Grain processing losses bibliography: Covering threshing, shelling, hulling, milling, grinding etc and excluding harvesting and storage (G117)

Tropical Products Institute

G117

Grain processing losses bibliography

Covering threshing, shelling, hulling, milling, grinding etc and excluding harvesting and storage

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Ministry of Overseas Development

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

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Preface

This is the first processing loss bibliography to be issued and it is hoped that, by presenting annotated references, the information will be readily accessible.

It is expected that supplements to this bibliography will be issued from time to time. It would be very helpful if readers could bring omissions to our attention; comments on the lay-out etc will also be welcome.

Introduction

This bibliography is a companion to G110, 'A bibliography on post-harvest losses in cereals and pulses with particular reference to tropical and sub-tropical countries', by J. M. Adams (TPI, 1977). Whereas G110 covered storage, the present bibliography deals with the post-harvest processes from threshing to milling, with some abstracts on the secondary processes (cooking, baking, fermentation etc).

The present world food situation has led technologists to look critically at all aspects of food production in order to increase the world's food resources. One aspect only recently studied with any great seriousness is the assessment and reduction of food processing losses.

Losses occur at all stages of the food chain. Moreover, some losses made manifest at one point are caused earlier in the chain. Some obvious examples come to mind: failure to apply fertilizer leads to low yields; over-ripeness leads to threshing losses; bad threshing or drying techniques with paddy lead to broken rice at the mill, and so on.

It is always possible to reduce loss empirically, without prior assessment of the loss. However, to justify the necessary inputs of finance, labour etc, to reduce loss it is wise to assess the loss and measure its cost.

In assessing loss two basic methods are available: (a) measurement of whole system, and (b) comparison of one process with a standard or optimal process. In (a) the loss itself is weighed. For example, by removing and weighing grain left on the stalk after threshing. In (b) the process is compared, in terms of yields and values, with an optimized, usually laboratory, process. All other unit operations in the processing chain are carried out in an identical way. For example, identical samples of maize cobs are dried to different moisture levels and then shelled: kernel damage is then compared.

In this bibliography are abstracts of many useful technical papers on processing losses of cereals and grain legumes. Some areas are much better covered than others, and it is hoped that this bibliography will spur researchers to concentrate on neglected areas. The introductory remarks to some sections are taken from the AACC/LIFE publication 'Post-harvest Grain Loss Assessment Methods' (see page 3, A1).

NOTE: The lay-out of this bibliography is similar to that which has been so successfully used in the Composite Flour Bibliographies (G89 and G111), and it is hoped that users will find the system appropriate in the present case.

Sampling

An excellent review of sampling procedures and their importance occurs in the AACC/LIFE publication 'Post-harvest Grain Loss Assessment Methods'. It must be emphasised that in loss measurement, sampling must be carried out successfully; otherwise results obtained will be invalid.

Reviews and papers of general interest

AMERICAN ASSOCIATION OF CEREAL CHEMISTS **A1**
1978
Post-harvest grain loss assessment methods
St. Paul: AACC, 194pp.

A manual of methods for the evaluation of post-harvest losses. (Published in co-operation with *Life*, TPI and FAO).

BOURNE, M. C. **A2**
1977
Post-harvest food losses — the neglected dimension in increasing the world food supply
Cornell Int. Agric. Mimeogr. (53) 49pp. Available from Dep. Food Sci. & Technol., Cornell Univ., New York 14456, USA.

This paper outlines the nature of the problem of post-harvest food losses, discusses the causes of loss, what is known of the extent of losses and where losses occur. It describes briefly the available techniques for preserving food and identifies those techniques that offer the greatest promise for increasing the available food supply in developing countries.

BUCHELE, W. F. & QUICK, G. R. (Eds) **A3**
1968
Proceedings of the symposium on grain damage
St. Joseph, Mich., USA: Am. Soc. Agric. Eng.

Symposium held at the Agricultural Engineering Department, IOWA State University, under the auspices of the ASAE PM53 Grain Harvesting Commission.

BYG, D. M. & SCHNUG, W. R. (Eds) **A4**
1972
Proceedings of the corn and soybean grain damage symposium
Ohio: Agric. Eng. Dep., Ohio State Univ.

CHOWDHURY, M. H. & BUCHELE, W. F. **A5**
1976
Development of a numerical damage index for critical evaluation of mechanical damage of corn
Trans. Am. Soc. Agric. Eng. **19** (3), 428–432.

