Grain processing losses bibliography: Supplement 1 to G117 (G168)

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Grain processing losses
bibliography
Supplement 1 to G117

Covering combine harvesting, threshing, hulling, milling, grinding, etc. and excluding storage

Ruth Kasasian
This report was produced by the Tropical Products Institute, a British Government organisation that co-operates with developing countries in helping them to derive greater benefit from their plant and animal resources. It specialises in post-harvest problems and will be pleased to answer requests for information and advice addressed to the Director.

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Preface

The Grain Processing Losses Bibliography (TPI Report G117) was issued in January 1979 and contained just 200 references. The present Supplement brings the total to 500, indicating the great interest now being shown in post-harvest loss assessment and reduction.

Those workers who found G117 useful will require to up-date their knowledge with this Supplement.

David A. V. Dendy
Head, Cereals Processing and General Food Technology Section
ADAMS, J. M. 1977
A review of the literature concerning losses in stored cereals and pulses published since 1964
The extent and type of losses incurred during storage and transportation of cereals and pulses are reviewed. Experimental estimates and field estimates are given, the latter subdivided under (1) gross losses, (2) transportation and handling, and (3) storage. Those areas where insufficient information is available for the formulation of loss reduction policies are highlighted.

ADHAOO, S. H. 1977
Post-harvest operations: need for avoiding wastes
*Productivity* 18 (2), 261–267.

ARAULLO, E. V., PADUA, D. B. de & GRAHAM, M. (Eds.) 1976
*Rice post-harvest technology*
Ottawa, Canada: International Development Research Centre.

ARKANSAS UNIVERSITY INSTITUTE OF SCIENCE AND TECHNOLOGY 1953
Pilot plant investigations of the effects of drying, storage and processing factors on the quality of rice: terminal report

ASIAN PRODUCTIVITY ORGANISATION 1974
Training manual: post-harvest prevention of waste and loss of food grains
Tokyo, Japan: APO Project TRC/1X/73, 358pp.

BAKER, D., NEUSTADT, M. H. & ZELENY, L. 1959
Relationships between values and types of damage in grain
Fat acidity tests were applied as a measure of different types of damage in corn, wheat, soybeans and grain sorghum. In general, field damage showed low correlation with fat acidity values, unlike storage damage.
BERK, Z. 1970  
Processing and storage damage to nutritional value of foods  

Loss of nutrients by destruction, fractionation or chemical inactivation is discussed.

BIREWAR, B. R. 1977  
Post-harvest operations  
Productivity 18 (2), 227-240.

Grain loss prevention is discussed in relation to all aspects of post-harvest operations.

BOURNE, M. C. 1977  
Wasted food in developing countries  

Primary and secondary factors leading to post-harvest losses are discussed.

BULOG (NATIONAL LOGISTICS AGENCY, INDONESIA) 1971  
Losses in rice marketing system (in Indonesia)  
Jakarta, Indonesia: BULOG.

CASWELL, G. H. Not dated  
The identification of season and place of maximum grain loss  
Zaria, Nigeria: Ahmadu Bello University, Institute of Agric. Res.

A hypothetical trace is followed through for a crop harvested in October until its consumption one year later. Loss sites are dealt with, mainly during storage.

CHAUDHRY, M. A. 1980  
Food grain losses in Pakistan  
Faisalabad, Pakistan: University of Agriculture, 574+xxxxivpp.

Six volumes deal with losses of wheat, rice and maize during all stages from harvesting to consumption in subsistence and commercial systems under the following categories:

Vol. 1 Farm level, 87+v pp.  
2 During storage, 141+vii pp.  
3 At market level, 122+ix pp.  
4 During transportation and processing, 63+ii pp.  
5 At consumer level, 95+vi pp.  
6 Loss aggregates, 66+xxii pp.

DENDY, D. A. V. 1978  
Significance of nutritional losses in the processing of grains  

The causes and effects of nutritional losses during processing are reviewed. The author concludes with the observation that nutritional loss is significant when the consumer receives only the minimum gross calorie intake and that resources should be directed towards increasing the actual quantity of food available.
DOHARY, R. B. SRIVASTAVA, P. K. & GIRISH, G. K. 1975
Studies on the assessment of losses of wheat in Punjab

ESMAY, M. L. Date unknown
Increasing rice production and minimizing losses through meaningful mechanization
Final Rep. MUCIA-MSU-sponsored research at Acad. for Rural Dev. at Comilla, Bangladesh, 39pp.

FAZLUL HUQ, A. K. & GREELEY, M. 1980
Rice in Bangladesh: an empirical analysis of farm-level food losses in five post-production operations

Estimates are provided of losses in five post-production operations in Bangladesh—from cutting to winnowing and farm-level storage of raw paddy and parboiled rice. Results of the study indicate that physical losses of food in these operations are considerably less than often suggested.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 1948
Effect of processing and household preparation on nutritive value. Improvement in the nutritive value of rice as consumed

Methods for the conservation of nutrient present in raw rice are discussed in relation to such processes as milling, washing and cooking, parboiling, 'conversion' and storage.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 1975
Reducing post-harvest food losses in developing countries

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 1977
Analysis of an FAO survey of post-harvest crop losses in developing countries

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS & UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA 1977
Sub-regional consultation on increasing food availability through waste reduction and improving the marketing system in West Africa, with special reference to food grains, fruits and vegetables, held in Monrovia, Liberia, 1976
Addis Ababa: FAO/UNECA.
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
1978
Action program for the prevention of food losses. Liberia—reduction of
post harvest rice losses in on-farm operations and primary marketing
Rome. FAO.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
1978
Promotion of food security with special emphasis on reduction of post-
harvest food losses
(14th FAO Regional Conf. for Asia and Far East, Kuala Lumpur)
FAO Bull. FERC/78/6.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
1980
Assessment and collection of data on post-harvest foodgrain losses
Headings are:
1 Introduction
2 Concepts, definitions and measurement techniques
3 Statistical methodology
4 Summary and recommendations
Appendix I Sample survey to estimate post-harvest foodgrain losses
Appendix II Sample survey to estimate post-harvest foodgrain losses
Appendix III Sample survey for estimation of crop losses in storage
Appendix IV Review of work done in brief

GOVINDASWAMI, S. & GHOSH, A. K.
1968
Assessment of losses of paddy and rice during harvesting, drying,
threshing, cleaning, storage and processing

GREELEY, M. & RAHMAN, S.
1980
Wet-season post-harvest food losses
Paper presented at: Post-production workshop on food grains, Dacca,
December, 22pp.
The authors report a study of wet season losses conducted in two areas of
Bangladesh during 1979 and 1980. Different types of food loss are discussed and
loss estimates for physical losses are presented.

GREELEY, M.
1981
Farm-level rice processing in Bangladesh: food losses, technical change
and the implications for future research
Paper presented at: Regional grains post-harvest workshop, Philippines,
January, 28pp.
A report is presented of the evidence that food losses are low in farm-level post-
harvest operations. The results indicate that research priorities need to be more
selectively identified that in the past. The importance of integrating post-harvest
research with crop-production research and of analysing post-harvest problems
associated with marketed surplus, especially in the wet season, is discussed.
GREEN, A. A. 1959/60
The control of insects infesting groundnuts after harvest in the Gambia

I A study of the groundnut borer Caryedon gonagra (F.) under field conditions
II Field trials on the control of the groundnut borer Caryedon gonagra (F.)
Trop. Sci. 1960, 2, 44.
III The effects of decortication on the infestation of groundnuts by Tribolium
castaneum (Hbst.) and other insects

GUPTA, C. P. 1975
Progress in technology to reduce losses in rice

HALL, D. W. & MCFARLANE, J. A. 1961
Post-harvest problems with paddy and rice in British overseas territories
IRC/WP/61/RP, 64, 9th Meet. Working Party on rice production and
protection, New Delhi, 28pp.

HARRIS, K. L. & LINDBLAD, C. 1978
Post-harvest grain loss assessment methods

HARRIS, K. L. 1979
Post harvest grain loss: measurement techniques
In: Proc. Third Advanced Seminar on Food Technology, Bogota, Colombia,
pp.79–97, 475pp.

Losses originating in early processing often show up only in later operations and
should be assessed in terms of the later loss. All losses should be converted to a
standard, and sampling should be performed to a set method. Methods of
assessing storage losses are described.

HULSE, J. H. 1975
Research and development requirements on post-harvest systems
(Commonwealth Ministerial Meeting on Food Production and Rural
Development)
INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES-OAS
1977
Proceedings of a seminar on the reduction of post-harvest food losses in
the Caribbean and Central America
Santo Domingo, Dominican Rep: Secretariat of State for Agric., Vols. I–VI
(English and/or Spanish).

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE &
INTERNATIONAL RICE RESEARCH INSTITUTE
1974
Report of the advisory group meeting on rice post-harvest problems, held
at the International Rice Research Institute, Los Banos, Laguna,
Philippines, April, 1974

JACKSON, C. R.
1967
Studies on control of peanut pod fungi. II. Value of fungicidal treatment
of windrowed peanuts in post-harvest reduction of pod-borne fungi and
aflatoxins
(11), 18pp.

KAMINSKI, T. L.
1968
Need for standards for evaluation of grain damage

KIK, M. C.
1945
Effect of milling, processing, washing, cooking and storage on thiamine,
riboflavin and niacin in rice

KRISHNAMURTHY, K.
1972
Postharvest problems of wheat
Review. Threshing, transportation, storage and processing are discussed, and
losses at each stage estimated. An increase in wheat production has emphasised
the need for improved facilities and expertise in post harvest operations in India.

LEE, C. W. & CHUNG, C. J.
1978
An evaluation of rice post-harvest systems in terms of grain losses and
maximum recoveries
In: Post-harvest rice systems in Korea, pp.41–122. Suweon, Korea: Seoul
National University College of Agriculture, 194pp.

1 Introduction
2 Experimental methodology
   1) Experimental materials and design
   2) Experimental methodology
3 Results and discussion
   1) Grain losses
   2) Determination of optimum harvesting timing
   3) Summary on grain losses and harvesting systems
4 Summary and conclusions
6
MAJUMDER, S. K. & PARPIA, H. A. B. 1966  
Possible losses of food grains in India  
_Vijnan Karmee_ 18 (4).

MAJUMDER, S. K. 1970  
Protecting food from deterioration during storage, handling and distribution in technologically less-developed countries of the world  

The author reviews pest control methods at various stages in post-harvest treatment of cereals, pulses, spices, oilseeds and composite foods.

MARTINEZ, E. A. & MARTINEZ, J. F. 1979  
Adaptation of a method to study post harvest losses in rice in the Dominican Republic  
Paper presented at: 26th Meeting of the Caribbean Food Crop Society, Santo Domingo, Dominican Republic (In Spanish).

McGINTY, R. J. 1970  
Development of a standard grain breakage test  

MOELJARNO, D., KAMARUDDIN, A. & RIZAL, S. 1979  
In-field post-production rice losses on farm in West Java  

The authors report a study designed to formulate post-production systems through simulation modeling and summarise findings from field data collected in West Java during wet and dry seasons in 1978. The data collected refer to IR-36 and IR-38 varieties and cover losses during harvesting, cutting, packing and transportation, threshing and drying.

