

Two colour measurements will be made: on *unground grain* (whole and brokens); and on *ground grain* (whole and brokens).

*Unground grain* Place sufficient sample into a clean glass Petri dish to fill (use the same dish for all measurements). Using a calibrated (against a white tile) Minolta CR210 Chroma Meter measure the colour of the sample by placing the recording head onto the surface of the grain. Take three consecutive readings, mixing the sample between each reading. Record (to two decimal places) the three separate L* a* b* readings displayed by the data processor.

*Ground grain* Grind 5 g of the grain (<1 mm in size) and place sufficient sample into the granular materials attachment to fill it. Using a calibrated

(against a white tile) Minolta CR210 Chroma Meter measure the colour by placing the recording head onto the surface of the grain and taking one reading. Record (to two decimal places) the L* a* b* colour readings displayed by the data processor.

3 Divide into two the second sub-sample of 94 g to obtain a sample (of approximately 47 g) for determination of **foreign matter** and **refractions**. Accurately weigh the sample (to two decimal places) and record.

*Foreign matter*

Place the sample onto a 0.5 × 0.5 mm mesh screen and collect the dust passing through the screen. Remaining foreign matter, excluding dead insects, manually sort and add to the dust, weigh and record (to two decimal places).

Count the number of live insects in the remaining sample and record.

*Refractions*

Assign grain to the following classes in order of reducing priority: (i) chips (1.4 mm diameter perforated screen); (ii) yellow grains; (iii) damaged grains; (iv) red grains; (v) paddy grains; (vi) brokens (<6/10ths average grain length).

*Chips* Pass the remaining sample over a 1.4 mm diameter perforated screen and weigh and record (to two decimal places) chips passing through the screen.

*Yellows* Select from the remaining sample true yellow grains (whole, head and broken grain). Weigh and record (to two decimal places) the true yellow grains.

*Damaged grains* Select from the remaining sample damaged grains (whole, head and broken grain). Weigh and record (to two decimal places) the damaged grains.

*Red grains* Select from the remaining sample red grains (whole, head and broken grain). Weigh and record (to two decimal places) the red grains.

*Paddy grains* Select from the remaining sample paddy grains. Count and record the number of paddy grains.

*Brokens* Select from the remaining sample broken grains (i.e. < 6/10ths of average grain length; N.B. excludes grain in categories yellow, damaged and red grain). Weigh and record (to two decimal places) the broken grains.

4 Take the second sample (approximately 47 g) and recombine if necessary non-broken grains of milled rice from the first sample and proceed to determine the **size/shape**.

*Size/shape*

By visual means sort and record the number of differing types of grain, ignoring **red** grain in this test. Continue with the test even if only **one** type of grain is present.

Take 10 whole grains of each type, lay end-to-end, and measure (using a ruler) and record the total length in mm. Use the same 10 whole grains of each type, lay side-by-side, and measure (using a ruler) and record the total breadth in mm.

**Note**: if fewer than 10 whole grains of the type are available, measure each by micrometer and record the individual length and breadth measurements and number of grains tested.

5 Re-combine from steps 3 and 4 the grains of milled rice including the brokens and proceed to determine the **potential yellows**.

*Potential yellows*

Place approximately 50 g of milled rice into a 250 ml Erhlenmeyer flask loosely sealed with a cotton wool plug. Autoclave (in a pressure cooker) the flask and contents at 121°C for 15 minutes. Allow the flask and contents to

cool then shake the rice grains from the flask onto a piece of absorbent tissue and pat the grains dry. Accurately weigh the autoclaved grains and record (to two decimal places). Visually select potential yellow grains, accurately weigh (to two decimal places) and record.

6 Record the results on Form 1.

### Intermediate samples

1 Divide the stack sample into 16 approximately equal portions using a Boerner divider. Do not adjust the weights of any of the samples. Label clearly each of the samples.

Perform the following analysis on the laboratory sample.

*Moisture content by Cera meter* (*See* procedure for Initial/Final samples above).

