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

Tropical Products Institute

G168

Grain processing losses bibliography Supplement 1 to G117

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

Ruth Kasasian

March 1983

Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU
Overseas Development Administration

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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Contents

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

Reviews and papers of general interest

ADAMS, J. M. **A27**
1977
A review of the literature concerning losses in stored cereals and pulses published since 1964
Trop. Sci. **19,** 1–27.

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. **A28**
1977
Post-harvest operations: need for avoiding wastes
Productivity **18** (2), 261–267.

ARAULLO, E. V., PADUA, D. B. de & GRAHAM, M. (Eds.) **A29**
1976
Rice post-harvest technology
Ottawa, Canada: International Development Research Centre.

ARKANSAS UNIVERSITY INSTITUTE OF SCIENCE AND TECHNOLOGY **A30**
1953
Pilot plant investigations of the effects of drying, storage and processing factors on the quality of rice: terminal report
Fayetteville, Arkansas: Arkansas Univ., Inst. Sci. & Technol., 55 pp.

ASIAN PRODUCTIVITY ORGANISATION **A31**
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. **A32**
1959
Relationships between values and types of damage in grain
Cereal Chem. **36,** 308–311.

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. **A33**
1970
Processing and storage damage to nutritional value of foods
In: *Proc. 3rd International Congress Food Science and Technology, pp. 189–191.* Chicago: Institute of Food Technologists, 591pp.

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

BIREWAR, B. R. **A34**
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. **A35**
1977
Wasted food in developing countries
New York's Food and Life Sci. Quarterly **11** (4), 8–9.

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

BULOG (NATIONAL LOGISTICS AGENCY, INDONESIA) **A36**
1971
Losses in rice marketing system (in Indonesia)
Jakarta, Indonesia: BULOG.

CASWELL, G. H. **A37**
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. **A38**
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. **A39**
1978
Significance of nutritional losses in the processing of grains
Paper presented at: XIth Food & Nutrition Congress, Rio de Janeiro.

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. **A40**
1975
Studies on the assessment of losses of wheat in Punjab
Bull. Grain Technol. **13** (3), 159–161.

ESMAY, M. L. **A41**
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. **A42**
1980
Rice in Bangladesh: an empirical analysis of farm-level food losses in five post-production operations
In: *Grain quality improvement,* pp.245–262. Proc. 3rd annual workshop on grains post-harvest technology, Kuala Lumpur, Malaysia, 430pp. Laguna, Philippines: SEARCA Cooperative post-harvest research and development programme.

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 **A43**
1948
Effect of processing and household preparation on nutritive value. Improvement in the nutritive value of rice as consumed
In: *Rice and rice diets, a nutritional survey,* pp.14–31. Washington: FAO Nutritional Studies (1), 72pp.

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 **A44**
1975
Reducing post-harvest food losses in developing countries
Rome: *FAO AGPP: MISC/21,* 15pp. + annexes.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS **A45**
1977
Analysis of an FAO survey of post-harvest crop losses in developing countries
Rome: *FAO AGPP: MISC/27.*

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS **A46**
& 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 **A47**
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 **A48**
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 **A49**
1980
Assessment and collection of data on post-harvest foodgrain losses
Rome: *FAO Economic and Social Development Paper* (13), 71pp.

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. **A50**
1968
Assessment of losses of paddy and rice during harvesting, drying, threshing, cleaning, storage and processing
FAO/IRC/AE/WP 13.

GREELEY, M. & RAHMAN, S. **A51**
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. **A52**
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. **A53**
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
Trop. Sci. 1959, **1**, 200.
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
Trop. Sci. 1960, **2**, 130.

GUPTA, C. P. **A54**
1975
Progress in technology to reduce losses in rice

In: *Post-harvest crop protection,* Proceedings of Planning Meeting, pp.42–48, East-West Food Inst., Honolulu, Hawaii.

HALL, D. W. & MCFARLANE, J. A. **A55**
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. **A56**
1978
Post-harvest grain loss assessment methods

St. Paul, Minnesota, USA: *Am. Assoc. Cereal Chem.,* 193pp.

1 Introduction
2 Terms of reference
3 Social and cultural guidelines
4 Representative sampling, interpretation of results, accuracy and reliability
5 Loss measurement techniques
6 Standard measurement techniques
7 Operations standardization and control
8 Application and interpretation of results
Appendices
Selected references
Index

HARRIS, K. L. **A57**
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. **A58**
1975
Research and development requirements on post-harvest systems (Commonwealth Ministerial Meeting on Food Production and Rural Development)

Ottawa: *Int. Dev. Res. Cent.,* 18pp.

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES-OAS **A59**
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 **A60**
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

Manila: *Int. Rice Res. Inst.,* 22pp.

JACKSON, C. R. **A61**
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

Athens, Georgia, USA: *Univ. Georgia Coll. of Agric. Exp. St. Res. Rep.* (11), 18pp.

KAMINSKI, T. L. **A62**
1968
Need for standards for evaluation of grain damage

In: *Proc. Symp. Grain Damage,* Iowa State Univ., pp.39–41. St. Joseph, Mich: Am. Soc. Agric. Eng.

KIK, M. C. **A63**
1945
Effect of milling, processing, washing, cooking and storage on thiamine, riboflavin and niacin in rice

Arkansas Agric. Exp. St. Bull. No. 458.

KRISHNAMURTHY, K. **A64**
1972
Postharvest problems of wheat

Bull. Grain Technol. **10** (4), 291–296.

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. **A65**
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

MAJUMDER, S. K. & PARPIA, H. A. B. **A66**
1966
Possible losses of food grains in India
Vijnan Karmee **18** (4).

MAJUMDER, S. K. **A67**
1970
Protecting food from deterioration during storage, handling and distribution in technologically less-developed countries of the world
In: *Proc. 3rd International Congress Food Science & Technology,* pp.518–531. Chicago: Institute of Food Technologists, 951pp.

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. **A68**
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. **A69**
1970
Development of a standard grain breakage test
US Dep. Agric. Mimeo. Rep. ARS 51–34 13pp.