MORRIS, R. F. 1978  
Post-harvest food losses in developing countries: a bibliography  

MPHURU, A. N. 1976  
Losses which occur during harvesting and storage of grains: a bibliography  

References, some annotated, are grouped under the following headings:  
Detection and microanalysis  
Estimate of losses due to insects, rodents and birds  
Harvesting, handling, conditioning and processing losses  
Nutrient losses, fungal damage and losses in germination

PADUA, D. B. de 1977  
Rice post-harvest problems in South-east Asia  
PADUA, D. B. de
1978
Rice post-harvest requirements for tropical Asia
Local conditions are considered with regard to failure in applying modern technology to post-harvest handling of an increased yield of rice leading to overloading of the traditional facilities and practices employed.

PARPIA, H. A. B.
1969
Foodgrain losses and the nutritional gap in developing countries

PILLAIYAR, P.
1978
Assessment of cumulative quantitative losses of paddy
Thiruvarur, India: Paddy Process Research Centre.

PIMENTAL, D. (Ed.)
1978
World food, pest losses and the environment
Losses occasioned by insect pests, plant diseases, weeds, animal pests and the effect on world food production are described. The section dealing with post-harvest food losses includes reports on losses of millet in Mali and a post-harvest losses study at the UN University.

PINGALE, S. V.
1968
Assessment of losses of paddy and rice during harvesting, drying, threshing, cleaning, storage and processing
FAO/IRC/AE/WP 1.

RODDA, E. D., STEINBERG, M. P. & WEI, L. S.
1972
Soybean damage detection and evaluation for food use

ROLSTON, W. D.
1974
Semi-annotated bibliography of research in post-harvest technology for cereal grains and grain legumes in African countries north of the equator

SABRY, Z. I.
1968
The nutritional consequences of developments in food processing
SATAKE, R. S.
1980
The reduction of losses through better processing
A brief history of the rice processing industry in Japan is followed by an account of the activities of the Satake Engineering Co. in developing machinery aimed for low losses and high efficiency and yields.

SAUNDERS, R. M., MOSSMAN, A. P., WASSERMAN, T. & BEAGLE, E. C.
1980

STANLEY, A.
1979
Grain losses in Paraguay
Processing and marketing of grains in Paraguay are discussed, with estimates of losses in rice, maize, wheat and soyabeans as related to climate and handling.

SWAMINATHAN, M.
1977
Effect of insect infestation on weight loss, hygienic condition, acceptability and nutritive value of food grains
A review covering weight loss and nutrition loss in cereals and pulses due to insect infestation.

TINDALL, H. D. & PROCTOR, F. J.
1980
Loss prevention of horticultural crops in the tropics

TOQUERO, Z., MARANA, C., EBRON, L. & DUFF, B.
1976
An empirical assessment of alternate field-level rice post-production systems in Nueva Ecija, Philippines
Int. Rice Res. Inst. Pap. No. 76–03AE.
Pilot trials were implemented in three villages of Nueva Ecija to test the farm level efficiency of alternative techniques and systems of harvesting, handling, threshing and drying.
TOUERQO, Z., MARANA, C., EBRON, L. & DUFF, B.  
1977  
Assessing quantitative and qualitative losses in rice post-production systems  

The authors report the preliminary findings of a rice post-production study, the objectives of which are given as:  
a to develop a suitable research methodology to determine the nature and characteristics of grain loss at the farm and mill level,  
b to inventory and assess technical efficiency in traditional and improved farm and mill level post-production systems,  
c to examine the economics of traditional and improved systems,  
d to determine the institutional factors constraining use of improved techniques and systems.

TROPICAL PRODUCTS INSTITUTE  
1978  
Introducing food loss assessment studies into loss reduction programmes  

Proceedings of a seminar on post-harvest grain losses, with abstracts of technical papers covering loss assessment and reduction in 36 tropical countries.

TROPICAL PRODUCTS INSTITUTE  
1979  
Equipment for measurement of grain losses: an annotated equipment list prepared for use with the manual 'Post-harvest grain loss assessment methods' (See TPI Report G117, A1)  

UNITED KINGDOM COMMONWEALTH SECRETARIAT  
1977  
Report of the regional workshop on post-harvest losses, Accra, Ghana  

UNITED NATIONS PROTEIN ADVISORY GROUP  
1975  
Losses  

UNITED STATES NATIONAL ACADEMY OF SCIENCES  
1978  
Post-harvest food losses in developing countries  

Report covering the following chapter headings:  
Introduction  
Cultural and socio-economic aspects  
Post-harvest food loss assessment and estimation  
Cereal grains and grain legumes  
Perishables  
Post-harvest losses of fish  
Education, training and extension  
Conclusions and recommendations
WIMBERLEY, J. E.
1975
Ford Foundation Rice Research Institute: Post-production projects in India and Sri Lanka


Studies of post-harvest practices in India and Sri Lanka indicated paddy losses of up to 30% (in Sri Lanka). The need for improved milling and parboiling techniques, for a degree of modern technology in the post-harvest system, for trained personnel and for collaboration is elaborated.
Combine harvesting

How to reduce soybean harvest losses

BURNETT, L. C. & BAKKE, A. I. 1930
The effect of delayed harvest upon yield of grain
_Iowa Agric. Exp. Station Res. Bull._ 130.

Studies conducted in Ohio indicate that soyabean harvesting losses amount to 12%. These can be reduced to 5% according to field experience and research studies. Methods of estimating losses occurring at various identified harvesting stages are detailed and corresponding adjustments in harvesting methods are described.

BYG, D. M. 1969
A guide for measuring soybean harvest losses
_Columbus, Ohio: Ohio State Univ., Agric. Eng. Dep._

Studies show that the average Ohio farmer could increase his harvested yield of soybeans by 5–8% by efficient combining. The authors discuss proposed improvements to combines, such as cutterbar extension, ground-contour-sensitive cutting mechanism, etc.
CASHMORE, W. H. 
1945
Grain losses with the combine harvester
_Agric. Eng. Record_ 1, 10–14.

Causes and measurement of losses from cutter-bar, thresher, sieve and straw-shaker are described. Trials indicated that losses can be of such an order as to make combining uneconomic, that cutter-bar losses were by far the largest, and that speed of travel affects the losses after the optimal limit is passed.

CHUNG, C. J. 
1977
Determination of optimum timing of paddy harvesting based on grain loss and milling quality
_Suweon, Korea: Seoul Nat. Univ. Coll. of Agric., Dep. Agric. Eng._

DIOS, C. A. de 
1973
Kernel damage in mechanical maize harvesting

Combine harvesting of Argentine maize is described. Methods of loss reduction by machine adjustment, grain damage estimation, etc. are given.

FAIRBANKS, G. E., JOHNSON, W. H., SCHROCK, M. D. & NATH, S. 
1979
Grain sorghum harvesting loss study

The influence of grain moisture content, cylinder speed and cylinder concave adjustment on the various combine harvesting losses was studied on Kansas farms. Only grain moisture content had a significant effect on shoe, walker, cylinder, header and total losses. Neither cylinder speed nor cylinder-concave clearance had a significant influence on the total combine harvesting losses. Even with optimum cylinder speed and cylinder-concave clearance adjustment, total harvesting losses at 20–30% grain moisture are sufficiently high to discourage early harvest.

GRAMER, R. Q. & MONTGOMERY, G. F. 
1968
Bibliography on combines and grain harvesting
_Am. Soc. Agric. Spec. Publ. SP-0274._

JOHNSON, I. M. 
1957
Cut grain losses from your combine this season
_East African Farmer and Planter_ 2_ (1), 25.

The author recommends and describes procedures for checking efficiency of combine harvesters and making necessary adjustments for improved efficiency in loss reduction.

JOHNSON, W. H. 
1967
Reducing unnecessary harvesting losses
_Soybean Farmer_ 4_ (6)._
JUDAH, O. M.  
1970  
*Mechanical damage to navy beans during harvesting in Michigan*  

KANG, W. S., LEE, C. H., CHUNG, C. J.  
1978  
*Determination of optimum timing of paddy harvesting based on grain loss and milling quality*  
Seoul, Korea: Korean Institute of Science and Technology.

KLINE, G. L.  
1973  
*Physical damage to corn (maize) during combine harvesting and heated-air drying*  

KUNZE, O. R. & PRASAD, S.  
1978  
*Grain fissuring potentials in harvesting and drying of rice*  

KUNZE, O. R. & PRASAD, S.  
1978  
*Grain fissuring potentials in harvesting and drying of rice*  

MANGJU, D.  
1969  
*Time of harvest for maximum grain yield and high milling and seed qualities of rice*  
Los Baños, Philippines: *Coll. of Agric. Cent. Exp. St., Univ. of Philippines.*

MESQUITA, C. M. & HANNA, M. A.  
1979  
*Belt conveyor system to reduce soybean harvester gathering losses*  

NAVE, W. R.  
1971  
*Reduction of losses and damage in soybean harvesting*  

McNEAL, X.  
1950  
*Effect of combine adjustment on harvest losses of rice*  
NYBORG, E. O., McCOLLY, H. F. & HINKLE, P. T.  1969
Grain combine loss characteristics

PALANIAPPAN, S. P. & VIJAYAKUMAR, M. R.  1976
Note on the effect of time of harvest on the nutritional quality of grain in two sorghum cultivars
  Two sorghum cultivars were harvested at 5-day intervals between 75 and 105 days after sowing (DAS). Grain weight and volume increased with delay up to 90 DAS. Grain protein and carbohydrate contents increased with delay up to 95 DAS.

QUICK, G. R. & BUCHELE, W. F.  1972
Reducing combine gathering losses in soybeans

RUTHERFORD, I.  1973
Combine harvesting losses: grain counts
  *Power Farming* 51 (1), 83–85.
  A method of checking front-end and threshing losses during combine harvesting, using simple apparatus, is illustrated and described.

SCHULER, R. T., RODAKOWSKI, N. N. & KUCERA, H. L.  1975
Grain harvesting losses in North Dakota
  *Farm Res.* 32 (6), 20–21.

SEETANUN, W.  1971
Milling and seed qualities, and protein content of rice as affected by times of harvest and nitrogen application
  Los Baños: Univ. of the Philippines, Coll. of Agric. Exp. St.

SEETANUN, W. & DATTA, S. K., de  1973
Grain yield, milling quality and seed viability of rice as influenced by time of nitrogen application and time of harvest
  A field study was conducted to determine the optimum time for nitrogen application to high-yielding rice cultivars grown on millions of hectares in South and South-east Asia. Lodging was minimized in some cultivars by split rather than single application of nitrogen. Based on maximum grain yield with highest milling recovery and seed viability, the best time for harvesting transplanted rice was between 30 and 42 days after heading in the wet season and between 28 and 34 days in the dry season.
WEBBER, C. R. & FEHR, W. R. 1966
Seed yield losses from lodging and combine harvesting in soybeans
Soybean seed yield losses due to lodging and to combine harvesting were evaluated for 3 years. The relationship of losses to inches of cut and losses attributable to lodging are given. Prevention of lodging by staking (also 3-year study) increased yield by 13%, mainly due to an increased number of pods and seeds in staked varieties.

Soybean kernel damage
Stillwater, Oklahoma: Oklahoma State Univ. Ext. Leaflet E-694.

See also: A65:72
G22
H24:30
K34
Threshing

ARBOLEDA, J. R., McMENAMY, J. A. & MANALIGOD, H. T. 1980
Mechanical threshers and dryers for reduced post-harvest losses and improved grain quality

Three axial flow threshers and two batch driers developed by the International Rice Research Institute are described. Graphs, illustrations and tables are included.

ARNOLD, R. E. 1960
How to cut grain damage
Practical Power Farming 24 (5), 37.