A numerical damage index was developed by using one of the many biological properties of the grain, germination in this instance, for critical evaluation of mechanical damage of corn.

EAST PAKISTAN AGRICULTURAL MARKETING DIRECTORATE **A6**
1969
Report of the study group on the feasibility of pilot project concerned with improved methods of harvesting, drying and storage of paddy and rice at farm level

Dacca: Gov. of East Pakistan, 56pp.

In the course of this general report, losses of rice at all stages of processing from threshing through milling and storage to cooking are dealt with.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS **A7**
1976
Government consultation on crop and post harvest protection needs in the Sahel. Proposal for an inter-country programme to improve post harvest food protection

Rome: *AGP:CPS/76/WP/13.*

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS **A8**
1977
Reducing post harvest food losses

Rome: *FAO Committee on Agriculture, COAG/77/6.*

GARG, O. P. & AGRAWAL, N. S. **A9**
1966
Quantitative and qualitative losses in the production of rice

Bull. Grain Technol. **4** (1), 24–27.

Harvesting, storage and processing of rice in India is briefly described, and measures necessary for assisting rice growers in the reduction of losses are reported.

GOMEZ, F. & ANDREW, C. H. **A10**
1971
Influence of mechanical injury on seed corn quality

In: *Agronomy Abstracts, 1971 Ann. Meet. Am. Soc. Agronomy,* p 43.
Available from: Seed Technol. Lab., Miss. State Univ., Miss., USA.

TEN HAVE, H. **A11**
1958
Investigation on the cracks and breaks percentage of rice

Surinaamse Landb. **6**, 77.

HENDERSON, S. M. **A12**
1954
The causes and characteristics of rice cracking

Rice J. **57** (5), 16.

JANICKI, L. J. & GREEN, V. E. **A13**
1976
Rice losses during harvest, drying and storage

Il Riso **25** (4), 333.

The authors report estimates of the percentages of various crops lost after harvesting, discuss the problems encountered in rice crops and assess the effectiveness of some remedies.

KHAN, A. U., DUFF, B., KUETHER, D. O. & McMENNAMY, J. A. **A14**
1975
Rice machinery development and mechanization research
Int. Rice Res. Inst. Semiannual Progress Rep. (21), 31 + xxx pp.

The report contains assessments of the causes of losses in post harvest techniques and describes progress in mechanical improvements to reduce these losses.

KOREA INSTITUTE OF SCIENCE & TECHNOLOGY **A15**
1976
Need for establishment of a pilot rice post-production centre
Available from: PO Box 131, Dong Dae Mun Seoul, Korea.

The report, subtitled 'A field demonstration model for systematic improvement of the post-harvest technology of rice in Korea', contains information on losses of rice in transport and storage and tables showing increased head rice yield using the solvent extractive milling process as compared with conventional processes.

KRISHNAMURTHY, K. **A16**
1975
Post harvest losses in food grains
Bull. Grain Technol. **13** (1), 33–49.

Review covering losses in cereal grain during all processes from threshing to milling.

McGINTY, R. J. **A17**
1970
Development of a standard grain breakage test (a progress report)
US Dep. Agric./ARS 51–34, 13pp.

SAMSON, B. T. & DUFF, B. **A18**
1973
The pattern and magnitude of field grain losses in paddy production
Int. Rice Res. Inst. Saturday Seminar Paper, July 7, 21pp.

This study covers field losses in rice with the aims: (1) to determine the magnitude and causes of field losses; (2) to determine the optimum time of harvest to obtain maximum grain yields with the use of two drying methods; and (3) to investigate alternative harvesting-threshing systems to minimise losses and increase incomes.

SHETTY, M. S. & AMLA, B. L. **A19**
1972
Bulgur wheat
J. Food Sci. Technol. (India) **9** (4), 163–165.

Production figures and processing methods for bulgur are reported, as are the effects of processing on chemical composition, losses of soluble and heat labile nutrients in current commercial processing and loss of riboflavin due to sun-drying as opposed to mechanical drying.

SPURGEON, D. **A20**
1977
Hidden harvest: a systems approach to post-harvest technology
PAG (Protein-Calorie Advisory Group) Bull. **7** (1/2), 45–58.
Int. Dev. Res. Centre (Ottawa) 062e.

Estimated cereals losses and their causes are discussed. The advantages of an overall plan involving a systems approach to the whole range of post-harvest problems under local conditions are dealt with and the Maiduguri Mill Project in Nigeria is cited as an example.