MOELJARNO, D., KAMARUDDIN, A. & RIZAL, S. **A70**
1979
In-field post-production rice losses on farm in West Java
In: *Proc. of the workshop on grain post-harvest technology,* pp.93–107. Bangkok, Thailand.

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. **A71**
1978
Post-harvest food losses in developing countries: a bibliography
Washington, DC: National Academy of Sciences, 356pp.

MPHURU, A. N. **A72**
1976
Losses which occur during harvesting and storage of grains: a bibliography
Food & Feed Grain Inst., Kansas State Univ. Spec. Rep. (4), 73pp.

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 **A73**
1977
Rice post-harvest problems in South-east Asia
Paper presented at: Institute of Food Technology Annual Meeting, Philadelphia. Manila: Univ. of the Philippines, Dep. Agric. Eng.

PADUA, D. B. de **A74**
1978
Rice post-harvest requirements for tropical Asia
Int. Congr. Food Sci. Technol. Abstracts, p.16.

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. **A75**
1969
Foodgrain losses and the nutritional gap in developing countries
FAO/WHO/UNICEF Protein Advisory Group Meet., Geneva, 8–11 Sept. 1969.

PILLAIYAR, P. **A76**
1978
Assessment of cumulative quantitative losses of paddy
Thiruvarur, India: Paddy Process Research Centre.

PIMENTAL, D. (Ed.) **A77**
1978
World food, pest losses and the environment
Boulder, Colorado, USA: Worldview Press, 206pp. *(Selected Symposia No. 13, Ser. Am. Assoc. Adv. Sci.)*

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. **A78**
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. **A79**
1972
Soybean damage detection and evaluation for food use
Am. Soc. Agric. Eng. Pap. pp.72–380.

ROLSTON, W. D. **A80**
1974
Semi-annotated bibliography of research in post-harvest technology for cereal grains and grain legumes in African countries north of the equator
Ottawa: *IDRC-document*–064, 164pp.

SABRY, Z. I. **A81**
1968
The nutritional consequences of developments in food processing
Can. J. Public Health **59,** 471–474.

SATAKE, R. S. **A82**
1980
The reduction of losses through better processing

In: *Grain quality improvement.* Proc. 3rd annual workshop on grains post-harvest technology, Kuala Lumpur, Malaysia, pp.58–62. Laguna, Philippines: SEARCA Cooperative post-harvest research and development programme, 430pp.

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. **A83**
1980
Rice post-harvest losses in developing countries. Part 1. A 1978 survey of rice post-harvest losses during threshing, drying, parboiling, milling and the potential for reducing such losses in developing countries Part 2. (Mossman, A. P.) Selected bibliography of rice post-harvest publications.

USDA/ARM-W-12, 227pp. (Western Regional Research Center, USDA, 800 Buchanan St., Berkeley, CA 94710, USA).

STANLEY, A. **A84**
1979
Grain losses in Paraguay

In: *Anales del Tercer Seminario Avanzado de Tecnologia de Alimentos (Proc. Third Advanced Seminar on Food Technology)* Bogotá, Colombia, 475pp.

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. **A85**
1977
Effect of insect infestation on weight loss, hygienic condition, acceptability and nutritive value of food grains

Indian J. Nutr. Dietet. **14** (7), 205–216.

A review covering weight loss and nutrition loss in cereals and pulses due to insect infestation.

TINDALL, H. D. & PROCTOR, F. J. **A86**
1980
Loss prevention of horticultural crops in the tropics

Prog. Food Nutr. Sci. **4** (3/4), 25–39.

TOQUERO, Z., MARANA, C., EBRON, L. & DUFF, B. **A87**
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.

TOQUERO, Z., MARANA, C., EBRON, L. & DUFF, B. **A88**
1977
Assessing quantitative and qualitative losses in rice post-production systems

FAO Workshop on postharvest losses, Alor Setar, Malaysia, 1977. *Int. Rice Res. Inst. Agric. Eng. Dep. Paper 77–01. Agricultural Mechanization in Asia,* **8** (3), 31–40.

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 **A89**
1978
Introducing food loss assessment studies into loss reduction programmes

Trop. Stored Prods. Inf. (36), 72+vii pp.

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 **A90**
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**)

London: *Trop. Prod. Inst.,* 17pp.

UNITED KINGDOM COMMONWEALTH SECRETARIAT **A91**
1977
Report of the regional workshop on post-harvest losses, Accra, Ghana

London: Food Prod. & Rural Dev. Div., Commonwealth Secretariat, 111pp.

UNITED NATIONS PROTEIN ADVISORY GROUP **A92**
1975
Losses

UN/PAG Compendium Vol. B. New York: Worldmark Press Ltd.

UNITED STATES NATIONAL ACADEMY OF SCIENCES **A93**
1978
Post-harvest food losses in developing countries

Washington, DC: NAS, Library of Congress Catalog No. 78–70607, 206pp.

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. **A94**
1975
Ford Foundation Rice Research Institute: Post-production projects in India and Sri Lanka

Paper presented to: Planning post-harvest crop protection, East-West Food Institute, Honolulu, Hawaii. *Tropical Storage Abstracts* 1975 (5), 73.

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

BUCHELE, W. F. & JOHNSON, W. H. **B27**
1967
How to reduce soybean harvest losses
Iowa Certif. Seed News **21** (4), 5–7.

BURNETT, L. C. & BAKKE, A. I. **B28**
1930
The effect of delayed harvest upon yield of grain
Iowa Agric. Exp. Station Res. Bull. 130.

Soil, climate and variety were three factors affecting yield, and losses increased with delay

BYG, D. M. **B29**
1964
A method for determining machine harvesting efficiency and total crop yield
Columbus: Ohio State Univ., Agric. Eng. Dep. Extension Mim.

BYG, D. M. **B30**
1967
Where your harvest loss occurs—ways to prevent it
Soybean Dig. **27** (12), 67–70.

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. **B31**
1969
A guide for measuring soybean harvest losses
Columbus, Ohio: Ohio State Univ., Agric. Eng. Dep.