Recommendations are made for threshing procedures, cylinder speeds, etc. intended to reduce losses from combines.

Effects of thresher drum speed on the quality of the milled rice

1 Introduction
2 Experimental method
   1) Threshing test
   2) Milling test
3 Results and discussion
   1) Effects of drum speed on the quality of products
   2) Analysis of field survey of traditional threshing operations
4 Summary and conclusion

GORBACHEV, I. V. 1975
Reduction of grain damage in a threshing device

It is proposed that under certain conditions, smooth beaters on a threshing drum will cause less damage to the grain portion of the cereal mass than riffled beaters. Tests using an SK-4 combine on wheat at 10% moisture, with automatic loading and speed of revolution at beater points 34.5 m/s, resulted in 17–19% damaged grains for smooth beaters as against 36–38% for riffled beaters.
HOKI, M. & PICKETT, L. K.  
1973  
Factors affecting mechanical damage of navy beans  
Experiments with a laboratory impact tester led to the conclusion that high thresher cylinder speed, low bean moisture (internal cracks or large space between cotyledons) and low temperatures (especially below 50°F) should be avoided if losses are to be kept to a minimum.

YOUNG, E. & BUCHELE, W. F.  
1968  
Threshing damage to soybeans  

See also: B33:51  
H24
Shelling of maize (corn)

CHOWDHURY, M. H. & BUCHELE, W. F.  
1978  
The nature of corn kernel damage inflicted in the shelling crescent of grain combines  

The authors report on a study of percentage kernel damage caused by cylinder and concave before and after shelling, and the effects of kernel moisture, cylinder speeds and the different concave zones on these two categories of damage. Fifty per cent of the mechanical damage to the kernel is to the embryo and pericarp (off-the-cob damage) and may be reduced by re-designing the shelling mechanism so that the shelled kernels can leave the shelling crescent immediately after shelling.

CHRISTENBURY, G. D. & BUCHELE, W. F.  
1977  
Photoelectric system for measuring mechanical damage of corn  

A technique for measuring mechanical injury to corn was developed for use in the grain trade. The test is made by soaking the sample in dye, grinding the sample and measuring the induced fluorescence.

HALL, G. E.  
1968  
Mechanical shelling damage  

SHARDA, R. & HERUM, F. L.  
1977  
A mechanical damage susceptibility tester for shelled corn  
Conveying

ASIAN PRODUCTIVITY ORGANISATION
1970
Report of the survey on the problems of transportation, storage and distribution of food grains

CHRZANOWSKA, H.
1972
Natural losses of grain, legumes and rapeseed during road haulage
Losses during transport of grain, etc. were on average over twice as heavy in bulk haulage as in bagged haulage. A method for predicting expected losses during road haulage is described.

CHUNG, D. S., CHUNG, C. J. & CONVERSE, H. H.
1973
Damage to corn from pneumatic conveying
Four variables were investigated: kernel size and shape, corn moisture content, air velocity of conveying system and distance conveyed. Analysis of total damage/conveying air velocity relationship showed that total damage to 20% moisture corn increased proportionally with increased air velocity, but that total damage to 12% moisture corn began a sharp increase at 5,400 f.p.m.

CRISTAL, A. N.
1967
Handling losses of palay grains of IR-8-288-3 at different stages of maturity

GUILFOY, R. F. & MONGELLI, R. C.
1969
Relationships between grain transit losses and boxcar defects

HALL, D. W.
1970
Handling and storage of food grains in tropical and sub-tropical areas
HOLMAN, L. E. 1969
Improving the handling of grain in Indian wholesale markets
New Delhi: Ford Foundation.

Effects of repeated freezing-thawing cycles on the mechanical strength of corn kernels
Successive freezing and thawing of corn indicated that overall effects were small even after 16 thawing-freezing cycles, and were considered to be of little practical significance in reducing resistance of corn kernels to mechanical damage during handling and storage.

KAUFMANN, H. H. 1973
Handling and resulting grain breakage
An extensive series of studies into factors affecting handling breakage of soya beans, pea beans, corn and wheat is reported. It is concluded that low velocity handling of grain at relatively high temperatures and moisture contents reduces breakage. Results are shown in numerous tables.

LUCERO, L. C. 1968
Effect of two methods of grain handling on the milling recovery of Raminad Strain-3 and BPI-76 rice varieties

MILLER, B. S., HUGHES, J. W., ROUSSE, R. & POMERANZ, Y. 1979
Note on a method for measuring breakage susceptibility of shelled corn during handling
Cereal Chem. 56 (3), 213–216.
An apparatus capable of accelerating corn kernels was developed and tested. Illustrations, diagrams and graphs show the apparatus and the results obtained. The device simulates a normal grain handling operation, impacting corn against corn at velocities both above and below that attained by corn falling vertically from a height of 30.5 metres.

PAULSEN, M. R. & HILL, L. D. 1977
Corn breakage in overseas shipments—two case studies
In a series of studies on handling and associated breakage during loading and transport of corn, the results of the first two studies are reported. Tests were made at various stages of the commercial handling procedures. High percentages of initial multiple cracks in breakage tests often indicated high percentages of broken corn and foreign material after repeated handling.
PELAYO, R. G.  
1968  
Handling losses of palay grains of Peta lowland rice variety  

PERRY, J. S.  
1959  
Mechanical damage to pea beans as affected by moisture, temperature and impact loading  

PINGALE, S. V.  
1976  
Handling and storage of food grains  
New Delhi: Indian Council of Agricultural Research, 186 pp.

SALAMANCA, H. R.  
1968  
Comparison between the conventional and the modified methods of harvesting, on handling losses of Raminad Strain-3 and BPI-76 varieties of rice  

STEPHENS, L. E. & FOSTER, G. H.  
1976  
Breakage tester predicts handling damage in corn  

STEPHENS, L. E. & FOSTER, G. H.  
1977  
Reducing damage to corn handled through gravity spouts  
Experiments with flow-retarders gave relatively small reductions in grain damage. Low-temperature drying was much more effective, especially field drying. Minimum handling would also produce higher grain quality.

WINTER, J. W. & FOSTER, G. H.  
1968  
Mechanical damage to grain during handling in commercial facilities  
Cleaning and winnowing

GROBE, A.  
1977  
*Should grain for milling still be scoured?*  

The author discusses the degree of scouring necessary for grain decontamination and recommends removal of layers down to the seed coat. Of the different scourer types described, abrasive rotor scourers without beaters are recommended as reducing breakage.
Drying (crops other than rice)

BLATCHFORD, S. M. & HALL, D. W. 1963
Methods of drying groundnuts. I Natural methods (Literature survey)  
*Trop. Sci.* 5, 6–33.

Summary of natural methods used for curing and drying groundnuts, with indications of possible ways of preventing development during curing and drying of the toxin-producing mould *Aspergillus flavus-oryzae*.

BLATCHFORD, S. M. & HALL, D. W. 1963
Methods of drying groundnuts. II Artificial methods (Literature survey)  

The authors survey available information on artificial drying of groundnuts, with the recommendation that curing prior to drying should take place on the plant in windrows, followed by threshing, rather than leaving the crop on the haulms. Driers used in the USA, Australia, Israel, Nigeria and Tanzania are described, batch driers being of particular importance.

BROOKER, D. B., ARKENA, F. B. & HALL, C. W. 1974
Drying cereal grains  
Westport, Conn., USA: AVI Publishing Co. Inc.

The chapter on grain losses covers losses in the field, in harvesting, in shelling, in drying, in handling and in storage.

BROWN, R. B., FULFORD, G. N., DAYNARD, T. B., MEIERING, A. G. & OTTEN, L. 1979
Effect of drying method on grain corn quality  
*Cereal Chem.* 56 (6), 529–532.

High-temperature batch drying, dryeration and low-temperature in-bin drying were tested using five corn hybrids, to determine effect on test weight, viability, stress cracking and steeping performance. It was concluded that the value of corn for wet milling might be underestimated if high viability is a major factor in quality estimation: that kernel stress cracking was much more severe in batch dried grain than with other drying methods; that dryeration improved quality (apart from viability) to some extent as compared with batch drying.

DEUBELIUS, I. 1978
Effect of drying under different conditions on the protein quality of corn (maize)  
*Getreide, Mehl und Brot* 32 (9), 233–236. (In German).
FAVIER, J. C.
1977
Nutritive value of two African staple foods: cassava and sorghum
Travaux and Documents de l'ORSTOM No. 67, 122 pp. (In French).

The effect of traditional processing methods (in Cameroon) on the chemical composition of cassava and sorghum are reported, as encountered in peeling, husking, soaking, sun drying, smoking and shade drying. Shade drying ensures better preservation of vitamins, etc. than other drying methods.

FOSTER, G. H.
1968
Grain damage from high-speed drying

FOSTER, G. H.
1975
Causes and cures of physical damage to corn

Corn kernel damage associated with harvesting, drying, and handling, and approaches to reducing physical damage are discussed. The need for practical methods of damage evaluation is stressed.

GUSTAFSSON, R. J., MOREY, R. V., CHRISTENSEN, C. M. & MERONUCK, R. A.
1978
Quality changes during high/low temperature drying

The effects on grain quality of combination high/low temperature drying were assessed in relation to conventional field scale high-temperature drying. The combination method significantly reduced susceptibility to mechanical damage where the final drying phase was high temperature to > 18% moisture.

HALL, C. W.
1956
Preventing crop losses by drying
Agric. Eng. 37, 414–415.

Heated-air and unheated-air crop drying methods are compared and evaluated with respect to benefits gained through prevention of crop losses.

JACKSON, C. R.
1967
Development of fungi in peanuts during artificial drying

McKENZIE, B. A., FOSTER, G. H., NOYES, R. T. & THOMPSON, R. A.
1967
Dryeration—better corn quality with high-speed drying
RHYNEHART, T.  
1960  
The control of insects infesting groundnuts after harvest in the Gambia.  
IV The practical application of control measures  

Where implemented, the recommendations made by Green (see A50) have been entirely successful, _C. gonagra_ infestation of trade nuts being markedly reduced and of seed nuts rapidly being controlled. Delay in shipment of decorticated nuts leads to serious infestation by _T. castaneum_, however.

ROJANASAROJ, C., WHITE, G. M., LOEWER, O. J. & ENGLI, D. B.  
1976  
Influence of heated-air drying on soybean impact damage  

Soybeans dried at four different temperatures were conditioned to 12% and 17% moisture and subjected to impact tests. Impact damage increased consistently with increases in drying-air temperature. Moisture content was also found to affect the amount of impact damage regardless of drying-air temperature or impact level.

SAUL, R. A. & STEELE, J. L.  
1968  
Relation of mechanical damage to drying and storage time  

SKOPEK, B. & KASTANKOVA, J.  
1977  
Effect of post-harvest treatment on the quality of wheat  
Mlynsko-Pekarensky Prumysl. 23 (8), 229–230. (In Czechoslovak).

Quality changes in wheat between harvesting and storage were investigated. Damage resulting from different driers is compared, and it is suggested that direct heat for drying wheat intended for human consumption be prohibited on the grounds that such grains contain carcinogens.

THOMSON, A. G.  
1954  
Grain drying in tropical countries  
World Crops 6 (4), 144–154.

Natural and artificial grain-drying methods are described. Drying methods as they affect other considerations of post-harvest treatment, such as transportation and fumigation are mentioned.