2 Divide the laboratory sample to obtain two sub-samples (approximately 94 g each).

Using one of the two sub-samples determine **moisture content** (oven method) and **colour** after removing obvious foreign matter and paddy grains.

*Moisture content by oven method* (*See* procedure for Initial/Final samples above).

*Colour* (*See* procedures for Initial/Final samples above).
Two colour measurements will be made on: *unground grain* (whole and brokens); and *ground grain* (whole and brokens).

3 Divide into two the second sub-sample of 94 g to obtain a sample (approximately 47 g) for determination of **foreign matter** and **yellows**. Accurately weigh the sample (to two decimal places) and record.

*Foreign matter*
Place the sample onto a 0.5 × 0.5 mm mesh screen and collect the dust passing through the screen. Remaining foreign matter, excluding dead insects, manually sort, add to the dust, weigh (to two decimal places) and record.

Count the number of live insects in the remaining sample and record.

Count the number of dead insects in the remaining sample and record.

*Yellows*
Select from the remaining sample true yellow grains (whole, head and broken grain). Weigh (to two decimal places) and record the true yellow grains.

4 Take the remaining sample (of approximately 47 g) and re-combine from step 3 the grains of milled rice including brokens and proceed to determine the **potential yellows**. (*See* procedure for Initial/Final samples above).

5 Record the results on Form 3.

## Olfactory/cooking quality analysis

### Initial and final samples

1 Divide the first laboratory sample to obtain a sub-sample (of approximately 94 g) for assessment of milled rice **odour** by organoleptic means, recording a minimum of 3 responses on a 1 – 5 hedonic scale.

2 Take the remaining sub-sample (of approximately 94 g) for separation and identification of *variety* or type by **size/shape**. By visual means sort and record the number of differing types of grain, ignoring *red* grain in this test. Continue with the test even if only one type of grain is present.

Take 10 whole grains of each type, lay end-to-end, and measure and record the total length in mm. Use the same 10 whole grains of each type, lay side-by-side, and measure and record the total breadth (width) in mm.

Use the same 10 (or smaller number) whole grains of each and every type to determine the **alkali spreading value**, recording the individual score of every grain.

**Note**: if fewer than 10 whole grains of the type are available, measure each grain by micrometer and record the individual length and breadth measurements and number of grains tested.

3 If in Step 2 the number of types=1 then take the second laboratory sample and determine **cooking quality** recording: **cooking time**; **hardness**; **stickiness**; **expansion**; and **aroma/odour**.

4 Record results on Form 2.

### Intermediate sample

1 Divide the first laboratory sample to obtain a sub-sample (of approximately 94 g) for assessment of milled rice **odour** by organoleptic means, recording a minimum of 3 responses on a 1 – 5 hedonic scale.

**If the sample reference contains a 'Y' suffix continue with Step 2, if the suffix is 'N' do not proceed further.**

2 Take the second laboratory sample and determine **cooking quality** according to Step 3 above.

3 Record results on Form 4.

## Lipids/yellows/mycological analysis

### Initial, intermediate and final samples

1 Weigh (to two decimal places) and record the weights of the stack sub-samples. Divide the sub-sample into 4 approximately equal portions using a Boerner divider. Do not adjust the weights of any of the samples. Label each sample clearly.

Perform the following analyses on one of the laboratory samples:

*Mycological analyses*
Take a sub-sample of approximately 2 g (whole, head and brokens) for mycological analysis. Place (evenly spaced) onto the surface of Dichloran Rose Bengal Chloramphenicol (DRBC) agar (pre-poured and dried in Petri dishes) 10-14 rice grains (or chips/brokens) per plate until all of the sample has been plated out. Incubate plates at 30°C for 5-7 days in the dark. After incubation record the total percentage of rice grains showing infection by fungi and the percentage infection by individual species.

*Yellows*
Weigh the remaining sample (to two decimal places) then select, weigh (to two decimal places) and record the true yellow grains (whole, head and broken grains).