BYG, D. M. & JOHNSON, W. H. **B32**
1970
Reducing soybean harvest losses
Ohio Rep. on Res. and Dev. in Agric., Home Economics and Natural Resources **55** (1), 17–18.

Studies show that the average Ohio farmer could increase his harvested yield of soyabeans 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. **B33**
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. **B34**
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 **B35**
1973
Kernel damage in mechanical maize harvesting
Ann. Technol. Agric. **22** (3), 211–216. (In Spanish).

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. **B36**
1979
Grain sorghum harvesting loss study
Trans. Am. Soc. Agric. Eng. **22** (2), 246–250.

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. **B37**
1968
Bibliography on combines and grain harvesting
Am. Soc. Agric. Spec. Publ. SP-0274.

JOHNSON, I. M. **B38**
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. **B39**
1967
Reducing unnecessary harvesting losses
Soybean Farmer **4** (6).

JUDAH, O. M. **B40**
1970
Mechanical damage to navy beans during harvesting in Michigan
MS Technol. Rep., Michigan State Univ., East Lansing.

KANG, W. S., LEE, C. H., CHUNG, C. J. **B41**
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. **B42**
1973
Physical damage to corn (maize) during combine harvesting and heated-air drying
Ann. Technol. Agric. **22** (3), 217–221.

New harvest shelled corn samples (500 over 3 years in the US corn belt) were analysed for quality after being collected from combines and delivery vehicles. Moisture content, combine operation, corn variety, etc. were recorded on collection. A similar study was conducted with corn samples collected before and after heated-air drying.

KUNZE, O. R. & PRASAD, S. **B43**
1978
Grain fissuring potentials in harvesting and drying of rice
Trans. Am. Soc. Agric. Eng. **21** (2), 361–366.

A wide range of grain moisture contents usually occurs within a mass of harvested rice. Low-moisture rice fissures when subjected to high RH environments, e.g. in the field, in bins of freshly-harvested grain and in certain types of drying ahead of the drying front. Milled rice is more liable to such fissuring than brown rice, which is in turn more sensitive than rough rice.

MANGJU, D. **B44**
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. **B45**
1979
Belt conveyor system to reduce soybean harvester gathering losses
Trans. Am. Soc. Agric. Eng. **22** (2), 243–245.

A belt conveyor system designed and adapted to a commercially available soybean head or bean bucket was effective in reducing shatter and stalk losses.

NAVE, W. R. **B46**
1971
Reduction of losses and damage in soybean harvesting
USDA/AERA/ARS Ann. Rep. 308–077–C20.

McNEAL, X. **B47**
1950
Effect of combine adjustment on harvest losses of rice
Univ. Arkansas Agric. Exp. St. Bull. 500.

NYBORG, E. O., McCOLLY, H. F. & HINKLE, P. T. **B48**
1969
Grain combine loss characteristics
Trans. Am. Soc. Agric. Eng. **12** (6), 727–732.

PALANIAPPAN, S. P. & VIJAYAKUMAR, M. R. **B49**
1976
Note on the effect of time of harvest on the nutritional quality of grain in two sorghum cultivars
Indian J. Agric. Res. **10** (2), 136–138.

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. **B50**
1972
Reducing combine gathering losses in soybeans
Am. Soc. Agric. Eng. Pap. 72–625.

RUTHERFORD, I. **B51**
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. **B52**
1975
Grain harvesting losses in North Dakota
Farm Res. **32** (6), 20–21.

SEETANUN, W. **B53**
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 **B54**
1973
Grain yield, milling quality and seed viability of rice as influenced by time of nitrogen application and time of harvest
Agronomy J. **65** (3), 390–394.

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.

UNITED KINGDOM AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICES **B55**
1973
Combine grain losses: an illustrated guide to the determination of losses from combine harvesters
Pinner, UK: Mech. Dep., Agric. Dev. Advis. Serv., Min. of Agric., 11 pp.

WEBBER, C. R. & FEHR, W. R. **B56**
1966
Seed yield losses from lodging and combine harvesting in soybeans
Agron. J. **58,** 287–289.

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.

WHITEHAIR, N. V., CLEAVINGER, G. A. & ENIX, J. R. **B57**
1968
Soybean kernel damage
Stillwater, Oklahoma: *Oklahoma State Univ. Ext. Leaflet* E-694.

See also: A65:72
G22
H24:30
K34

Threshing

ARBOLEDA, J. R., McMENNAMY, J. A. & MANALIGOD, H. T. **C10**
1980
Mechanical threshers and dryers for reduced post-harvest losses and improved grain quality
In: *Grain quality improvement,* pp. 363–389. Proc. 3rd annual workshop on grains post-harvest technology, Kuala Lumpur, Malaysia. Laguna, Philippines: SEARCA Cooperative post-harvest research and development programme, 430 pp.

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. **C11**
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.

CHUNG, C. J., KOH, H. K., LEE, C. H., & KANG, H. S. **C12**
1978
Effects of thresher drum speed on the quality of the milled rice
In: *Post-harvest rice systems in Korea,* pp. 125–161.
Suweon, Korea: Seoul National University College of Agriculture, 194 pp.

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. **C13**
1975
Reduction of grain damage in a threshing device
Dokl. TSKhA/S-KH. Akad. im. K. A. Timiryazeva (214), 168–170. (In Russian).

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. **C14**
1973
Factors affecting mechanical damage of navy beans
Trans. Am. Soc. Agric. Eng. **16** (6), 1154–1157.

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. **C15**
1968
Threshing damage to soybeans
In: *Proc. Symp. Grain Damage,* Iowa State Univ. St. Joseph, Mich.: Am. Soc. Agric. Eng.

See also: B33:51
H24

Shelling of maize (corn)

CHOWDHURY, M. H. & BUCHELE, W. F. **D10**
1978
The nature of corn kernel damage inflicted in the shelling crescent of grain combines
Trans. Am. Soc. Agric. Eng. **21** (4), 610–614.

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. **D11**
1977
Photoelectric system for measuring mechanical damage of corn
Trans. Am. Soc. Agric. Eng. **20** (5), 972–975.