SRINIVAS, T. **A21**
1975
Pattern of crack formation in rice grain as influenced by shape and orientation of cells
J. Sci. Food Agric. **26**, 1479–1482.

Results are given of a study to provide an explanation of the characteristic crack formation in rice grain.

SRIVASTAVA, A. K. **A22**
1974
Effect of freezing temperature treatment on rupture strength of corn kernels
Trans. Am. Soc. Agric. Eng. **17** (6), 1182–1184.

Effect of temperature changes on the mechanical strength of corn kernels was studied. Varietal differences and effect of moisture content on varietal differences were both significant for load and strain at rupture.

STILES, D. E. **A23**
1977
Post-harvest losses of food grains with special reference to Africa: an interim bibliography
London: *Food Prod. & Rural Dev. Div., Commonw. Secr.*

SUBRAHMANYAN, V. **A24**
1977
Causes and prevention of post-harvest rice losses
Rome: *FAO Action Oriented Field Workshop for Prevention of Post-harvest Rice Losses, WPPL/3,* 22pp.

The report covers the following headings:
A. Effects of high moisture, soaking and drying
B. Stabilisation of bran, production of protein and vitamin-rich rice flour
C. Planned approach for better utilisation of paddy husk
D. Spoilage of rice straw in wet season.

U THET ZIN & LEONG YUN LAU **A25**
1971
Losses and waste in rice processing in West Malaysia
Serdang: *Food Technol. Res. & Dev. Cent., Malaysia.*

WIMBERLEY, J. **A26**
1972
Review of storage and processing of rice in Asia
Int. Rice Res. Inst. Paper (72–01).

Throughout Asia, the traditional methods of paddy processing are being replaced with modern techniques and equipment. This paper presents some of the changes and results. It covers: harvesting and threshing, drying, storage, parboiling and milling of paddy. Some of the problems of the traditional systems are discussed along with the results of the modern systems.

Combine harvesting

ARNOLD, R. E. **B1**
1959
The effect of harvest damage on the germination of barley
J. Agric. Eng. Res. **4**, 24.

Results of experiments on malting barley showed little difference in germination of grain harvested at two moisture levels but that both high harvester cylinder speeds and small concave clearance caused damage, and this effect was cumulative.

ARNOLD, R. E. & JONES, M. P. **B2**
1963
A survey of grain damage incurred and drum setting used during the combine-harvesting of Cappelle Desprez wheat and Proctor barley
J. Agric. Eng. Res. **8**, 178–184.

Damage in wheat samples was shown to be related to the moisture content of the grain and drum setting at threshing, but barley sustained very little damage.

BODIFFORD, J. K. & RICHEY, C. B. **B3**
1975
Development of a puller-header for combining soybeans
Trans. Am. Soc. Agric. Eng. **18** (6), 1003–1005, 1010.

Harvesting of soybeans by pulling the entire plant from the ground substantially reduces harvesting losses. More development is needed to reduce or eliminate the problems of soil intake, large weeds and lodged or leaning plants.

BYG, D. M. *et al.* **B4**
1968
Machine losses in harvesting ear and shelled corn
Am. Soc. Agric. Eng. Pap. (66–611).

Reasons are given for high ear loss for combine harvesters and remedies are re-commenced, such as automatic stone sensing and ejecting devices and additional gathering chains.

CALDWELL, F. Y. K. & HAMPSON, A. G. **B5**
1958
Germination of acid-treated samples as a means of assessing mechanical damage of barley
J. Inst. Brew. **64** (4), 319.

Treatment with 50% (v/v) sulphuric acid affected germination in mechanically damaged barley grains, and the treatment allows differentiation of samples into groups corresponding to severity of harvest treatment.

DUNN, W. E., NAVE, W. R. & BUTLER, B. J. **B6**
1973
Combine header component losses in soybeans
Trans. Am. Soc. Agric. Eng. **16** (6), 1032–1035.

Field investigations determined the gathering losses attributable to each component of the header during soybean harvesting. Of the three main components, the cutterbar caused 85% of the loss in the three varieties tested.

GILL, W. E. **B7**
1965
Corn harvesting losses in the field, an Ohio study
Am. Soc. Agric. Eng. Pap. (65–562).

JOHNSON, W. H., LAMP, B. J., HENRY, J. E. & HALL, G. E. **B8**
1963
Corn harvesting performance at various dates
Trans. Am. Soc. Agric. Eng. **6** (3), 268–272.