*Potential yellows*
Place the remainder of the sample into a loosely sealed screw cap bottle. Autoclave the bottle and contents at 121°C for 15 minutes. Allow the flask and contents to cool then shake the rice grains from the bottle onto a piece of absorbent tissue and pat the grains dry. Accurately weigh (to two decimal places) the autoclaved grains and record. Visually select potential yellow grains, accurately weigh (to two decimal places) and record.

2 Take the second laboratory sample, divide as necessary and determine **total lipid** and **free fatty acid** as follows:

## TOTAL LIPIDS (SURFACE) and FREE FATTY ACID DETERMINATION

*Reagents*

- Extraction solution: chloroform:methanol (4:1)
- Internal standard: heptadecanoic acid ($C_{17}$) in chloroform:methanol (4:1), 10 mg/ml
- Thin-layer chromatography (TLC) reference: dodecanoic acid ($C_{12}$) in hexane, 10 mg/ml
- 14% methanolic boron trifluoride ($BF_3$)
- 0.5M methanolic potassium hydroxide (KOH)
- Hexane
- Diethyl ether
- Glacial acetic acid
- 0.05% 2,7-dichlorofluorescein in methanol
- Saturated sodium chloride (NaCl) solution
- Anhydrous sodium sulphate ($Na_2SO_4$)

*Extraction procedure*
Weigh 40 g rice into a 250 ml conical flask. Add 2 ml internal standard and 50 ml extraction solution. Stopper the flask and shake vigorously for 5 minutes.

*Determination of lipids (surface)*
Transfer 5 ml of the extract solution into a 50 ml round-bottomed flask, and evaporate to dryness over a water bath under a stream of nitrogen.

Prepare methyl esters from the residue; add 6 ml methanolic KOH and a few anti-bumping granules to the flask, fit a reflux condenser and boil for 5–10 minutes until all fat droplets disappear. Add 6 ml methanolic $BF_3$ through the top of the condenser and boil for 1 minute. Add 2 ml hexane down the condenser and continue boiling for 1 minute. Stop the heating and remove the condenser. Add a small amount of saturated NaCl to the flask and shake gently. Add more saturated NaCl to bring the liquid level into the neck of the flask. Allow to separate and transfer, using a Pasteur pipette, as much of the upper hexane layer as possible (without including any of the lower layer) into a screw-capped sample bottle. Add a small amount of anhydrous $Na_2SO_4$ to remove any traces of water. Store in the freezer until required for analysis.

Inject about 5 µl of the methyl ester into the gas chromatography column (Pye Unicam series 304 gas chromatograph fitted with a CP SIL 88 capillary column, with helium as carrier gas). Allow exactly 100 seconds to elapse before starting the integrator. The settings on the chromatograph should be as follows:

| | | |
|---|---|---|
| *Gas settings* | | |
| Carrier gas pressure | 25 psi | |
| Hydrogen pressure | 15 psi | |
| Air | 10 psi | |
| *GC setting* | | |
| Temperature of oven | 190°C | DP setting 195°C |
| Temperature of detector | 250°C | DP setting 255°C |
| Temperature of injector | 250°C | DP setting 255°C |
| Splitter setting | leave button set to OPEN | |
| Split rate | 40 ml/minute (on flow meter) | |
| Amplifier sensitivity | 10 | |

| | |
|---|---|
| Amplifier attenuation | try range 2 to 4, adjusting so that the largest peak is at least half way up to the chart, and the tops of the peaks are all on the chart. |

*Integrator settings*

| | | | |
|---|---|---|---|
| Start delay : | 4 minutes | Chart speed | : 0.5 cm/minute |
| Stop timer : | 30 minutes | Chart | : auto |
| Area reject: | 10 | Slope sensitivity: | auto |
| Attenuator : | 4 | | |

The area of the $C_{17}$ peak on the gas chromatograph trace corresponds to 20 mg of $C_{17}$ acid. Thus the weight of total fatty acids in 40 g rice sample:

$$= 20 \text{ mg} \times \frac{100 - \%\text{ area } C_{17}}{\%\text{ area } C_{17}}$$

and the weight in 100 g rice:

$$= 20 \text{ mg} \times \frac{100 - \%\text{ area } C_{17}}{\%\text{ area } C_{17}} \times \frac{100}{40}$$

*Determination of free fatty acids*

Evaporate the remainder of the extract solution to dryness over a hot water bath, under a stream of nitrogen. Dissolve the residue in about 1 ml hexane.