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. **D12**
1968
Mechanical shelling damage
In: *Proc. Symp. Grain Damage,* Iowa State Univ. St. Joseph, Mich.: Am. Soc. Agric. Eng.

SHARDA, R. & HERUM, F. L. **D13**
1977
A mechanical damage susceptibility tester for shelled corn
Am. Soc. Agric. Eng. Pap. 77–3504.

Conveying

ASIAN PRODUCTIVITY ORGANISATION **E12**
1970
Report of the survey on the problems of transportation, storage and distribution of food grains
Tokyo: APO, 112 pp.

CHRZANOWSKA, H. **E13**
1972
Natural losses of grain, legumes and rapeseed during road haulage
Biul. Cent. Lab. Technol., Przetworstwa i Przecho. w Warsawie **16** (4), 8–13. (In Polish).

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. **E14**
1973
Damage to corn from pneumatic conveying
US Dep. Agric., ARS-NC-5, 9 pp.

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. **E15**
1967
Handling losses of palay grains of IR-8-288-3 at different stages of maturity
Cent. Luzon State Univ. Exp. St. Contribution (394). Muñoz, Nueva Ecija, Philippines: Cent. Luzon State Univ. Exp. St.

GUILFOY, R. F. & MONGELLI, R. C. **E16**
1969
Relationships between grain transit losses and boxcar defects
US Dep. Agric., ARS Serv. Rep. ARS-52-25, 13 pp.

HALL, D. W. **E17**
1970
Handling and storage of food grains in tropical and sub-tropical areas
FAO Agric. Dev. Pap. (90), 350 pp.

HOLMAN, L. E. **E18**
1969
Improving the handling of grain in Indian wholesale markets
New Delhi: Ford Foundation.

JINDAL, V. K., HERUM, F. F. & MENSAH, J. K. A. **E19**
1978
Effects of repeated freezing-thawing cycles on the mechanical strength of corn kernels
Trans. Am. Soc. Agric. Eng. **21** (2), 367–370, 374.

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. **E20**
1973
Handling and resulting grain breakage
Ann. de Technol. Agric. **22** (3), 245–256.

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. **E21**
1968
Effect of two methods of grain handling on the milling recovery of Raminad Strain-3 and BPI-76 rice varieties
Cent. Luzon State Univ. Exp. St. Contribution (580). Muñoz, Nueva Ecija, Philippines: Cent. Luzon State Univ. Exp. St.

MILLER, B. S., HUGHES, J. W., ROUSSER, R. & POMERANZ, Y. **E22**
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. **E23**
1977
Corn breakage in overseas shipments—two case studies
Trans. Am. Soc. Agric. Eng. **20** (3), 550–557.

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. **E24**
1968
Handling losses of palay grains of Peta lowland rice variety
Cent. Luzon State Univ. Exp. St. Contribution (254). Muñoz, Nueva Ecija, Philippines: Cent. Luzon State Univ. Exp. St.

PERRY, J. S. **E25**
1959
Mechanical damage to pea beans as affected by moisture, temperature and impact loading
PhD Thesis, Michigan State Univ., East Lansing, Mich., USA

PINGALE, S. V. **E26**
1976
Handling and storage of food grains
New Delhi: Indian Council of Agricultural Research, 186 pp.

SALAMANCA, H. R. **E27**
1968
Comparison between the conventional and the modified methods of harvesting, on handling losses of Raminad Strain-3 and BPI-76 varieties of rice
Cent. Luzon State Univ. Exp. St. Contribution (583). Muñoz, Philippines: Cent. Luzon State Univ. Exp. St.

STEPHENS, L. E. & FOSTER, G. H. **E28**
1976
Breakage tester predicts handling damage in corn
US Dep. Agric., ARS-NC-49.

STEPHENS, L. E. & FOSTER, G. H. **E29**
1977
Reducing damage to corn handled through gravity spouts
Trans. Am. Assoc. Agric. Eng. **20** (2), 367–371.

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. **E30**
1968
Mechanical damage to grain during handling in commercial facilities
In: *Proc. Symp. Grain Damage,* Iowa State Univ. St. Joseph, Mich.: Am. Soc. Agric. Eng.

See also: A27:72
B42
G22:27:38:37
J40

Cleaning and winnowing

GROBE, A. **F2**
1977
Should grain for milling still be scoured?
Mühle Mischfuttertechnik **114**, 402–403.

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. **G20**
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. **G21**
1963
Methods of drying groundnuts. II Artificial methods (Literature survey)
Trop. Sci. **5**, 82–98.

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. **G22**
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. **G23**
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. **G24**
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. **G25**
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. **G26**
1968
Grain damage from high-speed drying
In: *Proc. Symp. Grain Damage,* Iowa State Univ. St. Joseph, Mich.: Am. Soc. Agric. Eng.

FOSTER, G. H. **G27**
1975
Causes and cures of physical damage to corn
In: *Corn quality in world markets,* (ed. L. D. Hill), pp. 221–229. Danville, Ill: Interstate. Libr. Congr. Cat. Card No. 74–24848.

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. **G28**
1978
Quality changes during high/low temperature drying
Trans. Am. Soc. Agric. Eng. **21** (1), 162–169.

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 $\geqslant$ 18% moisture.

HALL, C. W. **G29**
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. **G30**
1967
Development of fungi in peanuts during artificial drying
Univ. Georgia Coll. of Agric. Exp. St. Res. Rep. (19). Athens, Georgia: Univ. Georgia Coll. of Agric. Exp. St.

McKENZIE, B. A., FOSTER, G. H., NOYES, R. T. & THOMPSON, R. A. **G31**
1967
Dryeration—better corn quality with high-speed drying
Lafayette, Indiana: Purdue Univ. Coop. Ext. Serv.

RHYNEHART, T. **G32**
1960
The control of insects infesting groundnuts after harvest in the Gambia. IV The practical application of control measures
Trop. Sci. **2**, 134–139.

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. **G33**
1976
Influence of heated-air drying on soybean impact damage
Trans. Am. Soc. Agric. Eng. **19**, 372–377.