Methods of measuring harvesting losses in corn were scrutinised, and a method of adequate evaluation of wet shelling losses is proposed. The effect of delayed harvest and kernel moisture on shelling losses is discussed.

JUDAH, O. M. **B9**
1970
Mechanical damage of navy beans during harvesting in Michigan
Special Report, Agric. Eng. Dep., Michigan State Univ.

KAUL, R. N. & RAMESH, K. **B10**
1974
Loss of moisture in wheat and rice grown under field conditions and its effect on machine operation
Indian J. Agric. Sci. **44** (11), 760–767.

In six varieties of wheat and two varieties of rice studied, moisture loss varied greatly prior to maturity and could influence a machine-harvesting system. Wheat ear 'droop' had no definite correlation with moisture content. Unseen stress cracks in standing rice kernels could be a major cause of milling breakage.

KLEIN, L. M. & HARMOND, J. E. **B11**
1971
Seed-moisture – a harvest timing index for maximum yields
Trans. Am. Soc. Agric. Eng. **14** (1), 124.

Average loss for seven crops (grass and small legume seed) was found by USDA/ARS survey to be 47.4%. Studies have shown that harvest losses can be reduced by proper timing of the harvest. An optimum mowing time was identified, and additional information on seed losses and damage and site of occurrence was obtained.

KLINNER, W. E. & BIGGAR, G. W. **B12**
1972
Some effects of harvest date and design features of the cutting table on the front losses of combine harvesters
J. Agric. Eng. Res. **17**, 71–78.

Measurements were made on six successive harvest dates in barley and wheat to determine pre-harvest shedding losses and the transverse distribution of losses occurring at the cutting table of a combine-harvester.

LAMP, B. J., JOHNSON, W. W. & HARKNESS, K. A. **B13**
1961
Soybean harvesting losses – approaches to reduction
Trans. Am. Soc. Agric. Eng. **4** (2), 203–205, 207.

An effective method for reducing soybean losses proved to be harvesting when the straw was damp, total losses being reduced under these conditions by up to 50%. Cylinder speeds had to be almost doubled to ensure complete threshing. Reductions in germination were experienced.

MATTHEWS, J. & SPADARO, J. J. **B14**
1975
Rice breakage during combine harvesting
Rice J. **78** (7) 59, 62–63.

Samples of rough rice were collected from the fields of five farmers, one from the combine and one by hand-harvesting. By X-ray photography, the percentage of cracked and broken grains proved to be on average 5.6% higher for combine harvested grain both before and after milling.

MITCHELL, F. S. **B15**
1956
Grain damage during combine-harvesting
J. Inst. Br. Agric. Eng. **12** (2), 13–19, 28.

PATEL, B. M., PATEL, R. B. & SHUKLA, P. C. **B16**
1971
Effect of stage harvesting on the yield and composition of wheat straw and grain
Indian J. Nutr. & Dietetics **8** (5), 264–267.

Wheat was harvested at normal stage, one week early and one week late, and nutrient yields of the harvests were compared. It was concluded that an early harvest is advantageous, as higher total nutrient yields with unaffected grain yields were obtained.

PEPLINSKI, A. J., BREKKE, O. L., GRIFFIN, E. L., HALL, G. E. & HILL, L. D. **B17**
1975
Corn quality as influenced by harvest and drying conditions
Cereal Foods World **20** (3), 145–149, 154.

The overall effect of harvest moisture, sheller damage and drying temperature on given corn samples was investigated. It was concluded that harvest moisture should be 25% or under, shelling should involve as little damage as possible and drying may be conducted at temperatures up to 180°F, preferably less.

PICKETT, L. K. **B18**
1973
Mechanical damage and processing loss during navy bean harvesting
Trans. Am. Soc. Agric. Eng. **16** (6), 1047–1050.

Mechanical damage to navy beans during harvesting depends primarily on moisture content of the beans and cylinder speed. Since threshing speed is largely governed by the pod moisture, weather conditions before and during harvest are an important factor. The ideal conditions for threshing are described.

RUIZ, E. **B19**
1965
Harvest losses of palay grains of BPI-121 lowland rice variety at different levels of moisture content
Cent. Luzon State Univ. Sci. J. **1** (2).

TATE, D. E. & NAVE, W. R.
1973 **B20**
Air-conveyor header for soybean harvesting
Trans. Am. Soc. Agric. Eng. **16** (1), 37–39.

An air-conveyor header reduced harvesting losses from 8.8% (standard header) to 5.0%. