# SYMPOSIUM ON STATISTICAL ASPECTS OF POST-HARVEST TECHNOLOGY

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A symposium on "Statistical Aspects of Post-Harvest Technology" was organised during 36th Annual Conference of the Indian Society of Agricultural Statistics on 19th January, 1983 at M.P.A.U., Rahuri under the chairmanship of prof. D. K. Salunkhe, Vice-Chancellor, M.P.A.U., Rahuri. Welcoming the delegates to the Symposium, Prof. Solunkhe in his opening remarks stressed the importance of statistics in estimating quantitative as well as qualitative post-harvest food grain losses. He also stressed that standard methodologies for measuring and estimating losses for perishables should also be developed. After sometimes of Salunkhe he was to attend another urgent work, he requested Prof. Prem Narain, Director, IASRI, New Delhi to chair rest of the deliberations of the symposium in his absence.

13 papers were contributed to the symposium. Some of the contributors could not be present. However, the extended summaries of the papers received are as follows:

## Statistical Aspects of Post Harvest Technology

By

D. K. SALUNKHE[1]

Two obvious solutions to the population-food imbalance are to increase the food supplies through higher productivity and to limit the growth of population. Both these solutions, however, will require considerable amount of capital and time to achieve. A third

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and the most vital solution to the world food problems involves drastically reducing losses of food throughout its production, harvest and marketing processes. One estimate believed to be a conservative predicts that the total losses claim fully one-half of the world' sfood supply and that nearly 30 to 40 percent of the crops harvested in the developing countries never get to the consumer; it is lost through spoilage, waste etc., during the marketing processes between the farm gate and the consumer. A recent report published by National Research Council of the National Academy of Sciences in Washington states that post-harvest losses of perishable crops may be as high as 60-80 percent in some instances. A post harvest loss of 20 to 25 per cent of fruit and vagetable crops grown in India is worth more than rupees 15 billions annually. Apart from physical losses in quantity, serious losses also occur in the essential nutrients, notably of vitamins and minerals and nutritional quality. These are colossal losses which, if avoided, could positively improve the nutrient status of the poor tropical world where such losses occur to the maximum extent.

Statistics have a important role to play in estimating the magnitude of post harvest losses of food products. The food loss etimation is a complex process yielding results of limited accuracy. There is a need for quantitative as well as qualitative estimates of food losses. At present, standard methodologies for measuring and estimating losses are lacking for most kinds of food. A variety of loss estimation tecchniques available for durable food materials like cereals are not suitable for perishables. This is a challenging task for the statisticians to develop an accuarate methodology to assess these losses.

## Estimation Of Foodgrain Losses At Different Fost-Harvest Stages

By

PREM NARAIN[2] and R. K. KHOSLA[3]

Considerable foodgrain losses are incurred at different post-harvest stages every year. But reliable and objective estimates of those losses are not available in this country. Such estimates are

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very important rather pre-requisite for carrying out control measures more efficiently and economically and also for improving post-harvest technology so as to minimise those losses.

Keeping the importance in view statistical methodology for estimating foodgrain losses at different post-harvest stages, *viz.*, harvesting, threshing/shelling, cleaning/winnowing, drying, handling (at farm/market level), transportation, packaging, storing, etc., at farm, intermediary and warehouse level have been discussed. The methodology for working out the damage due to different causes of pests and diseases and other biological and chemical changes, etc., on the basis of the observations taken in the storage, the concepts, definitions, etc., and review of work done in brief have also been discussed. The various schedules for collection of data have also been framed.