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. **G34**
1968
Relation of mechanical damage to drying and storage time
In: *Proc. Symp. Grain Damage,* Iowa State Univ., St. Joseph, Mich: Am. Soc. Agric. Eng.

SKOPEK, B. & KASTANKOVA, J. **G35**
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. **G36**
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 **G37**
1971
Preservation of grain quality during drying and storage
Short-term leaflet No. 24., 5 pp.

WHITE, G. M., BRIDGES, T. C., LOEWER, O. J. & ROSS, I. J. 1980 **G38**

Seed coat damage in thin-layer drying of soybeans

Trans. Am. Soc. Agric. Eng. **23** (1), 224–227.

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 humdity (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 **H24**
1968
Pilot study of paddy losses in Thailand during harvesting, drying and threshing
FAO/IRC/AE/WP29.

HODGES, T. O. **H25**
1969
Rice drying technology and equipment which might be applicable to tropical developing countries
Kansas State Univ. Food & Feed Grain Inst., Food grain drying, storage, handling and transportation Rep. 1, 43 pp.

KOBAYASHI, H., MIWA, Y. & MATSUDA, R. **H26**
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
J. Soc. Agric. Mach. Japan **37** (4), 551–556. (In Japanese).

1976b
Studies on the strain and cracking of rice kernels during cracking. II The drying strain of individual rice kernels
J. Soc. Agric. Mach. Japan **38** (3), 367–377. (In Japanese).

KUNZE, O. R. & HALL, C. W. **H27**
1965
Relative humidity changes that cause brown rice to crack
Trans. Am. Soc. Agric. Eng. **8** (3), 396–399, 405.

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. **H28**
1980
Drying-air conditions, moisture content and tempering period as related to milling yield and quality of rice

In: *Grain quality improvement,* pp. 284–298, Proc. 3rd annual workshop on grains post-harvest technology, Kuala Lumpur, Malaysia. Laguna, Philippines: SEARCA Cooperative post-harvest research and development programme, 430 pp.

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. **H29**
1961
Effects of drying techniques and temperature on head rice yields

Univ. Arkansas Agric. Exp. St. Bull. (640).

OKANO, H., HIRASAWA, N., SHIMADA, H., AITANI, T. & SAKAMOTO, J. **H30**
1975
Effect of harvesting dates and drying methods on quality of rice grains and sensory quality of cooked rice

Bull. Ibaraki Exp. Stn. (16), 21–42. (In Japanese).

SORENSON, O. **H31**
1970
A review of rice drying and storage problems in Ecuador

Kansas State Univ. Food and Feed Grain Inst. Rep. (16).

SRINIVAS, T., BHASHYAM, M., MAHADEVAPPA, M. & DESIKACHAR, H. S. R. **H32**
1977
Varietal differences in crack formation due to weathering and wetting stresses in rice

Indian. J. Agric. Sci. **47** (1), 27–31.

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.

SRINIVAS, T., BHASHYAM, M., MUNE GOWDA, M. K. & DESIKACHAR, H. S. R. **H33**
1978
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%.

SUBRAHMANYAN, V. **H34**
1973
Drying of cereal and pulses—chemical methods and their implications
In: *Postharvest technology of cereals and pulses,* Proc. of a seminar held in New Delhi, December 1973 (ed. S. V. Pingale), pp. 64–71. New Delhi: Indian National Scientific Council.

The author discusses the treatment of paddy with salt to reduce moisture content and associated losses between harvesting and marketing.

See also: A30
B43
J21:22:41
K34:62

Parboiling

BALDZHIEV, D., NIKOLOV, N., KRSTEVA, A. & DASKALOVA, Z. **J20**
1976
Effect of various kinds of fissure (micro and macro) on rice yield and the cracking process during hydrothermal processing
Nauchnii Trudove, Vissh. Institut po Khranitelna i vkusova Promyshlennost **23** (3), 121–134. (In Bulgarian).

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. **J21**
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. **J22**
1971
Commercial drying of parboiled paddy with LSU dryers
J. Food Sci. Technol. (India) **8** (2), 57–63.

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. **J23**
1979
Effect of milling on mineral and trace element composition of raw and parboiled rice
J. Sci. Food Agric. **30**, 40–46.

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.

EL-GINDY, M. M., ASHMAWI, H., REFAI, F. Y. & ABD-EL-HALIM, A. M. **J24**
1974
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/cm^2) 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. **J25**
1975
Parboiling of rice. Effects of processing conditions and varietal differences in the quality of the finished product
Ann. Technol. Agric. **24** (1), 11–23. (In French).

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. **J26**
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. **J27**
1972
Hydrothermal processing of rice
Mukomolno-Elevatornaya Prom.-st. **38** (9), 19–20. (In Russian).

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.

KAZAKOV, E. D., KIREEV, V. M., MELNIKOV, E. M. & SAKHAROVA, I. A. **J28**
1974
Alteration of the mineral composition of rice grain during parboiling
Izv. Vyssh. Uchebn. Zaved. Pishch. Tekhnol. No. 6, 72–75. (In Russian).

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. **J29**
1955
Influence of processing on nutritive value of milled rice
J. Agric. Food Chem. **3,** 600–603.

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.

MITRA, B. R. & CHAUDHURI, D. K. **J30**
1963
Effect of parboiling and mechanical drying on thiamine retention in rice
Sci. Cult. **29** (7), 353–354.

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. **J31**
1969
Effect of parboiling and chemical treatment on vitamin B_1 (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. **J32**
1976
Studies on parboiled rice. Part 1: Comparison of the characteristics of raw and parboiled rice
Food Chem. **1** (1), 5–14.

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.

PRIESTLEY, R. J. **J33**
1976
Studies on parboiled rice. Part 2: Quantitative study of the effects of steaming on various properties of parboiled rice
Food Chem. **1** (2), 139–148.

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.

PRIESTLEY, R. J. **J34**
1977
Studies on parboiled rice. Part 3: Characteristics of parboiled rice on re-cooking
Food Chem. **2** (1), 43–50.

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 I). It is proposed that amylose was insolubilised by complexing with free fatty acids and the amylopectin by interaction with the complexed amylose.