UNITED KINGDOM MINISTRY OF AGRICULTURE, FISHERIES AND FOOD  
1971  
Preservation of grain quality during drying and storage  
Short-term leaflet No. 24., 5 pp.
Development of both seed coat cracks and cleavage cracks in thin-layer heated-air drying of soybeans was found to be closely related to relative humidity (r.h.) of drying air and initial moisture content. In general, increases in the percentage of seed coat cracks did not approach zero until the r.h. of the drying air was 50% or higher. Little or no increase in cleavage cracks occurred in the beans when the r.h. of the drying air was above 19% for 15% initial moisture, 25% for 20% initial moisture and 35% for 24% initial moisture.

See also: B42
Drying (rice)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 1968
Pilot study of paddy losses in Thailand during harvesting, drying and threshing
FAO/IRC/AE/WP29.

HODGES, T. O. 1969
Rice drying technology and equipment which might be applicable to tropical developing countries

KOBAYASHI, H., MIWA, Y. & MATSUDA, R. 1976a
Studies on the strain and cracking of rice kernels during drying. I A method for calculating the cross-section area and the modulus of elasticity of brown rice by compression testing

1976b
Studies on the strain and cracking of rice kernels during cracking. II The drying strain of individual rice kernels

KUNZE, O. R. & HALL, C. W. 1965
Relative humidity changes that cause brown rice to crack
Samples of six varieties and two ages of brown rice were tested for response to r.h. changes at specified temperatures. Response varied with variety, age, test conditions, etc., and results are tabulated and discussed.
LORENZANA, J. J. 1980
Drying-air conditions, moisture content and tempering period as related to milling yield and quality of rice

Studies of drying-air conditions and milling potentials of IR-28 and IR-26 rice in 1979 showed: a) a significant increase in head rice recovery of IR-28 with ambient air (mean 31°C, 65% humidity) over heated air, b) intermittent but continuous drying (1 hour heated, 1 hour ambient) had no significant effect on milling potentials of both varieties as compared with heated air, c) the drying period was longer and the moisture-removal rate lower in continuous- and lower-air drying than in higher-temperature drying. Tempering and temporary storage experiments showed no effect on the milling potential of IR-36 paddy as compared to freshly harvested and dried (to 14% m.c.) paddy.

McNEAL, X. 1961
Effects of drying techniques and temperature on head rice yields

OKANO, H., HIRASAWA, N., SHIMADA, H., AITANI, T. & SAKAMOTO, J. 1975
Effect of harvesting dates and drying methods on quality of rice grains and sensory quality of cooked rice

SORENSON, O. 1970
A review of rice drying and storage problems in Ecuador

SRINIVAS, T., BHASHYAM, M., MAHADEVAPPA, M. & DESIKACHAR, H. S. R. 1977
Varietal differences in crack formation due to weathering and wetting stresses in rice

Twenty rice varieties were screened for susceptibility to crack formation when subjected to natural weathering in the field and also wetting and drying stress in the laboratory. Results for the varieties are given and a close correlation was observed between percentage sun-cracked grains and percentage breakage during milling.

Factors affecting crack formation in rice varieties during wetting and field stresses
Indian J. Agric. Sci. 48 (7), 424–432.

Susceptibility to crack formation in four varieties of rice was found to increase with increase in temperature of soak water, a decrease in initial moisture content of paddy, with sun drying and with dew wetting (sun and dew having a synergistic adverse effect on milling quality). Crack susceptibility was in increasing order for paddy, brown rice and milled rice. Critical moisture content at or below which cracking occurred varied between 14.2% and 18.3%.
The author discusses the treatment of paddy with salt to reduce moisture content and associated losses between harvesting and marketing.
Parboiling

BALDZHIJEV, D., NIKOLOV, N., KRSTEVA, A. & DASKALOVA, Z. 1976
Effect of various kinds of fissure (micro and macro) on rice yield and the cracking process during hydrothermal processing
Commercial hulling and polishing of four varieties of rice caused destruction of 10–20% of micro-fissured grains and 45–57% of macro-fissured grains. The influence of steaming was studied. Yield was increased by 3.7–7.5%; incidence of macro fissures was reduced by 5–12%.

BHATTACHARYA, K. R. & INDUDHARASWAMY, Y. M. 1967
Conditions of drying parboiled paddy for optimum milling quality
Cereal Chem. 44, 592–600.
Parboiled paddy dried in the shade had excellent milling quality, but rapid drying with hot air (40°–80°C) or in the sun gave high breakage. The damage started as the moisture content reached 15% and increased sharply with further drying. Milling at different time intervals after drying demonstrated further that damage to the paddy occurred gradually only subsequent to its removal from the dryer. From this it was found that keeping the paddy hot after drying (conditioning) for about 2 h prevented the milling breakage. Drying in two stages with a tempering (2 h if hot, 8 h if at room temperature) just before attainment of the critical moisture content (at 15.5–16.5%) also preserved milling quality. Tempering at higher moisture contents was less beneficial, and multiple tempering gave no additional benefit. Drying in two passes with a tempering in the moisture range of 15–19%, followed by hot-conditioning after the final drying, was convenient in practice and satisfactory: a drying temperature up to 80°C could be used. After parboiled paddy was dried in this way, milling breakage did not exceed 1–2%.

BHATTACHARYA, K. R., ALI, S. Z. & INDUDHARASWAMY, Y. M. 1971
Commercial drying of parboiled paddy with LSU dryers
Batch drying of parboiled paddy using LSU and similar dryers cannot be completed in one operation as it leads to heavy milling breakage. Two stages are necessary, the first being performed at the highest possible air temperature and terminated at 16% m.c. The second stage should be performed at 70–75°C.
DOESTHALE, Y. G., DEVARA, S., SHANKAR RAO & BELAVADY, B. 1979
Effect of milling on mineral and trace element composition of raw and parboiled rice
Sixteen varieties of rice were investigated for content of ash, P, Mg, Ca, Fe, Zn, Mn, Cu, Mo and Cr in raw and parboiled samples before and after 5% and 10% milling. Percentage losses of the minerals and trace elements are recorded. Parboiling _per se_ had no effect on the composition of brown rice, but so altered the distribution of some nutrients in the grain that nutrient losses through milling were significantly lower (except for Zn, Mg and Cu) than was the case with raw rice.

The milling quality of paddy rice as influenced with parboiling
_Egyptian Food Sci._ **1** (2), 137–155.
Parboiling experiments with two rice varieties (short and long grain) involved soaking in distilled water (0–24 hours at 30°C or 0–6 hours at 40°C), followed by pressure steaming (0–1.5 kg/cm²) and finally drying at 30°C to 12–12.5% moisture. All milling properties were improved by the treatment, especially at higher steam pressures.

FEILLET, P. & ALARY, R. 1975
Parboiling of rice. Effects of processing conditions and varietal differences in the quality of the finished product
Eight rice varieties were studied for milling yield, yellowing, gelatinisation, cooking quality and canning quality. Variables included steeping for 15 or 30 minutes at 65°C or 75°C and 10, 20 or 30 minutes of steaming at 105°C, 112°C, or 120°C. Increased steaming time and temperature increased degree of gelatinisation and decreased milling yield and colour score. Steeping conditions had little effect. Steaming conditions also had an effect on the quality of cooked and canned rice. Varietal differences were apparent. Results are tabulated.

FELLERS, D. A. & DEISSINGER, A. E. 1978
Steam treatment of rice paddy as a means of reducing stickiness
_Cereal Foods World_ **23** (8), 488.
Paddy moisture (14–26%), steaming pressure (13–32 p.s.i.g.) and steeping time (0–14 minutes) were varied. Increased steam pressure and time and increased paddy moisture improved head yield but increased yellowness. Most rapid reduction in stickiness occurred at low paddy moisture and high steam pressure. Steamed samples milled at 10% moisture gave good head yield.

GUSEV, P. 1972
Hydrothermal processing of rice
An increase of up to 1.5% in yield and up to 3.5% reduction in broken grains were the result of steam treatment at higher pressures and for longer periods than those generally used in rice processing plants.
Alteration of the mineral composition of rice grain during parboiling
Head rice yield and content of ash and minerals in polished grain were increased by parboiling. Data are given relating the parboiling technique and degree of polishing to the content of P, K, Mg, Mn, Al, Si, Zn, Fe, Cu, Ni, Mo, Cd and Bi in the grain.

KIK, M. C. 1955
Influence of processing on nutritive value of milled rice
A comparative study was made of the nutritive value of treated and non-treated milled rice, with the albino rat used as the experimental animal. This study confirms the results of previous investigations that the treatment of milled rice, either by conversion or parboiling, causes marked increases in the concentration of thiamine, riboflavin, and nicotinic acid. Such methods of processing result in considerable increases in the concentration of biotin, folic acid (total and free), pyridoxine, choline, p-aminobenzoic acid, pantothenic acid (total and free), inositol, calcium, phosphorus, and iron (total and available). Treated milled rice has higher nutritive value than non-treated milled rice, under conditions of parboiling processes studied.

Effect of parboiling and mechanical drying on thiamine retention in rice
Experiments were conducted to determine the cause of reported losses of thiamine in mechanically-dried parboiled rice (Mazumder et al., 1960 see J11). Results indicated that the portion of thiamine in hulled rice 'lost' during parboiling and mechanical drying is actually retained in the bran and removed during the hulling process.

MOHITE, A. V. & SHINGTE, A. K. 1969
Effect of parboiling and chemical treatment on vitamin B, (thiamine) content of rice grains of high-yielding varieties of paddy
Poona Agric. Coll. Mag. 59 (1/2), 74–76.
There was only a little variation in the thiamine content of rice grains of high-yielding varieties of paddy (Taichung N–1 and I. R. 8) and local variety (Warangal–9). The thiamine content of rice grains of all the varieties was increased considerably by both parboiling and chemical treatment. Chemical treatment with urea seemed to be better than the Malekized process of parboiling in preserving thiamine in rice grains.

PRIESTLEY, R. J. 1976
Studies on parboiled rice. Part 1: Comparison of the characteristics of raw and parboiled rice
Changes induced in rice grains by parboiling include: less tendency to disintegrate on cooking, less solubilisation of the kernel on cooking and less leaching of solids into cooking water. This is due to the resistance of the starch in parboiled rice to swelling, etc. in hot water. From the results of X-ray diffraction spectra it was concluded that the behaviour of parboiled rice is influenced by the presence of an insoluble helical amylose complex and not, as is generally assumed, by retrogradation.
The effect of steaming on the solubilisation of starch in paddy was studied. Rate of gelatinisation and solubilisation of the starch were extremely dependent on steaming pressures. Solubilisation continued long after complete gelatinisation. Slight steaming markedly increased milling breakage, and yields were improved only after complete gelatinisation of the starch. Relative crystallinity of the dried product was significantly correlated with the extent of solubilisation.

Samples of parboiled rice, re-cooked in boiling water, showed reduction of solubility and cook-water loss according to the severity of the preceding steam treatment. Results showed a highly significant negative linear correlation \((r = 0.972)\) between apparent solubility and the relative amount of complexed amylose in the starch. (See Part 1). It is proposed that amylose was insolubilised by complexing with free fatty acids and the amylpectin by interaction with the complexed amylose.