Before conducting a random sample survey for estimating post-harvest foodgrain losses appropriate concepts, definitions and measurement techniques should be settled so as to have a uniform approach for adoption within a region or the country. Such survey should be linked with other agricultural surveys such as crop cutting experiments for the estimation of total food production so as to avoid setting up an independant agency for estimating foodgrain losses thereby eonomising the cost involved in data collection. In each case the sampling design, the sizes of the samples as well as its distribution at various stage of sampling should be decided in advance on the basis of a well-designed pilot sample survey. A co-ordinated approach is very much necessary in the estimation of post-harvest losses since efforts to estimate such losses cut across various scientific disciplines such as Entomology, Plant Pathology, Agronomy, Engineering, statistics, etc. Since the loss assessment methodology is primarily a sample survey methodology, there is no guarantee that the results obtained in a particular survey should be reproducible. Nevertheless if the standard error of the estimate of losses are properly worked out, confidence intervals within which the estimates are expected to lie can be constructed. Surveys, than repeated should give results which are expected to lie within these confidence limits. Although the loss estimates methodology, when attempted in its entirety, is a stupendous task, efforts should be made to attempt it gradually. Ultimately the entire work can be established on a permanent footing in more or less the same way as the crop cutting surveys for various cereal crops have almost attained a permanent structure in a vast country like India.

## Storage Losses and Methodology For Its Determination

By

NAWAB ALI,[4]

The harvested biomass goes through a number of post-harvest operations such as cleaning, grading, drying, transport, storage, milling,, processing, packing, marketing and distribution, cooking, etc., which are location specific. During these operations, a considerable amount of food commodities get lost due to improper technologies and equipment. The loss has been estimated by various agencies and it is generally quoted that the losses vary from 10 to 15% for durable commodities, 20 to 30% for semi-perishables and 30 to 50% for perishable commodities. More than 50% of post harvest losses occur during storage as evident from the published literatures. However, in making storage loss estimate, it seems that methodology used by various workers differ and hence it is difficult to compare the results. Thus, in order to make a reasonable quantitative estimate of actual food loss during storage, it is necessary to use a scientifically sound procedure by different workers to get reliable and comparable results.

The methodology proposed for assessing storage loss of durables is based on representativeness of sampling. Loss estimation would be done by collecting samples and its analysis. Types of losses incur during storage have also been described in brief. Proforma for collection, analysis and interpretation of data are also suggested. Storage loss estimates arrived at by this method would be reliable and useful in deciding suitable post harvest measures for loss reduction.

Technology for assessing various post harvest losses in the laboratory and the interpretation of data is available but the extrapolation of such results over a large area and covering various unit operations in post harvest technology may not provide reliable estimates unless the samples taken for analysis are true representative of the population. Help of Statisticians will be necessary for such work.

Foodgrains are stored in the country at various levels namely; farmers, traders; cooperatives, government agencies in various storage facilities such as gunny bags, mud bins, metallic bins, RCC silos, etc,,

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Statistics is necessary to know what percentage of foodgrain is stored in each type of storage structure and at each level and for how long. These information are must to get reliable estimates of storage loss with respect to time.

This shows that Statisticians can play a very strong role in reliable estimate of post harvest losses. It was therefore recommended that the Indian Agricultural Statistics Research Institute may take a lead and call a meeting of post harvest experts to develop suitable methodology for assessing post harvest losses.

**A study on estimation of losses in foodgrain caused by rats**

By

G. D. DIWAKAR[5] O. P. GUPTA[6] and D. V. SINGH[7]

In view of the wide variations in the agroclimatic and socio economic conditions, 13 centres of Save Grain Campaign situated in different parts of the country were selected purposely. From each centre, 3 villages were selected randomly and in each village 10 households were selected randomly.

To assess rat population, catch and kill method was adopted. In each selected house, rat traps were kept for estimation of the rat population. Rat traps were kept in such places which are visited frequently by rats to eat foodgrains. The traps were kept open for the first 3 nights with unpoisoned bait meterials. On the 4th night the traps were closed from one end so that the rats did not escape after once entered into the trap. On the following 5th day, the body weight of the rats were estimated with the help of balance. On the basis of body weight, rats were divided into two categories i.e., those having body weight of 50 g or less and other having body weight above 50 g. In case different species of rats were observed, the data of each species was recorded. After obtaining the data, the rats caught and killed. On the 5th and 6th nights rat traps were again kept open as earlier 3 days. On the 8th day the number of rats trapped and their body weight were recorded. The pupulation of rats obtained on the 5th and 8th days was added to arrive at total population of rats in house. Number of rats of all the selected 10 houses were added and then average number of rats per house was calculated by dividing with 10.