RAGHAVENDRA RAO, S. N., NARAYANA, M. N. & DESIKACHAR, H. S. R. **J35**
1967
Studies on some comparative milling properties of raw and parboiled rice
J. Food Sci. Technol. (India) **4**, 150–155.

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.

RAGHAVENDRA RAO, S. N. & JULIANO, B. O. **J36**
1970
Effect of parboiling on some physico-chemical properties of rice
J. Agric. Food Chem. **18**, 289–294.

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

RAMA RAO, G. **J37**
1958
Nutritive value of rice in relation to its degree of parboiling
Food Sci. **7**, 331–332.

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. **J38**
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. **J39**
1976
Studies on soaking and parboiling of paddy

J. Agric. Eng. **13** (3), 1–6.

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. **J40**
Pilot plant studies on soaking and parboiling of paddy

Annamalai University, Dep. Eng., Heat Power Lab. Rep., 5 pp.

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. **J41**
1972
Traditional and modern methods of parboiling and drying of paddy

J. Food Sci. Technol. (India) **9** (1), 7–9.

Among the modern methods studied, brine steeping and pressure parboiling proved to involve lower costs than hot soaking and steaming.

SHIVANNA, C. S. **J42**
1974
Economics of pressure parboiling of paddy
J. Food. Sci. Technol. (India) **11** (6), 286–287.

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. **J43**
1977
Nutrient losses during parboiling
Il Riso **26** (4), 337–340.

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. **J44**
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% $NaHSO_3$. 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. **K28**
1976
Milling costs of palay and recovery rates of rice mills, 1976
Philippine Min. of Agric., Bureau of Agric. Econ., Econ. Res. Rep. Series (1979) (2), 32 pp.

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%, 62.12% and 65.34% respectively).

ANON **K29**
1976
A report on rice milling recovery
Grains J. **1** (1), 3–5.

BARBER, S., & BARBER, C. B. de **K30**
1977
An approach to the objective measurement of the degree of milling of rice
Rev. Agroquim. Tecnol. Aliment. **17** (2), 223–234. (In Spanish). Also *Rice Process Eng. Cent. Reporter* No. 2, Kharagpur, India (1976) (In English).

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. **K31**
1976
Report on the effect of processing conditions on milling and grain quality of parboiled rice
Paddy Marketing Board Res. Bull. 5/76, 19 pp.

CHIRKOVA, L., KENDYSH, T., KOLOMIETS, M. & KISLYAK, A. **K32**
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. **K33**
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. **K34**
1961
Breakage of rice during milling
Trop. Stored Prods. Inf. **3,** 64–67.
(Extract from *Sci. Rep.* No. 11 of W. African Rice Res. Stn., Rokupr, Sierra Leone).

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. **K35**
1979
Effect of milling on mineral and trace element composition of raw and parboiled rice
J. Sci. Food Agric. **30** (1), 40–46.

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 **K36**
1979
System modeling on rice milling technology in Indonesia
Diss. Abstr. Int. **B40** (3), 1266. Order No. 79–21146, 128 pp.

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. **K37**
1972
Milling problems
In: *Rep. of the meet. of experts on the mechanization of rice prod. and process.*, Paramaribo, Surinam, 1971, GP 4/1 TF INT 36, 145–148.
Rome: Food and Agriculture Organization of the United Nations, 203 pp.

HOGAN, J. T. & DEOBALD, H. J. **K38**
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. **K39**
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 **K40**
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, amylose 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 amylose and total starch, 8 times as much ash and 17 times as much ether-extractable fat. Except for amylose and starch, concentrations of these components decreased with each successive pass. Residual kernels contained as much amylose 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. **K41**
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. **K42**
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. **K43**
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; ×5 for riboflavin, ×8 for thiamine and pyridoxine and ×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 **K44**
1943
Thiamine in products of commercial rice milling
Cereal Chem. **20**, 103–109.

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. **K45**
1951
Determining the degree of milling by photo-electric means
Rice J. **54** (12), 18–22.

KOGA, Y. **K46**
1976
Topics relating to the post-harvesting stage of rice—is small rice mill wasteful?
Agric. Mech. Asia **7** (2), 38–40. (In Japanese).

LATIF SHARIAR, M. **K47**
1980
Food losses during rice husking
Agricultural Development Agencies in Bangladesh (ADAB) Newsletter, November.

LE VAN CHOANG, AUERMAN, L. & GINZBURG, M. **K48**
1979
Use of Hagberg-Perten instrument for determining degree of rice polishing
Mukomolno-elevatornaya i Kombikormovaya Prom.-st. (5), 43. (In Russian).

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. **K49**
1978
Milling parameters for maximum milling yield and quality of milled rice
In: *Proc. workshop on grain post-harvest technology*, Bangkok, Thailand, 27–58.

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. **K50**
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 **K51**
1976
Comparative performance test of rice mills using rubber-roll and stone disc hullers
In: *Second Ann. Rep. UPLB–NFAC Grain Process. Prog. 1975/76*, pp. 8–17.

POMERANZ, Y., STERMER, R. A. & DIKEMAN, E. **K52**
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. **K53**
1976
Relation between humidity and milling yield in lowland rice
In: *An. VI Reuniao Geral da Cultura do Arroz*, EMBRAPA-IRGA, Pelotas, pp. 85–86. (In Portugese).

RUITEN, H. van **K54**
The prevention of losses in rice mills
Grains J. **1** (2), 3–5, 58–60.

SAHAY, M. N., DASH, A. B. & LODH, S. B. **K55**
1980
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. **K56**
1978
On the meaning of the degree of milling of rice
J. Food Technol. **13**, 99–105.

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. **K57**
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. **K58**
1956
A preliminary study of some factors affecting the milling recovery of rice in the Philippines
Philippine Agriculturist **40** (2), 69–77.

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. **K59**
1979
Separation, processing and utilization of rice germ
J. Food Sci. Technol. **16** (3), 116–118.

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. **K60**
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. **K61**
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. **K62**
1975
Report on drying, storing and milling in the Philippines
Sci. Rep. Lab. Agric. Process Eng. 11, *Fac. Agric., Kobe Univ., Kobe, Japan*, 97 pp.