Parboiled rice required greater abrasive force and/or longer period of milling than raw rice for milling to the same degree of polish on a laboratory McGill polisher. Breakage increased slowly during milling of both raw or parboiled rice up to 7.8 per cent polish; at higher percentages of polish, breakage increased rapidly. Breakage was lower in parboiled rice than in raw rice both during shelling and milling. The sticking of bran to rice while polishing parboiled rice is caused by the ‘oiliness’ of the surface; it can be overcome by using a moderate abrasive force and increasing the milling time. The use of a sieving-cum-brushing device helps in eliminating the bran. Bran from parboiled rice contains a certain proportion of large particles and this contributes to the clogging of sieves while polishing. Bran from parboiled rice can be removed with little loss of endosperm. Colour extraction studies using a red variety of rice showed that for equal weight of bran removed during polishing, a greater amount of surface bran can be removed from parboiled rice than from raw rice.

Parboiling reduced the solubility of starch in cooking water and increased the girth of cooked kernels of non-waxy varieties.

Summary of a seminar contribution, reporting on the nutritional value of over-milled and under-milled rice, and on studies to determine an optimal degree of polishing which would not deplete thiamine below a safe level and would not adversely affect mineral and nitrogen balances in human subjects.
RAMACHANDRA RAO, M. R., JAMES, W. H., NOVAK, A. F. & SHAMSUDIN, I. B. 
1972
Rice processing effects on milling yields, protein content and cooking qualities

Louisiana State University and Agricultural and Mechanical College,
Agricultural Experiment Station Bull. No. 663, 51 pp.

The effect of variations in parboiling conditions on eight selected qualities and characteristics of milled rice was studied under controlled laboratory conditions. Chapter headings are:
   Literature review
   Materials and methods
   Results and discussions
   Summary and conclusions

Treatment variables are four-fold as follows:
A Two replicate experiments
B Five group treatments involving untreated rice, rice soaked in hot water, and rice soaked in hot water and then steamed for 10 minutes at 100°C, 110°C and 120°C.
C Three levels of soaking temperature, 50°C, 60°C and 70°C
D Five soaking periods, 3, 6, 9, 12 and 15 hours

Qualities of product selected for study are:
   Total yield of milled rice
   Percentage of head rice in the milled product
   Colour of milled rice
   Water uptake ratio of milled rice
   Volume of cooked milled rice
   Residual solids in cooking water
   Protein content of brown rice
   Protein content of milled rice.

RAMALINGAM, M., ANDIAPPAN, A. N. & RAMANATHAN, A. R. 
1976
Studies on soaking and parboiling of paddy

The laboratory research results on parboiling of paddy through hot humid air soaking are presented. The sources of kernel loss in parboiling, selection of parameters, experimental apparatus and technique are discussed. The study indicates that parboiling might be improved by the new method.

RAMALINGAM, M., ANDIAPPAN, A. N. & RAMANATHAN, A. R.
Pilot plant studies on soaking and parboiling of paddy

A parboiling technique involving hot humid air soaking is described. Results of experiments with the technique are regarded as promising, as there is no leaching of solids, no discolouration, and soaking, steaming and drying can be carried out in the same tank, eliminating handling losses.

SHIVANNA, C. S. 
1972
Traditional and modern methods of parboiling and drying of paddy

Among the modern methods studied, brine steeping and pressure parboiling proved to involve lower costs than hot soaking and steaming.
SHIVANNA, C. S. 1974
Economics of pressure parboiling of paddy

At the modern Thiruvarur rice mill, pressure parboiling of paddy is 50% less expensive than hot soaking and steaming and produces a higher head rice yield with higher fat content.

SUBRAHMANYAN, V. & DAKSHINAMURTHY, A. 1977
Nutrient losses during parboiling

Parboiling studies showed that prolonged soaking increased loss of protein and soluble carbohydrate. Soaking for 8 hours followed by 1–2 hours boiling is sufficient to achieve optimum parboiling effect with minimal loss in nutritive quality.

VITTI, P., LEITAO, R. de F. & DIZZINATTO, A. 1975
Parboiling of rice varieties
Coletanea do Inst. de Tecnol. de Aliment. 6 (1), 103–119.

Eleven varieties of rice were parboiled for 150 minutes at 65°C in 0.12% NaHSO₃. Most varieties suffered reduction in pH and reflectance but showed an increase in thiamine content (> 100% in some cases) and enhanced milling yields.

See also: A43:94
K31:35
R62:67
Hulling and polishing (rice)

ALMEDA, J. P. & CADDARAO, R. A. 1976
Milling costs of palay and recovery rates of rice mills, 1976
This study updates and supplements existing data on the cost of milling palay and the average recovery rate of rice for kiskisan, cono small and cono large mills (head rice figures 55.37% and 62.12% respectively).

ANON 1976
A report on rice milling recovery

BARBER, S., & BARBER, C. B. de 1977
An approach to the objective measurement of the degree of milling of rice
The proportion of kernel surface covered by bran, defined as CBB (Coloured Bran Balance) was adopted as a criterion for evaluating the degree of rice milling. Bran and kernel areas of magnified images of rice kernels are measured by planimetry directly or after staining. CBB values range from 100 for brown rice to 0 for completely milled rice. Commercial samples of well-milled rice had CBB values around 5.

BRECKENRIDGE, C. 1976
Report on the effect of processing conditions on milling and grain quality of parboiled rice

CHIRKOVA, L., KENDYSH, T., KOLOMIETS, M. & KISLYAK, A. 1979
Reduction of broken rice yield by improved hulling
Mukomolno-elevatornaya i Kombikormovaya Prom.-st No. 3, 41.
(In Russian)
Huller design, optimal roll speed and operational patterns are discussed relative to the success of a method to reduce broken grain to a minimum while obtaining maximum reduction of high-ash bran.
CIUSA, W. & SANTOPRETE, G. 1978
Improvement of rice milling processes from a marketing and economic-nutritional point of view.
Il Riso 27 (1), 63–71. (In Italian).

The results of milling experiments to determine composition and cooking quality of rice grains at five stages of milling are shown in graphs and tables, and indicate that the refining process could best be halted at the semi-polished stage.

CRAUFORD, R. Q. 1961
Breakage of rice during milling

Early harvesting reduces the proportion of cracked grains. Raw milling of paddy should be performed at 10–11% moisture content. Parboiled paddy should either receive slow artificial drying or, if sun-dried, be milled at 14% moisture.

DOESTHALE, Y. G., DEVARA, S., RAO, S. & BHAVANI, B. 1979
Effect of milling on mineral and trace element composition of raw and parboiled rice

Effect of milling on the mineral and trace element composition of raw and parboiled grain samples of 16 varieties of rice was investigated. Mean values are tabulated for nutrient content of brown rice and nutrient losses after 5% and 10% milling. Parboiling appeared to alter the distribution of some nutrients in the grain with result that milling losses for these nutrients were significantly lower in parboiled than in raw rice.

ERIYATNO 1979
System modeling on rice milling technology in Indonesia

The first of three computer models simulating rice milling operations in Indonesia was designed to estimate losses in rice mills. Losses averaged 4.8% in rough rice production. Mechanisation of milling would reduce losses and increase milling yield.

GARIBOLDI, F. M. 1972
Milling problems

HOGAN, J. T. & DEOBALD, H. J. 1961
Note on a method of determining the degree of milling of whole milled rice
Cereal Chem. 38, 291–293.

A method is described whereby milling degree is determined by bran-oil extraction in a petroleum solvent.
HOGAN, J. T. & DEOBALD, H. J. 1965
A review: measurement of the degree of milling of rice
Rice J. 68 (10), 10–13.

Chemical, bran oil extraction and photometric methods for determining milling degree are described.

KENNEDY, B. M., SCHELSTRAETE, M. & ROSARIO, A. R. del 1974
Chemical, physical and nutritional properties of high-protein flours and residual kernel from the over-milling of uncoated milled rice. I Milling procedure and protein, fat, ash, amyllose and starch content
Cereal Chem. 51 (4), 435–448.

Twelve lots of commercially milled rice of different varieties and treatment were abraded in a rice polishing machine. Three passes gave an average yield per pass of 2% 40-mesh flour and 87% residual kernel. First pass flours contained twice as much protein as the original rice, about two-thirds as much amyllose and total starch, 8 times as much ash and 17 times as much ether-extractable fat. Except for amyllose and starch, concentrations of these components decreased with each successive pass. Residual kernels contained as much amyllose as the original rice, slightly more starch and less of the other constituents. Variations due to variety and processing are discussed.

KENNEDY, B. M. & SCHELSTRAETE, M. 1974
Chemical, physical and nutritional properties of high-protein flours and residual kernel from the over-milling of uncoated milled rice. II Amino acid composition and biological evaluation of the protein
Cereal Chem. 51 (4), 448–457.

The amino acid composition of the protein in 60 samples from the overmilling of 12 different lots of uncoated milled rice was similar. Varietal differences were apparent. Relatively little difference was found in the amino acid composition or in the protein efficiency ratios of the various samples from a given lot of rice. Results show that the flours contain more protein and had an amino acid balance equal to that of the original rice.

KENNEDY, B. M. & SCHELSTRAETE, M. 1975
Chemical, physical and nutritional properties of high-protein flours and residual kernel from the over-milling of uncoated milled rice. III Iron, calcium, magnesium, phosphorus, sodium, potassium and phytic acid
Cereal Chem. 52 (2), 173–182.

Six lots of uncoated, commercially milled rice were abraded in a rice polishing machine to determine the percentage of constituents removed by successive passes. Rice flour amounting to about 6% of the original kernel contained nearly all the phytic acid, 73% of the Fe, 50% of the Mg, 38% each of ash and P, 25% each of Ca and K and 8% of the Na.
KENNEDY, B. M., SCHELSTRAETE, M. & TAMAI, K. 1975
Chemical, physical and nutritional properties of high-protein flours and residual kernel from the over-milling of uncoated milled rice. IV Thiamine, riboflavin, niacin and pyridoxine.
*Cereal Chem.* **52** (2), 182–188.
Percentage vitamin contents of rice flours obtained by one pass of abrasive milling were greater than those of the original kernel; \( \times 5 \) for riboflavin, \( \times 8 \) for thiamine and pyridoxine and \( \times 14 \) for niacin. Milled fractions from the periphery amounting to 6–7% of the total kernel contained 25–50% of the vitamins present in the whole endosperm. Tables compare the results with those obtained for two samples of parboiled rice.

KIK, M. C. & LANDRINGHAM, F. B. van 1943
Thiamine in products of commercial rice milling
The authors report a loss of 80% thiamine in commercially milled rice. Thiamine contents for various rice varieties are quoted, together with thiamine contents for whole rice, under-milled rice, milled rice, screenings, hulls, rice polish, bran, etc.

KIK, M. C. 1951
Determining the degree of milling by photo-electric means
*Rice J.* **54** (12), 18–22.

KOGA, Y. 1976
Topics relating to the post-harvesting stage of rice—is small rice mill wasteful?

LATIF SHARIAR, M. 1980
Food losses during rice husking
Agricultural Development Agencies in Bangladesh (ADAB) Newsletter, November.

LE VAN CHOANG, AUERMAN, L. & GINZBURG, M. 1979
Use of Hagberg-Perten instrument for determining degree of rice polishing
The Hagberg-Perten instrument can be used to develop an optimum procedure for rice grit hulling, reducing kernel losses and increasing the yield of grits. The procedure is described.

MANALABE, R. E., PADUA, D. B. de & LOZADA, E. P. 1978
Milling parameters for maximum milling yield and quality of milled rice
Quantity and quality of brown rice recovered from single pass hulling systems was studied. Results showed that in general, milling systems using rubber-roll hullers produced better rice recovery and quality than stone-disc huller systems. Multi-pass whitening for both systems improved the milling result.
MILLER, B. S., LEE, M. S., POMERANZ, Y. & ROUSSER, R. 1979
A rapid objective method to measure the degree of milling of rice
Cereal Chem. 56 (3), 172–180.
The method involves solvent extraction (5 minutes) of milled rice and measurement of the electrical conductivity of the extract. Subjective and objective methods were highly correlated. The test is sensitive to the percentage of broken kernels in the sample.