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To estimate loss caused by rats per house, the averages body weight of rats (50 g. or less) were multiplied by 12 percent as their food requirement per day. On the other hand, the rats having body weight more than 50 g. the average weight of rats were multiplied by 8 percent. Thus total loss caused by rats estimated by adding the loss caused by both categories of rats.

The average population of rats (50 g. or less) per house were found to be 1.23 while the population of rats/houseof above 50 g. were found to be 6.16. Thus, on an average, 7.39 rats were observed per house of farming community in our country. Population range of both categories varied considerably from one centre to another. However, out of the 13 centres, at 6 centres, population of rates were found to be higher than the average population of all the centres.

In selected villages of all the centres four species of rats were identified. Among the 4 species of rats, *Rattus rattus* and *Mus musculus* are found in villages of all the centres except *Rattus rattus* at Varanasi and *Mus musculus* at Bangalore and Trivandrum. *Rattus norvegicus* is found in villages of Varanasi and Calcutta and *Bandicota bengalensis* are found in villages of Calcutta centre only. *Rattus rattus* constituted major portion i.e. 77.90 percent of the average population and 13.80 percent by *Mus musculus*. However, the population range of both species are quite high. Other two species of rats are not of much importance in comparison to *Rattus rattus und Mus musculus*.

Loss caused by rats/house per day was about 64.60 g. This loss of foodgrain was mainly (89.71 percent) caused by rats having more than 50 g. of body weight. Rest of the loss, i.e., 10.29 percent was caused by the rats having body weight of 50 g. or less. Range of the food loss caused by both the categories of rats varied considerably from one centre to another. Even within the centre variation of food loss at different selected villages were found considerably higher. However, out of 13 centres, at 7 centres, the loss of foodgrains was higher than that of the averages of all the centres.

Above loss of food grains is a very important problem of farming community when we take into account the value for the entire country. When we take into the account the additional food damage by rats in the form of spillage, gnawing etc. as much higher than that of eaten by them than it become very serious problem to

our nation. The study has brought up clearly the fact that rats are great menace in our country. An all out efforts to reduce rat population through improved pest management technology is needed to be planned at every village of India. This will result into saving of sufficient quantity valuable foodgrains.

### Post Harvest Losses in Dairy Industry : A Perspective Analysis

By

M. B. KULKARNI[8], D. G. BHAPKAR[9] and N. D. BELHE[10]

The term post harvest losses in dairy industry embraces the losses of milk or its products quantitatively or qualitatively after its production. Today, India produce annually about 33 Million tonnes of milk. Out of this nearly 90 percent is handled by the unorganized sector (private sector). Due to certain factors such as unhygienic milk production, unfavourable climatic conditions, lack of refrigeration facilities and negligence in management at various level about 5-15 per eent of the liquid milk is lost in organized sector at reception dock itself. Besides, about 50-60 percent of the milk produced is processed by traditional sector for products preparation. This also causes a considerable amount of losses of milk solids. For instance, in *ghee* production alone about 0.37 lakh tonnes of milk fat is lost. It has been suggested that some suitable statistical methodology or technique be evolved by which the exact losses and the reasons therefore, particularly, in unorganized sector of the India dairy industry could be estimated.

### Statistical Aspects Of Post-Harvest Technology In Sugarcane

By

S. SHUNMUGASUNDARAM [11], K. C. RAO[12] and K. M. NAIDU[13]

Various aspects connecting to post-harvest technology in sugarcane crop, viz., Nature and extent of post-harvest deterioration proper scheduling of harvesting, efficient transport system and other management practices in order to reduce sugar losses in white sugar and jaggery manufacture were discussed in this paper. Statistical methodologies wherever required have been outlined. Most of those aspects are being covered in two major research programme of this

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Institute namely, Investigations on post-harvest deterioration and Ethanol scheme which are undertaken in collaboration with nearby sugar factories of this region since 1980. Few of the research findings have been reported elsewhere and also in the annual reports of this Institute. Further work is in progress.