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. **K63**
1975
Loss of food quality of grains during storage and milling
In: *Post-harvest crop protection, Proc. of Planning Meeting*, pp. 95–106. Honolulu: East-West Food Inst.

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. **L7**
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. **M6**
1976
Costs in milling corn and recovery rates
Philippine Min. of Agric., Bureau of Agric. Econ., Econ. Res. Rep. Series (1979) (1), 24 pp.

A survey of corn processing costs and milling recovery rates was undertaken to supplement existing information on milling efficiency.

BARTLOVA, D. **M7**
1971
Loss of important nutrients during grain processing and possibilities for their restitution, III
Mlynsko-Pekarensky Prumysl. **17** (5), 142–145. (In Czechoslovak).

Milling technology and nutritional value were studied in rye, and the addition of minerals and vitamins was investigated.

CARR, W. R. **M8**
1961
Observations on the nutritive value of traditionally ground cereals in Southern Rhodesia
Brit. J. Nutr. **15**, 339.

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.

HULSE, J. H., LAING, E. M. & PEARSON, O. E. **M9**
1980
Grain processing
In: *Sorghum and the millets. Their composition and nutritive value,* p. 396–440. New York: Academic Press, 997 pp.

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.

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE **M10**
1974
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.

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE **M11**
1976
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.

KHARE, R. N., KRISHNAMURTHY, K. & PINGALE, S. V. **M12**
1966
Milling losses of food grains. I Studies on losses of red gram (*C. cajan*) during milling
Bull. Grain Technol. **4** (3), 125–132.

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.

KHARE, R. M., KRISHNAMURTHY, K. & PINGALE, S. V. **M13**
1966
Milling losses of food grains. II Studies on losses of peas during milling
Bull. Grain Technol. **4** (4), 169–176.

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.

VOJNOVICH, C., PFEIFER, V. F. & GRIFFIN, E. L. **M14**
1970
Reducing microbial populations in dry milled corn products
Cereal Sci. Today **15** (12), 401–407.

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. **N10**
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. **N11**
1977
Recovery of soluble protein from wheat starch factory effluents
Austr. Inst. Chem. Eng. Symp. Ser. **73**, 198–205.

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. **N12**
1975
Effect of milling and baking on the retention of thiamine and riboflavin in some new wheat varieties of Pakistan
Agric. Pak. **26** (1), 1–14.

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. **N13**
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 **N14**
1977
High-extraction flour milling techniques
Indian Miller **8** (2/3), 7–13.

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. **N15**
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. **N16**
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).

NORMAND, F. L., HOGAN, J. T. & DEOBALD, H. J. **N17**
1965
Protein content of successive peripheral layers milled from wheat, barley, grain sorghum and glutinous rice by tangential abrasion
Cereal Chem. **42**, 359–367.

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. **N18**
1973
Thiamine losses during wheat flour processing and storage
Izv. Vysshikh. Uchebn. Zaved. Pishch. Tekhnol. (4), 37–38. (In Russian)

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. **N19**
1975
Influence of ergot on spring wheat milling and baking quality
Cereal Chem. **52** (1), 101–107.

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.

WATSON, C. A., SHUEY, W. C., CRAWFORD, R. D. & GUMBMANN, M.R. **N20**
1977
Physical dough, baking and nutritional qualities of straight-grade and extended extraction flours

Cereal Chem. **54** (3), 657–664.

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.

ZOTEV, A. I., ZABELINA, L. F., PASHCHENKO, L. P., ZUBCHENKO, A. V. & KOBANOV, I. V. **N21**
1977
Improvement in wheat flour quality as a result of reduction on roughened rolls

Izv. Vyssh. Uchebn. Zaved. Pishch. tekhnol. (5), 53–56. (In Russian)

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. **P1**
1980
Loss reduction by introducing locally-made paddy separators
In: *Grain quality improvement* Proc. 3rd annual workshop on grains post-harvest technology, Kuala Lumpur, Malaysia, pp. 58–62, Laguna, Philippines: SEARCA Cooperative post-harvest research and development programme, 430 pp.

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. **R10**
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.

ALI, S. H., SIDDIQI, A. M. & AL-SAIDY, M. **R11**
1978
The effect of the physico-chemical properties of infected wheat on the baking quality
Int. Congr. Food Sci. Technol. Abstracts, p. 215. (Proc. 5th Congr., 321 pp.)

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% KIO_3 and 2.5% ALS emulsion improved the baking quality of infected flours when mixed 1:1 with normal strong flour.

ALTSCHUL, A. M. **R12**
1965
The effect of heat on food proteins
In: *Proteins,* pp. 149–165. London: Chapman & Hall, 337 pp.

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. **R13**
1951/52
The loss of vitamin B_1 through washing and cooking of rice
Ann. Rep. Nat. Inst. Nutr. Japan, pp. 32–34.

Loss of vitamin B_1 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. **R14**
1939
Losses of protein and minerals in cooked rice
Sci. & Culture (Calcutta), **5**, 262.

BARBER, S. **R15**
1978
Rice bran as a potential source of food
Int. Congr. Food Sci. Technol. Abstracts, p. 17. (Proc. 5th Congr., 321 pp.)

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. **R16**
1978
Potential value of rice bran fractions as protein food ingredients.
Int. Congr. Food Sci. Technol. Abstracts, p. 73. (Proc. 5th Congr., 321 pp.)

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.

CHEIGH, H.-S., RYU, C.-H., JO, J.-S. & KWON, T.-W. **R17**
1977
Effect of washing on the loss of nutrients in rice
Korean J. Food Sci. Technol. **9** (2), 170–174. (In Korean)

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 B_1, 11–24% vitamin B_2 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. **R18**
1979
Bioprotein from banana wastes
Developments in Ind. Microbiol. **20**, 723–732.

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. **R19**
Reduction of solids losses
In: Rice and bulgur quick-cooking processes. *Food Process. Rev.* No. 16, pp. 108–111, 267 pp.