PADUA, D. B. de 1976
Comparative performance test of rice mills using rubber-roll and stone disc hullers

POMERANZ, Y., STERMER, R. A. & DIKEMAN, E. 1975
NMR-oil content as an index of degree of rice milling
Cereal Chem. 52, 849–853.
Oil in 26 brown rices and 173 milled sub-samples was determined by nuclear magnetic resonance. Consistent varietal differences were found in each group. Weight loss during milling was significantly correlated with oil content of the milled samples at the 1% level.

REGINATTO, M. P. V. 1976
Relation between humidity and milling yield in lowland rice

RUITEN, H. van 1976
The prevention of losses in rice mills

Effect of polishing time on head rice yield
Oryza 17 (3), 235–237.
Tests were conducted on ten varieties of Indian rice to determine the head rice yield for various shapes of grain after various polishing times. Head rice yield decreased linearly in most cases as polishing time increased up to 150 seconds, after which a sharp fall occurred in all cases except two (at 120 seconds). Short grain types gave higher head rice recovery than long slender grain, indicating that the geometry of the grain influences recovery, confirming earlier work by Govindaswamy and Ghosh (1968) and Govindaswamy (1973).

SHAMS-UD-DIN, M. & BHATTACHARYA, K. R. 1978
On the meaning of the degree of milling of rice
Brown rice was milled to different degrees with four laboratory mills—two metal roller mills, one emery roller mill and one emery cone mill. It was observed that the emery mills had to remove a greater weight of kernel (as bran) to yield a milled rice of given pigment or fat. Hence the conventional uses of weight loss as an index of quality is inadequate.
STERMER, R. A.  
1968  
An instrument for objective measurement of degree of milling and colour of milled rice  
Cereal Chem. 45, 358.

The author describes an instrument intended for rice quality control and inspection or grading. Three important quality factors of milled rice are measured: degree of parboiling, colour (both by light reflectance) and degree of milling (by light transmittance) in the same instrument.

UMALI, D. L., SILVERIO, M. C. & SANTOS, I. S.  
1956  
A preliminary study of some factors affecting the milling recovery of rice in the Philippines  

The best milling recovery of sun-dried Milfor 6 was obtained at 10% moisture content. Oven-drying at 50°C was found very satisfactory especially when the rice was milled at 8.5–9.0% moisture content. The milled rice dried at 50°C included more head rice than that dried at 80°C. Rough rice dried at 70°C showed some milling breakage after sudden exposure to humidity. No advantage was noted when grain dried at 50°C down to 8.5% was re-moistened to 12.3%.

VASAN, B. S., VENKATESAN, V., KOUSALYA, K., GANESAN, G. & SUBRAHMANYAN, V.  
1979  
Separation, processing and utilization of rice germ  

In the Kyowa modern rice mill the germ recovery is only 41% of the total germ content. The Paddy Processing Research Centre in Tiruvarur (India) has designed a de-germer in which 90% de-germing is possible with raw rice. 25% of the germ is viable and capable of germination.

VASAN, B. S.  
1980  
Effect of germination on loss of dry matter and processing of paddy  
Oryza 17 (3), 231–234.

Loss of dry matter and reduction of out-turn in germinating paddy was investigated. Soaked and drained paddy was incubated at 90% humidity and 30°C for up to three days. Samples were milled raw or parboiled and milled, also cooked for estimation of cooking time and gruel loss. Lots containing high percentages of germinated paddy (92%) showed corresponding increases in dry matter loss in both raw and parboiled samples. Yield of brown rice also decreased with increasing percentage of germinated grain; in parboiled samples, yield was further decreased owing to leaching of the exposed kernel in the soaking phase. Gruel loss on cooking was higher for raw germinated paddy than for parboiled samples. Oil content was not reduced by germination but the f.f.a. content was higher in the oil from germinated paddy.

WATSON, C. A., DIKEMAN, E. & STERMER, R. A.  
1975  
A note on surface lipid content and scanning electron microscopy of milled rice as related to degree of milling  
Cereal Chem. 52, 742–747.

Rice kernels were examined by SEM and relations to the visual degree of milling and surface contents of lipid, ash and protein were studied.
YAMASHITA, R.
1975
Report on drying, storing and milling in the Philippines


The author reports on an investigation into post-harvest rice processing in the Philippines with a view to loss reduction. Problems of rice drying and storage are dealt with in so far as they relate to polishing losses, which constitute the main theme of the investigation. There are pages of tables and figures.

YANG, Y. H.
1975
Loss of food quality of grains during storage and milling


See also: A30:43:94
B53:54
J20:23–27:35:37:38
R21
Hulling and de-branning (other crops)

NARAYANA RAO, M., SUR, G., SWAMINATHAN, M. & SUBRAHMANYAN, V.
1958
Effect of milling on the nutritive value of jowar (Sorghum vulgare) Food Sci. 7, 154–255.

The reputed indigestibility of unpolished sorghum may be due to the presence of pentosans and fibre. Experiments to establish the digestibility and nutritive value of polished as compared to unpolished jowar showed that larger amounts of nitrogen and phosphorus were retained by rats on a diet of the unpolished grain, whereas the calcium balance was maintained.
Grinding (milling)

ALMEDA, J. P. & CADDARAO, R. A. 1976
Costs in milling corn and recovery rates
A survey of corn processing costs and milling recovery rates was undertaken to supplement existing information on milling efficiency.

BARTLOVA, D. 1971
Loss of important nutrients during grain processing and possibilities for their restitution, III
Milling technology and nutritional value were studied in rye, and the addition of minerals and vitamins was investigated.

CARR, W. R. 1961
Observations on the nutritive value of traditionally ground cereals in Southern Rhodesia
Extraction rates for traditional grinding methods (described) in Southern Rhodesia were 55% for maize, 66% for sorghum and 75–80% for millet. Proximate analyses are given for meal and grain. Losses of 90% thiamine and riboflavin are reported for maize meal, smaller losses for sorghum and bulrush millet, negligible losses for finger millet.

Grain processing
A section of Chapter 5 is devoted to comparisons between traditional (household) and mechanical methods of sorghum and millet milling and further comparisons between the various types of mill in relation to milling efficiency and nutritional factors.
Research in milling seeks to cut food crop wastage

IDRC News/Nouvelles No. 32/74.

Report on seven research projects into more efficient milling of grains and legumes with a view to reducing post-harvest crop wastage in a number of countries.

Maiduguri Mill Project: grain milling and utilization in West Africa

IDRC–TS2, 16 pp.
Available from IDRC, Box 8500, Ottawa, Canada, K1G 3H9.

A joint Nigerian-Canadian project to reduce post-harvest grain losses is reported.

Milling losses of food grains. I Studies on losses of red gram (C. cajan) during milling


Concerned mainly with losses due to pests in India, the article also contains some comments on milling methods and possible reduction of losses in processing.

Milling losses of food grains. II Studies on losses of peas during milling


Studies on losses in the milling process of peas (Pisum sativum) and due to pests in mill premises are reported. Losses at each stage of milling are indicated with the aid of a flow diagram. Bird and rat populations and losses due to these and other pests are reported.

Reducing microbial populations in dry milled corn products


Microbial populations of dry-milled corn fractions can be reduced by treatment a) before milling, b) after de-germination before further milling and c) after separation. Heat treatment, when combined with efficient grain cleaning, washing and good milling techniques would seem to be the most practical method of reducing microbial populations, with least disruption of procedures at stage c). Treatment with propylene oxide is more effective than heat treatment in the reduction of thermophiles.

See also: R20
Wheat milling

CREWE, G. A. 1977
Problems in flour mills and some answers
Milling Feed and Fert. 160 (10), 26–29.
Possible sites of infestation in flour mills are described and the possible insects, birds and vermin contributing to losses by contamination are listed. Problems with finished flour, offal and warehouse storage are included, and various methods are described whereby mills and transport machinery can be rendered and maintained infestation-free.

FANE, A. G. & FELL, C. J. D. 1977
Recovery of soluble protein from wheat starch factory effluents
Soluble protein and residual starch can be recovered from the effluent resulting from wheat starch manufacture. Ultra-filtration and spray-drying yields a gluten substitute suitable for baked goods or animal feeding. A pilot-scale investigation at an Australian wheat starch factory is reported and discussed.

FARHATULLAH & BHATTI, M. B. 1975
Effect of milling and baking on the retention of thiamine and riboflavin in some new wheat varieties of Pakistan
The retention of thiamine and riboflavin in nan and flat bread baked from atta milled from five varieties of wheat is shown in tabulated form.

HAWELLEK, K. H. 1978
Bran duster and impact grinder in the milling diagram
Getreide, Mehl und Brot 32 (1), 4–8. (In German)
The effect of rotational speed of the bran duster on screenings output and particle size is illustrated. Impact and roller milling are discussed. A higher ash content was obtained with an impact mill.

HENRY SIMON LTD 1977
High-extraction flour milling techniques
Cleaning, tempering and milling techniques used to produce 85% extraction flour are described. Milling at lower moisture content can increase extraction rate by 1.5% and raise the vitamin B content of the flour without too great a deleterious effect on colour.
JEFFERS, H. C. & RUBENTHALER, G. L. 1977
Effect of roll temperature on flour yield with the Brabender quadramat experimental mills
Cereal Chem. 54 (5), 1018–1025.
Flour yield was found to be lower for samples milled late in the day. Temperature of the rolls and mill housing was found to be the influencing factor, flour yield falling as the temperature increased due to friction and use of the mill. Over a range of 24°C temperature increase, flour yields fell by 4–6%. Roll gaps widened with increasing temperature due to differences in expansion of materials in the roll housings. The variation in yield was corrected by installation of thermostatically controlled heaters.

NEMENUSHCHII, A., MAKSIMCHUK, B., ILIN, A. & LOMAKA, A. 1979
Use of impact-friction mills in high grinding of wheat
Mukomolno-elevatornaya i Kombibormovaya Prom.st-. (1), 29–30. (In Russian)
Flour yield was shown to increase by 18–29%, with no reduction in baking quality and other properties, when impact-friction mills replaced roller mills (fluted).

Protein content of successive peripheral layers milled from wheat, barley, grain sorghum and glutinous rice by tangential abrasion
The protein content of successive peripheral layers of grain was found to differ according to depth of milling. The experimental data suggest that the milling technique may be adaptable to production of high-protein-content cereal flours.

SHASHKINA, Z. N. & ZAITSEV, V. N. 1973
Thiamine losses during wheat flour processing and storage
The thiamine content of vitamin-enriched and unenriched wheat flour was determined during processing and during a two-month storage period. Loss of thiamine depended on flour quality, minimum loss occurring in second quality flour and maximum loss in high quality flour. (36% and 57% respectively). Thiamine loss was 27% during the first month of storage, decreasing over the second month.

SHUEY, W. C., SIBBITT, L. D. & D'APPOLONIA, B. L. 1975
Influence of ergot on spring wheat milling and baking quality
Ergot sclerotia (0.3%, 1.5% and 3.0%) was added to a spring wheat mix followed by milling and baking. The percentage flour extraction decreased in proportion to the amount of ergot added. Baking properties remained largely unaffected.