## Estimation of Post-harvest Losses in Milk and Dung

By

B.B.P.S. GOEL[14] AND K.B. SINGH[15]

Post-harvest technology refers to operations carried out on harvested crop, animal and aquatic products and there by-products for the purpose of preservation or enhancement of quality for marketing. It helps the producer in getting a remunerative price for the produce and generates more employment. Milk is one of the important livestock products. According to nutritional standards its availability is short of requirement by about 65 percent. The position is still worse if the post harvest losses are excluded from the production. A major proportion of its production is from rural areas where post harvest technology such as chilling and transportation is not available and as such a considerable quantity of it is lost in storage and handling. Since this is a perishable commodity and the technology to preserve it is not available, the producer has no option but to convert it into ghee and khoa adopting the age old techniques resulting in qualitative as well as economic loss to the producer. Thus the production becomes unremunerative to the producer. Dung and urine are important by-products in milk production and a good post harvest technology for these by-products will be an incentive for more production of milk.

*Post harvest losses in milk production* : It can be divided in two categories, *viz*, (*i*) quantity lost in handling, storage and transportation and (*ii*) qualitative loss in storage of milk and during its conversion into products. No data are available on these losses. However, the pattern of utilisation of milk as obtained from the sample surveys conducted by the Indian Agricultural Statistics Research Institute for estimation of milk production can be taken as an indicator of the post harvest technology being adopted in the rural areas. About 1/3rd of the milk produced is consumed as fluid

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milk whereas the rest of it is a marketable surplus out of which less than 1/3rd is sold and the rest is converted into milk products. The main reason of a small percentage of sale is the non availability of the technology for chilling and transportation. Reliable statistics on losses which will be useful to the planners and policy makers can be collected through sample surveys covering the producers, consumers and intermediaries. The surveys will also help in identifying the gaps between the best and available post harvest technology and its level of adoption.

*Post harvest losses in dung and urine production :* About 1/3rd of the total dung production is evacuated by bovines outside the households and is not collected by the householders. Further there is an economic loss due to poor technology adopted for dung utilisation. Although no reliable estimates of losses of dung are available but its pattern of utilisation as estimated from the sample surveys conducted by I.A.S.R.I. give an idea of the technology adopted in the rural areas. About 2/3rd of the dung produced is thrown into the manure pits and rest is covnerted into dung cakes. If the entire dung production is subjected to anaerobic fermentation, the availability of nutrients can be doubled and the heat anergy from the gobar gas will be 10 times more than what is available now.

Cattle urine is rich in soil nutrients and can be readily absorbed by crops. The estimates of its production, pattern of utilisation and losses are not available at present. Estimation of its production should also be given due importance and suitable post harvest technology should be developed for its efficient utilisation.

**Foodgrain losses in storage at farm level**

By

S.K. RAHEJA[16] AND P.C. MEHROTRA[17]

Losses in foodgrains occur at a number of stages after harvest like harvesting-shedding of grains ; threshing-breaking of grains, spillage ; cleaning/winnowing at farm/consumer level-spillage; drying-loss of weight, spillage, transporation-from field to threshing floor,

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from threshing, cleaning/winnowing, drying place to storage, from farm to market from market to wholesalers, public distribution agencies etc ; transit to retailers, fair price shops etc ; transact from retailers to consumers, handling-bagging, weighing, loading, unloading at market and other places, storage-farm level, wholeseller level, retailers level consumers level, etc., and processing-bulk processing, processing at small mills, etc. Also these losses may be qualitative or quantitative or both. For planning appropriate measures to control or minimise these losses, reliable estimates of the extent of the losses at various stages alongwith their causes are required. However, these estimates are not accurately known nor is there any well known procedure for determining the same on an objective basis. Of the various stages after harvest, storage losses alone accounts for nearly 50 per cent of the total losses in foodgrains. Farm level storage is perhaps the most important involving as it does millions of farmers and bulk of the production. In this paper farm level storage practices and extent of losses in storage have been studied with the help of data collected under the project "pilot sample survey to study the impact of new technology on crop production, its disposal and employment in Delhi state" conducted by the IASRI during the period 1979-80. The data were collected from a randomly selected sample of 360 cultivators spread over 36 villages (10 cultivators per village) in the various community development blocks (strata) of Delhi state.