Carry out pre-operative TLC as follows:

Dry a 25 × 25 cm TLC plate (precoated with a 0.25 mm layer of silica gel) for 10 minutes in an oven at 100°C.

Using a spotting frame over the TLC plate, spot 10 µl of the $C_{12}$ reference solution 1 cm from the edges of both sides of the plate.

Starting 1 cm from the $C_{12}$ spot, streak the sample solution along half the width of the plate. The other half of the plate can be used for another sample.

Run the plate in a solution composed of 20 parts diethyl ether, 80 parts hexane and 2 parts acetic acid.

When the solvent front reaches to within 2 cm of the top of the plate, remove the plate from the tank and dry it for 1 minute at 100°C. Spray the plate with the dichlorofluorescein solution and dry again for 1 minute in the oven.

View the plate under UV light and observe the position of the $C_{12}$ marker which shows the position (Rf) to which the fatty acids in the sample will run. If there are free fatty acids in the sample, they will form a band at the same Rf as the $C_{12}$ marker above the position where the sample was spotted on the plate. Mark around the free fatty acid bands with a pencil, not including the $C_{12}$ spots. Scrape off the free fatty acids with a razor blade into a 50 ml round-bottomed flask.

Prepare methyl esters from the free fatty acid; add a few anti-bumping granules and 4 ml methanolic $BF_3$ to the flask, fit a reflux condenser and boil for 5 minutes. Next add 3 ml hexane through the top of the condenser and continue boiling for 1 minute. Stop the heating and remove the condenser. Add a small portion of saturated NaCl solution to the flask and shake gently. Add more saturated NaCl to bring the liquid level into the neck of the flask. Allow to separate, and transfer using a Pasteur pipette as much of the upper hexane layer as possible (without including any of the lower layer) into a screw-capped sample bottle. Add a small amount of anhydrous $Na_2SO_4$ to remove any traces of moisture, and store in the freezer till required for analysis.

Carry out a gas chromatography run using the same procedure and conditions as for the total fatty acids. The percentage area of the $C_{17}$ peak again corresponds to 20 mg $C_{17}$ acid. Thus the weight of free fatty acid in the 40 g rice sample:

$$= 20 \text{ mg} \times \frac{100 - \%\text{ area } C_{17}}{\%\text{ area } C_{17}}$$

and the weight in 100 g rice:

$$= 20 \text{ mg} \times \frac{100 - \%\text{ area } C_{17}}{\%\text{ area } C_{17}} \times \frac{100}{40}$$

Express the weight of free fatty acid present as a percentage of the total fatty acid in the sample.

Percentage free fatty acid:

$$= \frac{\text{wt. free fatty acid in 40 g rice}}{\text{wt. total fatty acid in 40 g rice}} \times 100$$

**FORM 1**

Initial/Final Sample

QUALITY/VALUE STUDY

RESULTS PROFORMA

PHYSICAL ANALYSIS

Sample Reference

T B

Date of Analysis

D D M M Y Y

1 MC oven method — Container

| | | |
|---|---|---|
| wt of sample container empty | _____ g | _____ g |
| wt of sample container and ground sample before drying | _____ g | _____ g |
| wt of sample container and ground sample after drying | _____ g | _____ g |

2 MC Cera meter method

| | |
|---|---|
| dial reading | _____ % |
| correction factor | _____ % |

3 DOM (DS)

| | |
|---|---|
| comparison with standard | _____ % |

4 COLOUR whole grain

| | | | |
|---|---|---|---|
| L value | ____ | ____ | ____ |
| a value | ____ | ____ | ____ |
| b value | ____ | ____ | ____ |