Physical dough, baking and nutritional qualities of straight-grade and extended extraction flours


Mixograms and baking qualities were similar for straight-grade and extended extraction (80%) flours from six HRS wheat samples. Nutritional value of the 80% extraction flours was generally superior to straight-grade flours in minerals, thiamine and lysine.


Improvement in wheat flour quality as a result of reduction on roughened rolls


A comparison is made between flours produced by fluted rolls and those by smooth rolls roughened by electro-erosion. Breadmaking and other characteristics of the roughened roll flour were found to be superior, and the reasons for this are discussed.
Separation

HALIM, A.
1980
Loss reduction by introducing locally-made paddy separators

The usefulness of paddy separators is well recognised in large rice mills. Small rice milling units would benefit from low-cost paddy separators. The use of a locally-made paddy separator increased milling yield by 2.33% in performance tests in Bali.

See also: K59
Secondary processes (cooking, baking, fermenting, etc.)

ADRIAN, J. 1972
Nutritional aspects of the Maillard reaction. II Behaviour of individual foods

Inds. Aliment. et Agric. 89 (12), 1713–1720. (In French)

Foods studied include fishmeal, milk powder, meat products and cereal products. Destruction of lysine occurs during industrial baking of cereal products.

The effect of the physico-chemical properties of infected wheat on the baking quality


Protein content and quality were lower in infected wheat flour than in normal flours, and were unsuitable for dough mixing. Addition of 2.5% NaCl, 0.007% KI0₃ and 2.5% ALS emulsion improved the baking quality of infected flours when mixed 1:1 with normal strong flour.

ALTSCHUL, A. M. 1965
The effect of heat on food proteins


Chapter 11, sub-headings as follows:

Chemical and physical changes
Destruction of toxic materials
Losses in cooking
Effect on proteins
Practical consequences of heating foods
The general problem of heat injury

ARIMOTO, K., MATSUMURO, H., HO, K., HAYASHI, R., TANAKA, K., YOKOI, M. & TSUDA, K. 1951/52
The loss of vitamin B₁ through washing and cooking of rice


Loss of vitamin B₁ in typical methods of home cooking and group cooking was estimated by the thiochrome method on 93% and 91% recovery milled rice. In view of heavy loss of the vitamin in washing, it is recommended that polished rice be provided suitable for boiling without washing.
BANERJEE, S.
1939
Losses of protein and minerals in cooked rice
   *Sci. & Culture* (Calcutta), 5, 262.

BARBER, S.
1978
Rice bran as a potential source of food
Rice bran is largely wasted as food. More information on the chemical and physical characteristics of bran is required for industrialisation as oil-extraction by-products, defibred bran, bran protein concentrates, etc.

BARBER, S., BARBER, C. B. de & MARTINEZ, J.
1978
Potential value of rice bran fractions as protein food ingredients.
By selective grinding and sieving in water followed by centrifuging and spray-drying, low-fibre and high-fibre fractions were obtained from full-fat rice bran, and corresponding fractions from defatted rice bran. These four fractions, together with raw full-fat bran and a protein concentrate obtained from it were investigated as to their potential as protein food ingredients.

1977
Effect of washing on the loss of nutrients in rice
50–90% polished rice of Japonica and Indica varieties gave mean losses on washing of 1–2% solids, 5–7% protein, 18–26% Ca, 19–47% Fe, 22–40% vitamin B1, 11–24% vitamin B2 and 36–45% niacin. Losses of solids, N-free extract and vitamins were lower in 70% than in 90% polished rice, and in the latter, lysine loss (over 6%) was greater than that of other amino acids.

CHUNG, S. L. & MEYERS, S. P.
1979
Bioprotein from banana wastes
Studies of *Pichia spartinae* yeast in batch culture included analyses of growth and carbohydrate utilization on banana solubles from waste skin and pulp. *P. spartinae* develops readily at pH 3.0, permitting low technology production techniques. Yeast conversion increased crude protein levels of waste whole bananas from 9% to 27% DM.

DANIELS, R.
Reduction of solids losses
Hydration, cooking and drying methods are described. Minimum soaking is recommended, as is successive spraying. The degree of milling causes variability and longer soaking time is necessary for parboiled milled rice.
DASSENKO, S. & FRYER, B.
1979
Effect of milling, fermentation and cooking on nutritional value of pearl millet (Pennisetum americanum (L.) Leeke)
Pearl millet meal and a 67% extraction flour were evaluated for nutritional value and digestibility. Effect of fermentation and cooking was also studied. Amino acid content remained stable during milling, fermentation and cooking. Fermentation increased vitamin B content.

DAWLATANA, M.
1980
Effects of milling and percent brokens on cooking loss of rice in Bangladesh

DOWNS, D. E. & MECKEL, R. B.
1943
Destructive effect of toasting upon thiamine in bread
Cereal Chem. 20, 352.
Thiamine losses in samples of standard white, enriched white and wholewheat bread increased with longer periods of toasting, and after 70 seconds were found to be 31, 17, and 21% respectively.

EDIJALA, J. K.
1980
Effects of processing on the thiamine, riboflavin and protein contents of cowpeas (Vigna unguiculata (L.) Walp.)
I. Soaking, cooking and wet milling processes
J. Food Technol. 15, 435–443.
II. Alkali ('potash') treatment
J. Food Technol. 15, 445–453.
The effect of soaking was not significant, but cooking resulted in considerable losses of the two B-vitamins. Decortication resulted in high losses of the vitamins for the brown varieties of cowpea. Conversion to a paste product (moin-moin) retained the vitamins well. Protein content was largely unaffected by processing.

Alkali treatment with sesquicarbonate and bicarbonate of soda had little effect on the total N. Vitamin losses were high even with low alkali concentrations. Therefore the traditional Nigerian use of 'potash' in treatment of cowpeas is not to be recommended, especially as there is also a latent danger to health in the possible formation of lysinoalanine.

EGGUM, B. O. & DUGGAL, S. K.
1977
The protein quality of some Indian dishes prepared from wheat
Protein quality of cooked Indian foods (chapati, puri, bread, etc.) prepared from whole and refined wheat flour was measured in N-balance experiments in rats. Amino acid levels were slightly reduced by cooking. NPU of the cooked products was therefore approximately 5% lower in cooked than in uncooked samples, but true digestibility was in general only slightly influenced by processing.
EGGUM, B. O., RESURRECCIÓN, A. P. & JULIANO, B. O. 1977
Effect of cooking on nutritional value of milled rice in rats. Digestibility of protein
Cooking reduced mean true digestibility (TD) by growing rats of protein of three varieties of rice, with a corresponding increase in biological value (BV), giving a slightly higher net protein utilization (NPU) for two of the three varieties as cooked rice. In one variety, parboiling had less effect than cooking on TD and BV. In two samples, the decrease in amino acid digestibility on cooking was lowest for lysine. Starch was completely digestible in raw and cooked rice of two varieties but digestible energy decreased slightly on cooking.

ERIKSSON, C. 1978
Food from waste
Techniques, projected yields and nutritional values of edible protein recovered from waste products are reviewed. Waste products dealt with include whey, animal offal, potato protein and starch and gluten processing wastes.

FOX, B. A. & CAMERON, A. G. 1977
Food spoilage, preservation and hygiene

Thermal and 2450 MHz microwave energy effect on the destruction of thiamine
Food Technol. 22, 1266–1268.
Destruction of thiamine was studied using conventional thermal energy and microwave energy at 2450 MHz, at 102.8°C, 33°C and 0°C for 50, 30 and 45 minutes respectively. Destruction of thiamine at 102.8°C was due solely to the temperature. No destruction was observed at 0°C for 45 minutes or at 33°C for 30 minutes.

HANSEN, L. P., JOHNSTON, P. H. & FERREL, R. E. 1975
Heat-moisture effects on wheat flour. I. Physical-chemical changes of flour proteins resulting from thermal processing
Cereal Chem. 52 (4), 459–472.
Wheat flour was processed in a reversed-heat exchanger designed to control temperature, moisture and time. Among the effects on proteins noted were disappearance of albumins and globulins and destruction of lysine, arginine and cystine-cysteine. Temperature was the main parameter responsible for the occurrence of the changes.
HANSEN, L. P., JOHNSTON, P. H. & FERREL, R. E. 1975

The assessment of thermal processing in wheat flour proteins by physical, chemical and enzymatic methods


Results of temperature/moisture/time tests in a model system showed that high temperature caused loss of lysine, arginine and cystine and decreased the release of lysine and arginine by trypsin-carboxypeptidase B. High-temperature commercial products also showed a decrease in PER as compared with products subjected to lower temperatures.

HARRIS, R. S. & von LOESECKE, H. 1960

Nutritional evaluation of food processing

New York: John Wiley.

HEGAZI, S. M., FODA, M. S., SALEM, S. A. & ELDIN, S. M. B. 1973

Recovery and amino acid composition of protein precipitates isolated from rice starch processing liquors

Stärke 25 (3), 92–94.

Precipitates containing 30–47% protein were isolated from rice starch steep and sorter liquors by pH adjustment. Acid hydrolysates of both precipitates contained at least seventeen amino acids. The industrial application of this method of recovery of protein is discussed.

IENGAR, N. G. C., RAJENDRAN, G., YUSSUFF, K. M. & SUBRAHMANYAN, V. 1980

Application of pressure parboiling process for the production of bulgur wheat


Large-scale bulgurisation of wheat is claimed to be a simple and inexpensive method of processing wheat for feeding programmes in India. Heavily-spoiled wheat was found to be rendered free from mycotoxins by this process.

KENNEDY, B. M. & TSUJI, F. 1952

Thiamine retention in brown rice


The effect on thiamine retention of ‘dry’ cooking of rice was determined in view of losses reported due to conventional washing and cooking practices. Results indicated that toasting or frying before ‘baking’ (in minimum of water under cover) should not be recommended because of large loss of thiamine. Baking alone had a minor effect.

KENNEDY, M. B. & JOSELYN, M. A. 1966

Changes in iron, thiamine and riboflavin content of flour during dough formation and baking

Baker’s Dig. 40, 60, 64.
KHAN, A., KOLTE, A. U. & SHIRALKAR, N. D.  
1977  
Minimising during matter loss in malting of sorghum and maize  
Maize and sorghum seeds absorbed more moisture from 0.3% NH$_3$ solution than from water, minimising rootlet and acrospire formation and thus increasing malt yield. Steeping periods of 40 hours for maize and 16 hours for sorghum are recommended.

LEONG, P. C. & STRAHAN, J. H.  
1952  
Thiamine loss due to washing and cooking of enriched rice  
Loss of thiamine in washing of polished rice and due to heating in two methods of large-scale steam cooking is illustrated by tables. Washing was found to remove an average of 5±% (38–70%). Enriched rice (0.5% by weight 'Rochemix') steamed over a perforated tray lost 12% by heat and 10% in steaming water; enriched rice cooked over a non-perforated tray lost 5% due to heat destruction.

LIENER, I. E.  
1958  
Effect of heat on plant proteins  
Chapter 5 deals with the effect of heat on the proteins of cereals, legumes and oilseeds, headings as follows:  
1. Introduction  
2. Processes involving the application of heat  
3. Effect of heat on the nutritive value  
4. Chemical and physical changes induced by heat  
5. Importance of heat treatment in the industrial usage of vegetable proteins  
6. Conclusions

MAKINDE, M. A.  
1977  
The optimization of the protein nutritive value of ogi  
High losses of tryptophan were recorded after the first 24 hours of the 3–5 day steeping and fermentation of high-lysine Opaque-2 maize for the production of ogi. Post-processing supplementation with DL-tryptophan had no effect on protein nutritive value. The improvement effected by addition of three types of soya flour is described.