The proportion of holding having improved storage like pakka store/metallic container was only of the order of 10 percent for the small holdings (less than 2 hectares). For holding of 2 hectares and above use of improved storage practices increased with increase in the size of holding, being around 70 per cent for very large holdings (more than 8 hectares) the average life of a pakka store was around 60 years, of a metallic container 20 years and for the traditional type of storage like bags etc. 2-3 years. Taking into account the cost and average life of the different types of stores, it was observed that a pakka store would prove much more economical in the long run followed by metallic container.

The study showed that nearly 38 percent of the holdings suffered foodgrain losses of varying intensities in storage due to pests and diseases attack, moisture effects, etc. In these holdings of the total foodgrains stored, nearly 16 per cent of the grains was affected on account of various causes of damage. Nearly 3 per cent (out of

the 16% affected grains) was completely lost and about 13 per cent suffered from loss in quality and nutritive content and thus rendered unfit for consumption. These losses were mainly the consequence of conventional methods of storage adopted by the farmer without taking adequate protective measures to save the grains from moisture effects, pests and diseases attack, etc.

An examination of the foodgrain loses under traditional storage *vis-a-vis* improved storage in different holding size classes showed that losses under traditional storage were of a much higher order than those under improved storage in all the holding size classes being as high as 32 per cent under traditional storage against 7 per cent under improved storage in the very large size class of 8 hectares and above. The method of storage by and large continues to be the traditional, particularly with small farmers, which leads to higher losses compared to the improved method of storage. For an effective programme of saving the grains in storage and minimising losses at various levels, apart from protective and remedial measures like treatment of grains, etc., intensive drive needs to be undertaken to educate the farmers for adoption of improved type of storage which will also prove cheaper in the long run. To mitigate the poor cash resources of the small farmers, suitable subsidy/loan may be advanced for the purpose.

Information on statistical aspects of losses in foodgrains at other post harvest stages is not fully known. There is, therefore, a need for planning a comprehensive survey to determine losses of foodgrains at different stages after harvest alongwith their causes to develop an effective post-harvest technology for minimising these losses.

## Nutritional Aspects of Post-Harvest Losses of Foodgrains in India

BY

DR. (MRS.) K.K. SHARMA[18] AND M. RAMAKRISHNA RAO[19]

A lot of available energy (Calories) and protein are being lost due to the post-harvest losses of foodgrains in India which have been estimated by the Expert Committee of the Government of India in 1966 and by the Administrative Staff College of India (1976) as 9.33% and 5.25% respectively.

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According to the All India Revised Estimates, foodgrains production in 1980-81 was 118.962 million tonnes of cereals and 10.627 million tonnes of Pulses. Thus 9.33% of this produce lost would amount to 11.099 million tonnes of Cereals and 0.991 million tonnes of Pulses, If, however, we take the ASCI's estimate of 5.25%, the losses of foodgrains amount to 6.245 million tonnes of Cereals and 0.558 million tonnes of Pulses. Even if the lower of these two estimates is taken, it would be seen that the lost Cereals could suffice for 39.245 million persons and the lost Pulses for 32.522 million persons per annum as per the recommended balanced diet consisting, *inter alia*, of 436 gm of Cereals and 47 g. of Pulses per capita per day.

Similarly, taking into consideration the lower estimate of foodgrain losses and distributing them equally among the entire population of the country, per capita availability could be augmented by 9.945 kgs per annum, contributing 33,704 calories and 1066.4 g. of protein per annum, or 27.25 g. of foodgrains per day contributing to 92 calories and 2.9 g. of protein.

The foregoing facts reveal the need for reduction of post-harvest losses to augment availability of nutrients and for better statistical appraisal of losses as the two available estimates are wide apart.

## Ginning of Cotton-some Statistical Aspects

BY

S. SATISH[20] A.K. BHATTACHARJI[21], A.N. BOSE[22], AND S.K. MISHRA[23]

Marketing of Agricultural Commodities should be thought of in a Comprehensive-rural producer to urban consumer-manner. However, several market functions such as pricing, processing, packaging, transporting and retailing of agricultural commodities and considered as just incidental matters in our country. This has led to a fragmented marketing system characterized by a low producer's share in the price paid by the final consumer. The share of the producer could be increased if the farmer himself ventures to undertake some of the marketing functions, especially the processing. The present study attempts to compare the prices received by farmers who are processing the produce and those who do not process. Further an enquiry is made into the factors coming in the way of the farmers is not processing the produce.