5 COLOUR ground grain

| | |
|---|---|
| L value | _____ |
| a value | _____ |
| b value | _____ |

6 REFRACTIONS

sample wt ____ g

| | | | |
|---|---|---|---|
| Foreign matter Dust (<0.5mm) including other FM | ____ g | Chips (<1.4mm diam) | _____ g |
| | | Yellow whole and broken | _____ g |
| Dead insects | ____ (number) | Damaged - " - | _____ g |
| Live insects | ____ (number) | Red - " - | _____ g |
| | | Paddy | _____ (number) |
| | | Broken (<6/10) | _____ g |

CONTINUED OVERLEAF

7 SIZE/SHAPE
Use grain from Refractions test to supplement if necessary

Number of visibly different types or varieties of grain (excluding Red grain) _____ (number) *

Total length by ruler of 10 whole grains of visibly similar type, predominant grain type _____ mm

Total breadth by ruler of 10 whole grains of visibly similar type, predominant grain type _____ mm

If fewer than 10 whole grains are available record the individual measurements made by micrometer

| Length | Breadth | Length | Breadth |
|---|---|---|---|
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | | |

* Tick here if more than one grain type ☐

8 POTENTIAL YELLOWS
Use grain from Refractions test to supplement if necessary

wt of dried autoclaved sample _____ g

wt of extracted yellows, whole and broken _____ g

Initial/Final Sample

QUALITY/VALUE STUDY

RESULTS PROFORMA

OLFACTORY/COOKING QUALITY TESTS

Sample Reference

S K

Date of Analysis

D D M M Y Y

1 ODOUR uncooked rice
Hedonic rating on a scale of 1 to 5, 1 = Good, 5 = Poor

Minimum of 3 panellists to be used

Panellist 1 _____

Panellist 2 _____

Panellist 3 _____

Panellist 4 _____

Panellist 5 _____

2 SIZE/SHAPE
Save these grains for assessment of Alkali Spreading Value
Identify and separate whole grains into
type by appearance (excluding red grains) number of types * . . . _____

Total length by ruler of 10 whole grains of visibly similar type, predominant grain type _____ mm

Total breadth by ruler of 10 whole grains of visibly similar type, predominant grain type _____ mm

If fewer than 10 whole grains are available record the individual measurements made by micrometer

| Length | Breadth | Length | Breadth |
|---|---|---|---|
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | _____ mm | _____ mm |
| _____ mm | _____ mm | | |

* Tick here if more than one grain type ☐

CONTINUED OVERLEAF

3 ALKALI SPREADING VALUE

Use the individual grains from the Size/Shape test
Enter the Length and Breadth measure of 10 grains to identify the type
If fewer than 10 grains were measured, use a code to identify the Size
with the Alkali values

| | Predominant grain type | ..... ( ) | Other grain types ( ) | ..... ( ) |
|---|---|---|---|---|
| Length 10 grains | _____ mm | _____ mm | _____ mm | _____ mm |
| Breadth 10 grains | _____ mm | _____ mm | _____ mm | _____ mm |
| Alkali spreading value of individual grains | _____ | _____ | _____ | _____ |
| | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |
| : | _____ | _____ | _____ | _____ |

==========

4 COOKING QUALITY

If the number of grain types was 1, determine the Cooking Quality

Expansion
Initial volume _____ cm Expanded volume _____ cm

Cooking Time _____ min

Hardness _____ kg

Stickiness _____ g.cm

Aroma/Odour
Hedonic rating on a scale of 1 to 5, 1 = Good, 5 = Poor
Minimum of 3 panellists to be used