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. **R20**
1979
Effect of milling, fermentation and cooking on nutritional value of pearl millet (*Pennisetum americanum* (L.) Leeke)

In: *Improvement of pearl millet—Second Ann. Rep. Oct. 1978—Sept. 1979, Project 931–1040,* pp. 131–143. Manhattan, Kansas 66506, USA: Kansas State University.

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. **R21**
1980
Effects of milling and percent brokens on cooking loss of rice in Bangladesh

Paper presented at the Post-production workshop on food grains, Dacca, December.

DOWNS, D. E. & MECKEL, R. B. **R22**
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. **R23**
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. **R24**
1977
The protein quality of some Indian dishes prepared from wheat

J. Sci. Food & Agric. **28** (12), 1052–1056.

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. **R25**
1977
Effect of cooking on nutritional value of milled rice in rats. Digestibility of protein

Nutr. Reps. Int. **16** (5), 649–655.

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. **R26**
1978
Food from waste

In: *Biochemical aspects of new protein food,* pp. 43–52. Gothenburg, Sweden: SIK-Swedish Food Inst.

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. **R27**
1977
Food spoilage, preservation and hygiene

In: *Food Science, a chemical approach* (3rd edn.), pp. 305–342. London: Hodder and Stoughton, 380 pp.

GOLDBLITH, S. A., TANNENBAUM, S. R. & WANG, D. I. C. **R28**
1968
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. **R29**
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. **R30**
1975
The assessment of thermal processing in wheat flour proteins by physical, chemical and enzymatic methods
In: *Nutrition and clinical nutrition,* Vol. 1, Part II, pp. 393–415, 674 pp.

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. **R31**
1960
Nutritional evaluation of food processing
New York: John Wiley.

HEGAZI, S. M., FODA, M. S., SALEM, S. A. & ELDIN, S. M. B. **R32**
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. **R33**
1980
Application of pressure parboiling process for the production of bulgur wheat
J. Food Sci. Technol. (India) **17** (6), 263–265.

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. **R34**
1952
Thiamine retention in brown rice
J. Am. Dietet. Assoc. **28,** 1144–1145.

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. **R35**
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. **R36**
1977
Minimising during matter loss in malting of sorghum and maize
J. Food Sci. Technol. (India) **14** (6), 275–277.

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. **R37**
1952
Thiamine loss due to washing and cooking of enriched rice
Med. J. Malaya **7** (1), 39–47.

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. **R38**
1958
Effect of heat on plant proteins
In: *Processed plant protein foodstuffs,* pp. 79–129. (Ed. A. M. Altshcul), New York: Academic Press.

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. **R39**
1977
The optimization of the protein nutritive value of ogi
Diss. Abstr. Int. B **38** (2), 575. Order No. 77–17548, 165 pp.

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. **R40**
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. **R41**
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 **R42**
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
Alex. J. Agric. Res. **19** (2), 279–284.

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. **R43**
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. **R44**
1979
Cooking, processing and storage of food in relation to nutritional value
In: *Human Nutrition,* 3rd edn., pp. 157–167. London: Edward Arnold, 179 pp.

MURATA, K., TAKARADA, S. & NOGAWA, M. **R45**
1979
Loss of supplemental lysine and threonine during the baking of bread
J. Food Sci. **44** (1), 271–273, 281.

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. **R46**
1972
Losses of protein and B-vitamins in grains during traditional Nigerian processing
Nigerian J. Sci. **6** (1), 23–28.

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. **R47**
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
Japan J. Nutr. **32** (1), 19–23. (In Japanese)

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. **R48**
1978
Effect of heat treatment on certain nutritional attributes of wheat flour products
Int. Congr. Food Sci. Technol. Abstracts p. 288. (Proc. 5th Congr., 321 pp.).

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. **R49**
1979
Stability of vitamin B_6 during bread making and storage of bread and flour
Cereal Chem. **56** (6), 577–580.

Stability of vitamin B_6 was determined during dough fermentation and baking using three flours (whole-wheat, white and B_6 enriched white). Sponge dough and straight dough breads (under home conditions) and commercially baked breads were compared. Vitamin B_6 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. **R50**
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.

REINECCIUS, G. A., WOLF, J. C. & THOMPSON, D. R. **R51**
1978
Available lysine losses during thermal processing of unconventional proteins with glucose
J. Agric. Food Chem. **26** (5), 1256–1257.

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. **R52**
1953
Effect of cooking water on thiamin stability
J. Indian Chem. Soc. (Ind. & News Ed.) **16** (1), 50–56.

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. **R53**
1957
Further observations on cooking water and thiamin stability
J. Indian Chem. Soc., (Ind. & News Ed.) **20** (1), 42–43.

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. **R54**
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. **R55**
1973
Canning and pH stability of epichlorhydrin-treated parboiled rice
J. Agric. Food Chem. **21** (3), 458–459.

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. **R56**
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. **R57**
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. **R58**
1977
Potential food-grade materials from rice bran
International Rice Commission Newsletter No. 26, 19–21.

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. **R59**
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. **R60**
1971
Losses of vitamins and trace minerals resulting from processing and preservation of foods
Am. J. Clin. Nutr. **24,** 562–573.

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.

SEKHON, K. S., RANDHAWA, S. K., SAXENA, A. K. & GILL, K. S. **R61**
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. **R62**
1942
The effect of washing and cooking on the vitamin B_1 content of raw and parboiled milled rice
Indian J. Med. Res. **30** (3), 409–416.

Whereas raw milled rice loses about 60% of its vitamin B_1 during washing, parboiled milled rice loses much less (8%) and contains on average 4 times as much vitamin B_1 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. **R63**
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 soyabean flour was evaluated from animal experiments. Earlier workers had shown that mild heating of soyabean 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. **R64**
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. **R65**
1979
Improvement of boiled noodle making. IV Improved boiled noodle-making to decrease loss in boiling
Rep. Nat. Food Res. Inst., Min. of Agric., Forestry & Fisheries, Japan (34), 8–12. (In Japanese)

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. **R66**
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. **R67**
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).

See also: A43
J25: 32: 36: 38
K60
N21

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Commodity index

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