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Cotton, an important commercial crop of Karnataka has been chosen for the purpose. Ginning and pressing are two important processing functions for Cotton. An enquiry has been made into the effect of ginning on the prices received by the farmers and the marketing cost incurred by them.

The price received per quintal, the quantity brought in and the marketing costs incurred at the regulated market of Raichur (Karnataka) were collected from 81 farmers who brought Kapas (unginned cotton) and 55 farmers who brought lint (ginned cotton).

**MODEL :**

The general model connecting $P$, price received by the farmer : $Q$, quantity disposed by him : and $M$, his marketing costs may be taken to be

$$P=f(Q)$$
$$M=f(Q,P)$$

**Test based on parametric assumptions :**

Assuming linearity models 1 and 2 reduces to

$$P=A_1+A_2D_1+B_1Q+B_2D_2+U_1 \quad ...(1)$$
$$M=B_3Q_1+B_4D_3+B_5P+B_6D_4+2 \quad ...(2)$$

where dummy $D_1$ is used to test for any differences in the intercept term and $D_2$ is employed to account for any difference in slopes. Dummies $D_3$ and $D_4$ measure the differences in slopes associated with quantity brought in and prices received. $U_1$ and $U_2$ the error terms with usual assumptions.

Employing Three-stage-least squares method, to estimate jointly the parameters of the equation, we get

$$P=335.07+44.41\ D_1+3.35\ Q_1+15.38\ D_2 \quad ...(3)$$
$$(2.03) \quad (2.34) \quad (12.89)^2 \quad R^2=0.58$$

$$M=7.38Q_1+13.38\ D_3-0.0076P-0.0106D_4 \quad ...(4)$$
$$(2.91) \quad (15.61) \quad (0.95) \quad (0.98) \quad R^2=0.99$$

high $R^2s$ are in support of the model support of the model specified. The positive and significant values $D_1$ and $D_2$ indicates that a person bringing lint is consistently better placed as regards the price he receives compared to the farmer bringing Kapas. The positive and significant $D_3$ reflects that the farmer willing to gin the produce will have to incur higher marketing costs. The non-significant $D_4$ indicates the lack of responsiveness of price to the marketing cost.

**Non Parametric Test**

Kolmogorov-Smirnov's Two Sample test was used to compare the distributions of the number of people receiving a particular price, when cotton is sold in the form of kapas and when it is sold in the form of lint. This has been used to overcome any doubts regarding parametric assumptions.

Let $S^{(x)}$ denote the number of persons selling kapas and lint-seed at price $x$ or below respectively. $n_1$ and $n_2$ be the total number of persons selling kapas and lint-seed separately. Under the null hypothesis the two distributions of prices are identical, the test statistic,

$$T = \frac{4D^2 n_1 n_2}{n_1 + n_2}$$

follows a chisquare distribution with two degrees of freedom.

$$D = \text{Maximum } (s_1^{(x)} - s_2^{(x)})$$

The value of $T$ for our observed data came out to be 39.84 which is highly significant. It could be thus concluded that the farmers who gin their cotton get a better price.

The main reasons for non-ginning by the farmers were the small quantity of the produce at their disposal, difficulty encountered in selling the lint and seed separately and their preference for paddy or jowar stalks to cotton stalks. The first two reasons putforwarded definitely speak of the oligopsonic tendencies in the market. Further the farmers were of the opinion that cotton seeds of irrigated varieties (High Yielding Varieties) were harmful to be used as feed for the cattle.

## Use of Statistical Techniques for Research and Industry in Food Technology.

BY

U.M. INGLE,[24] D.N. KULKARNI[25], AND H.S. ACHARYA[26]

Food processing, quality control and nutrition form the major aspects in to which research in food technology can be divided. Each of these can benefit from the latest techniques of data analysis available.