MALAKAR, M. C. & BANERJEE, S.  
1959  
Effect of cooking rice with different volumes of water on the loss of nutrients and on digestibility of rice in vitro  
*Food Res.* **24** (6), 751–756.  
Losses of nutrients (thiamine, riboflavin, niacin, Ca, P, Fe and N) in washing and cooking of five strains of rice were determined. Retention of nutrients in the cooked rice corresponded well with the loss of nutrients in cooking water (6 and 8 times rice volume). Loss of nutrients in rice cooked with just sufficient water was negligible but the product showed the least *in vitro* digestibility.
MALEKI, M. & DAGHIR, S.
1967
Effect of baking on retention of thiamine, riboflavin and niacin in Arabic bread
Cereal Chem. 44, 483–487.
Tests showed that destruction of thiamine was greater in brown than in white Arabic bread and was positively related to intensity of heating. The loss of riboflavin was uniform in brown and white bread. Loss of niacin was negligible in all samples and added niacin was retained completely.

MANSOUR TABEKHIA & SAFWAT MOHAMED
1971
Effect of processing and cooking operations on thiamine, riboflavin and nicotinic acid content of some Egyptian national foods. I. Wheat flour, bread and rice
Wheat flour, three main types of Egyptian bread and rice were studied to determine the effect of extraction rate of flour, the main stages of dough fermentation, baking and toasting of bread, and milling, parboiling, steeping and cooking of rice on the levels of thiamine, riboflavin and nicotinic acid.

MENDEN, E. & HORCHLER, V.
1978
Effect of crust formation in bread on the protein quality and utilization of calories
Getreide, Mehl und Brot 32 (7), 184–188. (In German).

MOTTRAM, R. F.
1979
Cooking, processing and storage of food in relation to nutritional value

MURATA, K., TAKARADA, S. & NOGAWA, M.
1979
Loss of supplemental lysine and threonine during the baking of bread
After baking for 43 minutes at 210°C, loaves containing added L-lysine (0.48%) and L-threonine (0.3%) were analysed colorimetrically and microbiologically. Baking losses for lysine and threonine were determined in crumb and crust; lysine loss was 14±8% and threonine loss 15±5% in the whole loaf. These losses could not be verified in rat feeding tests.

OGUNMODEDE, B. K.
1972
Losses of protein and B-vitamins in grains during traditional Nigerian processing
Content of crude and true proteins in cowpea, rice and maize is reduced during processing, though digestibility of crude protein is increased. In processing of cowpeas the addition of potash altered the pH, leading to a greater loss of thiamine and riboflavin while increasing crude protein digestibility. Losses of vitamins varied with processing method. The implications of these results are discussed.
ONO, F. & DAIMATSU, T. 1974
Effect of cooking on the sodium and potassium content in foods.
I. Changes in sodium and potassium content of rice caused by polishing and washing


Laboratory-milled rice (90% yield) contained 3.6 mg% Na and 112.8 mg% K as compared with average contents in raw rice of 6.6 and 258 mg%. Polished rice lost about 36% K when washed in water for 5 minutes.

PALAMIDES, N. & MARKAKIS, P. 1978
Effect of heat treatment on certain nutritional attributes of wheat flour products


Wheat flour and various bread samples were examined for effect of heat treatment by toasting and baking. PER and net protein ratio decreased with increasingly severe heat treatment.

PERERA, A. D., LEKLEM, J. E. & MILLER, L. T. 1979
Stability of vitamin B₈ during bread making and storage of bread and flour

_Cereal Chem._ 56 (6), 577–580.

Stability of vitamin B₈ was determined during dough fermentation and baking using three flours (whole-wheat, white and B₈ enriched white). Sponge dough and straight dough breads (under home conditions) and commercially baked breads were compared. Vitamin B₈ losses of 0–15% occurred during baking; losses of 10% occurred in bread stored at room temperature for 3 days.

REHANA, F., BASAPPA, S. C. & MURTHY, V. S. 1979
Destruction of aflatoxin in rice by different cooking methods

_J. Food Sci. Technol._ (India) 16 (3), 111–112.

Rice naturally and artificially infested with aflatoxin-producing moulds was subjected to normal cooking, cooking with excess water and pressure cooking. Results showed that pressure cooking seems to be effective in reducing aflatoxin content.

Available lysine losses during thermal processing of unconventional proteins with glucose


Prepared model systems consisting of glucose, cellulose and sufficient protein source to yield 15% protein were heated to 130°C for 2 minutes and analysed for loss of available lysine. Protein sources were cottonseed, yeast, soy, bacterial, algal, casein and purified bacterial protein.

ROY, J. K. 1953
Effect of cooking water on thiamin stability


The loss of thiamine added to samples of water from various sources as related to changes in pH resulting from boiling was investigated. Prolonged boiling increased pH and resulted in the destruction of about 90% of the added thiamine.
ROY, J. K.
1957
Further observations on cooking water and thiamin stability
Tests were conducted on the influence of pH of foodstuff and pH of cooking water on the retention of thiamine in rice and lentils. It was shown that the relation between amounts of cooking water and foodstuff, and the total alkalinity of the water and acidity of foodstuff are of great significance in controlling the pH and therefore in stabilising the thiamine.

RUTLEDGE, J. E., ISLAM, M. N. & JAMES, W. H.
1972
Improved canning stability of rice by chemical modification
Cereal Chem. 49 (4), 430-436.
The process developed involves intra- and intermolecular cross-linking of rice starch by epichlorhydrin. Reinforcing the bonds holding the granules together within the kernel results in marked changes in the swelling behaviour of the rice grain and its subsequent resistance to overcooking. The process would eliminate the need for parboiling rice for use in heat-processed formulations such as canned soups. Solids losses were 78% less than those obtained from commercial parboiled rice suitable for canning.

RUTLEDGE, J. E. & ISLAM, M. N.
1973
Canning and pH stability of epichlorhydrin-treated parboiled rice
Rice starch in the parboiled grain was etherified by epichlorhydrin in an alkaline environment. Samples were evaluated after canning and retorting for 60 min. at 240°F in semiliquid media. The treatment vastly improved the kernel stability for canning in excess water even under acidic conditions. Cross-linked samples showed approximately 68% less leaching at pH7 and about 82% less leaching at pH5 as compared with untreated samples.

RUTLEDGE, J. E., ISLAM, M. N. & JAMES, W. H.
1974
Improved canning stability of parboiled rice through cross-linking
Cereal Chem. 51, 46.
Hydroxyl groups of rice starch were randomly cross-linked by phosphorus oxychloride, epichlorhydrin and sodium trimetaphosphate in an alkaline medium. Marked changes were introduced in the swelling behaviour of the kernel and its resistance to overcooking during processing, with a highly significant reduction in solids loss and an improvement in other attributes over unmodified samples. Phosphorus oxychloride treatment was inferior to the other two treatments.

SANDERSON, J., WALL, J. S., DONALDSON, G. L. & CAVINS, J. F.
1978
Effect of alkaline processing of corn on its amino acids
Cereal Chem. 55 (2), 204-213.
Alkaline treatment of maize to prepare tortilla flour or hominy grits results in losses of the amino acids arginine and cystine.
SAUNDERS, R. M.  
1977  
Potential food-grade materials from rice bran  

Techniques for the preparation of food-grade materials from rice bran are reported. The nutritional quality of rice by-products and materials derived from them are tabulated.

SCHNEEWEISS, R.  
1975  
The diagnosis of quality damage in flours  
*Bäcker und Konditor* 23 (9), 262–265.

The author discusses sprouting of grain in relation to wheat flour quality and reports baking tests on flours affected by sprouting and other factors. Damaged flour required longer baking time and gave a lower dough yield than normal flour. Associated excessive enzyme activity can be counteracted by processing modifications.

SCHROEDER, H. A.  
1971  
Losses of vitamins and trace minerals resulting from processing and preservation of foods  

Vitamins and trace minerals in raw, frozen, processed, refined and canned foods were evaluated in the light of probable human requirement and recommended allowances. The results suggest that enrichment of refined flours, sugars and fats may be necessary if daily allowances of vitamins and trace elements are to be met.

1981  
Effect of washing/steeping on the acceptability of Karnal Bunt infected wheat for bread, cookie and chapatti making  
*J. Food Sci. Technol.* (India) 18 (1), 1–2.

Wheat infected to different degrees by Karnal Bunt (a disease caused by *Neovissia indica* (Mitra)) was improved for baking purposes by washing and steeping. Loaf volume and specific volume of bread were improved by the treatment, as were taste and flavour of bread, cookies and chapattis.

SWAMINATHAN, M.  
1942  
The effect of washing and cooking on the vitamin B₁ content of raw and parboiled milled rice  

Whereas raw milled rice loses about 60% of its vitamin B₁ during washing, parboiled milled rice loses much less (8%) and contains on average 4 times as much vitamin B₁ as washed raw rice. A further 25% of the vitamin in washed and parboiled rice is dissolved out into cooking water.
TAIRA, H., KOYANAGI, T., TAKANOHASHI, T. & OIKAWA, K. 1969
Studies on amino acid contents of processed soybean. XI Evaluation of nutritional losses of overheated defatted soybean flour
Agric. & Biolog. Chem. 33 (10), 1387–1398.
Loss of nutritive value due to overheating of defatted soybean flour was evaluated from animal experiments. Earlier workers had shown that mild heating of soybean was beneficial whereas overheating destroyed amino acids and reduced the biological value of the flour. The present experiments showed that the replacement of lost amino acids in overheated flour did not restore its nutritive value to that of properly heated flour when used in the diet of weanling rats.

TARA, K. & BAINS, G. S. 1971
Effect of cooking rice on the stability of lysine and threonine in a model system
Indian J. Nutr. Dietet. 8, 186.
The effect of cooking on the stability of lysine and threonine was studied in a model system containing 0.2 g lysine monohydrochloride and 0.1 g L-threonine per 100 g of rice compared with samples optimally cooked in plain water for 14 minutes (milled rice) and 28 minutes (parboiled rice). Losses of lysine and threonine were negligible under both sets of conditions. A slight loss of lysine in parboiled rice cooked in water could be attributed to the longer cooking time.

TOYOSHIMA, H. & SHIBATA, S. 1979
Improvement of boiled noodle making. IV Improved boiled noodle-making to decrease loss in boiling
Changes in processing techniques were found to halve the material loss in boiling of noodles. The adjustments to processing consisted of changing the protein content of the flour, the amount of added salt and water, the concentration of solids in the boiling water and the rolling process.

TSEN, C. C. & REDDY, P. R. K. 1977
Effect of toasting on the nutritive value of bread
J. Food Sci. 42 (5), 1370–1372.
The nutritive value of bread was significantly reduced by toasting, the reduction in PER being correlated with degree of browning.

WEBB, B. D. & ADAIR, C. R. 1970
Laboratory parboiling apparatus and methods of evaluating parboil-canning stability of rice
Cereal Chem. 47, 708–713.
Apparatus and methods used to evaluate the canning stability of new rice varieties and early-generation breeding material are described. Subjective evaluation was based on broth-clarity, kernel splitting and fraying of edges and ends. Objective evaluation was based on soluble and insoluble solids lost during canning of parboiled rice (variations 9–44% in present study).

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