Panellist 1 _____ Panellist 3 _____ Panellist 5 _____

Panellist 2 _____ Panellist 4 _____

**FORM 3**

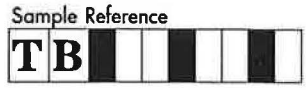
Intermediate Sample

QUALITY/VALUE STUDY

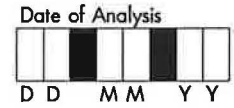
RESULTS PROFORMA

PHYSICAL ANALYSIS

Sample Reference




Date of Analysis




1 MC oven method — Container —

wt of sample container empty _____ g _____ g

wt of sample container and ground sample before drying _____ g _____ g

wt of sample container and ground sample after drying _____ g _____ g

2 MC Cera meter method
dial reading _____ %

correction factor _____ %

3 COLOUR whole grain

L value ____ ____ ____

a value ____ ____ ____

b value ____ ____ ____

4 COLOUR ground grain

L value _____

a value _____

b value _____

5 REFRACTIONS
sample wt ____ g

Foreign matter
Dust (<0.5mm) including other FM ____ g

Yellow whole and broken _____ g

Dead insects ____ (number)

Live insects ____ (number)

6 POTENTIAL YELLOWS
Use grain from Refractions test to supplement if necessary

wt of dried autoclaved sample _____ g

wt of extracted yellows, whole and broken _____ g

**FORM 4**

Intermediate Sample

QUALITY/VALUE STUDY

RESULTS PROFORMA

OLFACTORY/COOKING QUALITY TESTS

Sample Reference

S K

Date of Analysis

D D M M Y Y

1 ODOUR uncooked rice
Hedonic rating on a scale of 1 to 5, 1 = Good, 5 = Poor

Minimum of 3 panellists to be used

Panellist 1 _____

Panellist 2 _____

Panellist 3 _____

Panellist 4 _____

Panellist 5 _____

---

2 COOKING QUALITY
Intermediate Samples for assessment of Cooking Quality will be identified by BULOG Project Coordinator

Expansion
Initial volume _____ cm Expanded volume _____ cm

Cooking Time _____ min

Hardness _____ kg

Stickiness _____ g.cm

Aroma/Odour
Hedonic rating on a scale of 1 to 5, 1 = Good, 5 = Poor
Minimum of 3 panellists to be used

Panellist 1 _____ Panellist 4 _____

Panellist 2 _____ Panellist 5 _____

Panellist 3 _____

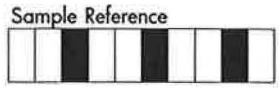
**FORM 5**

QUALITY/VALUE STUDY

RESULTS PROFORMA

TEST MARKETING

Sample Reference



Trader _____ Market _____

Enumerator _____ Date _____

Price _____

Characteristics which influenced your assessment of the price:

1 _____ Code _____

2 _____ Code _____

3 _____ Code _____

4 _____ Code _____

5 _____ Code _____

Variety _____

Whether mixed varieties (Y/N) ____

Whether odour (Y/N) ____

**Figure 18** Typical warehouse used for conventional bag storage in the tropics. Under ambient conditions significant changes in grain quality can be predicted.