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Biochemists have been using statistical techniques to study the kinetics involved in enzymatic reactions since long, (Banks, 1975). Various pretreatments could affect an enzymatic reaction. In the case of a study on enzymatic digradability of wheat straw, Kulkarni and Joergensen, (1980) have tried to find out the effect of chopping, pretreatments with selected acids at different concentrations, at different temperature on the reaction rate. Standard techniques of experimental design and analysis of variance can help us in getting information regarding the best choice of pretreatment, the inter-dependence or otherwise of the basic factors namely chopping, type of acid, levels of concentration and temperature.

Chavan and Kadam (1980) have reported thot Tannins can be removed from grain sorghum by soaking the grains in different media. Soaking time, concentration of the soaking medium and soaking temperature are the factors which affect the removal of tannin.

**Non parametric methods applied to sensery evaluation of foods :**

Sensory perceptions of appearance, feel, texture, taste, aroma and residual mouth feel being variables measured in ordinal scale the resulting sensory criteria are highly variable in character. However, use of statistical methods have given the confidence towards establishment of controlled experiments aiming at objective sensory analysis and consumer evaluation (Govindarajan, 1981).

**Statistical methods for Industry :**

Most powerful management tools like operations research and statistical quality control methods have not yet been organized for the benefit of food industry. Production line selection, economics of size and market discounts can make use of Integer applications of linear programming. Continuous inprovement of industrial operations is one of the most important aspects of evolutionary operations. This is normally achieved using the response surface techniques and the slope of steepest descent methods.

Inventory control has a special inportance in food industry because of the perishability of goods. Kramer and Twigg (1970) have given a good description of statistical methods usefull for acceptance sampling and inspection.

From the preparation of the producttill it reaches the marketing department the food product has to pass through various tests like

shelf life taste, taste panel tests, commercial prototype production on one side and packing designs, use of varying packing materials and their quality evaluation on the other side. Use of critical path methods can help in organizing these steps in an efficient way. Programme evaluation and review techniques of system analysis can help maintaining the operations at an optimum efficiency level (Bender, Kramer and Kahan, 1976.)

Higher degree of efficiency in management of industries can be achieved through use of methods of system analysis and statistical quality control A regular channel must be established through which latest techniques of statistics should be fed to active research workers in post harvest Technology.

## Assessment of Grain Storage and Movement Pattern A Methodological Review

BY

S.L. KUMBHARE[27]

The problems in the areas of storage, transportation and processing have assumed critical importance with the introduction of high potential varieties and the consequent spurt in foodgrain production. The paper endeavours to review the methodology base of studies which assessed, in recent years, the grain movement pattern, location of public storages and the spatial estimation of storage requirements at macro level. While two approaches are generally employed : one follows arithmetical technique after incorporating the practical wisdom of the people entailed in movement planning and the other makes use of operational research technique-transportation model. But the studies based on transportation model are mostly concerned with minimisation of transportation cost alone and the general conclusion which emerges from these studies is that it is possible to effect considerable saving in transporation cost if knowledge were available of surpluses and deficits, and other conditions such as freedom of movements and facility of transport.

Keeping in view some of the limitations of the transportation model, a linear programming formulation, taking care of simultaneous

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minimisation of transport and storage cost, rail carrying capacity constraints and procurement and distribution requirements of various states ; was used by the author for working out the optimum spatial distribution of storage quantities and movement pattern in achieving it. The simple methods/formulae used by others and suggestions made by the experts in location of public storages and estimation of storage space have also been briefed. The inter-locking of the problems of movement and storage, volatility of production leading to imports in bad years and exports in years of bountiful harvests make the task of formulation of suitable statistical model both challenging as well as rewarding. In this area of research of critical importance one faces an added limitation of lack of suitable information base on key variables but this cannot be an indefinite *alibi*. Linear programming with suitable alterations and simulation bestow the key to new possibilities of suitable models. Data constraints to use of developed statistical models have to be identified and the requisite arrangements have to be made to remedy them.

Further, the reliability of solutions, obtained through the use of statistical models which involve future projections, depend upon the actual realisation of estimated values of constants used.