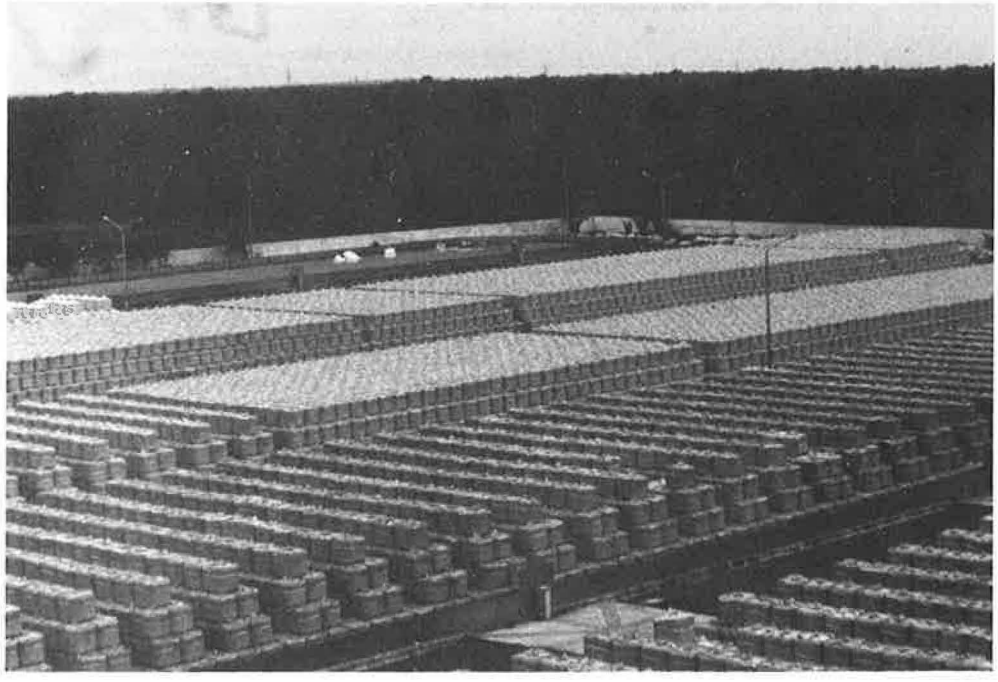
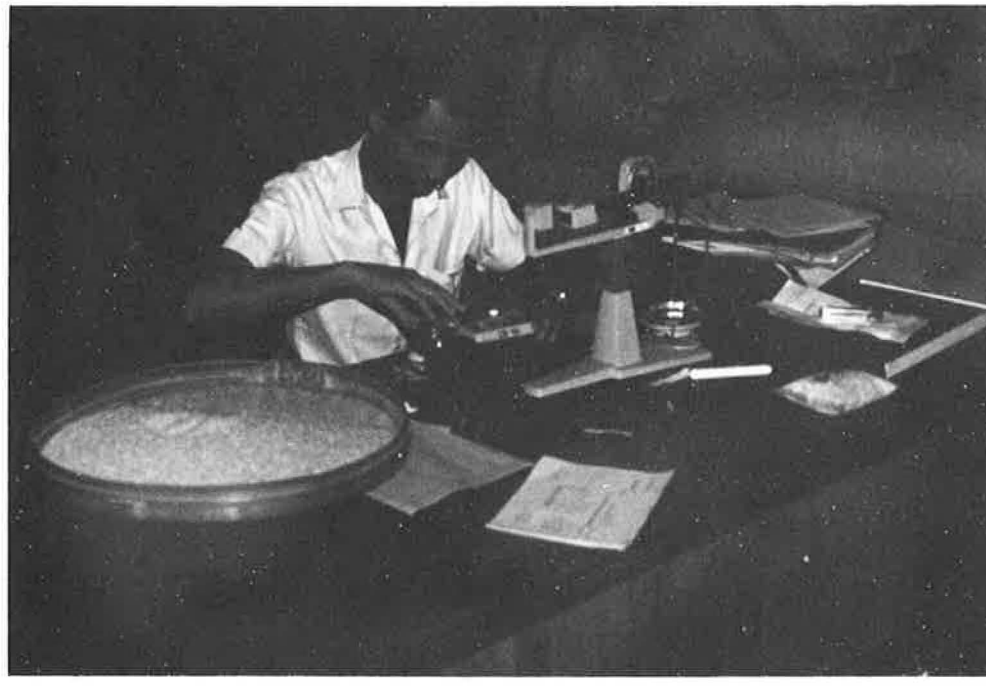


**Figure 19** A high technology vacuum packing and storage plant for milled rice. Qualitative changes are minimized but at high capital and running costs.

a



b

**Figure 20 (a, b)** Quality inspection and determination are routine duties in a conventional bag storage system.

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The Bulletin series presents the results of research and practical scientific work carried out by the Natural Resources Institute. It covers a wide spectrum of topics relevant to development issues ranging from land use assessment, through agricultural production and protection, to storage and processing.

Each Bulletin presents a detailed synthesis of the results and conclusions within one specialized area, and will be of particular relevance to colleagues within that field and others working on sustainable resource management in developing countries.

The general movement towards liberalization in grain trading has had far-reaching effects for many developing countries. **A Study in the Determination of Quality/Value Relationships in Rice** describes how a recent development in evaluation techniques was applied in a major national rice market.

The Bulletin is intended for organizations wishing to evaluate their grain stock-holding and marketing policies.