**Save Grain Campaign in Maharashtra**

BY

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Intensive efforts have been made to step up foodgrain production which is still not sufficient to feed the country's growing population. This is because considerable quantitative as well as qualitative losses occur during post harvest operations due to insects, rats, birds, moisture etc. With a view to help the farmers to minimise these losses the Department of Food, Govt. of India launched the 'Save Grain Campaign' as a country-wide programme during 1965-66 as a pilot project and from 1969-70 as a regular plan Scheme. The Regional team was set up at Bombay in 1970-71 later shifted to Pune in 1976 which at present is carrying out its activities in Maharashtra, Goa, Daman & Diu. The objectives of the campaign are training, demonstration, publicity and assistance to State Government in implementing the programmes on prevention of food losses on a large scale. Geographic, geological, climatic and vegetative features have been discussed in the paper. The total

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foodgrain production in Maharashtra has stepped upto 105.7 lakh tonnes in 1981-82 from 70.45 in 1973-74 which is still not sufficient for the State. This is mainly because the storage practices and facilities at the level of farmers are not satisfactory. Some of the structures are Bamboo bins Dholies (prepared from fur & cotton stalks), mudbins, cemented bins etc. The main disadvantage of these bins is that they are not moisture proof. The grain stored in such bins gets quickly infested and absorbs moisture from the atmosphere during the rainy season and can be gnawed by rats. Grain is also stored in metallic drums. In addition, Khatti and Pev are sparingly used for storage of foodgrains. These are underground storage structures and stocks get absorbtion of moisture and hence get infested soon. It is evident from the prevalent storage practices discussed above that storage practices are not satisfactory and hence considerable losses occur due to unscientific storage. The steps taken by the Save Grain Campaign to minimise losses are summarised below :

(*i*) To organise training programmes for all those who are concerned with handling of foodgrains ;

(*ii*) Demonstrations to farmers for prevention of infestation by way of prophylactic treatment and also foodgrain fumigation. The rat control measures are undertaken by rat burrow fumigation and rat control measures in houses ;

(*iii*) Publicity through radio talks, T.V. programmes, press reports, distribution of semi-technical literature, Exhibitions, organisation of slide shows and film shows, postal enquiries and distribution of literature :

Grant-in-aid is given to the Govt. for improvement of existing storage structures/construction of Pucca Kothis under the Intensive Grain Storage Project with assistance from E.E.C. Some financial assistance is also given to the farmers for construction of Pucca Kothi etc. and improvement of existing storage structures are popularised by providing incentives in the form of inputs free of cost *i.e.* outlets and inlets, re-inforcing steel rods, polythene film, tin sheets etc. Similarly, sanctioned by Government of India provides some money to the Goverment of Maharashtra towards purchase of pesticides for making available to the farmers. The achievements of Save Grain team since inception have been given in the paper.

All efforts have to be made to prevent losses in foodgrains stored at all levels to make more foodgrains available for consumption that

will be better in quality and nutritious too. In India a majority of the population depend on agriculture as their living hence storage of food-grains in a proper way is essential. The Save Grain Campaign, Pune which was launched in Bombay initially aims at education, motivation and persuation of the farmers to adopt scientific techniques for storage and preservation of foodgrains in the State of Maharashtra, Goa, Daman & Diu. Co-operation of a number of agencies like Central and State Goveinments, village level workers, voluntry organisation, educational and research institutions ete. is needed for boosting up the campaign activities following *Recommendations* were made based on the papers presented and discussions held :

1. Standard methodologies for measuring and estimating quantitative, qualitative and economic losses for durables as well as for perishable food products should be developed
2. A co-ordinated approach involving various disciplines such as Entomology, Plant pathology, Agronomy, Agril. Engineering, Post-harvest Technologist, Statistics etc. is very necessary in the estimation of post-harvest losses.
3. Since no objective estimates of post-harvest food grain losses are available, attempts should be made to collect reliable statistics of those losses at the earliest by adopting statistical methodology for estimation of post-harvest losses suggested in the paper by Dr. Prem Narain and R.K. Khosla.
4. Statistical methodology should also be developed for estimating post-harvest production losses in livestock-products, fruits and vegetables, fish catch and other commodities.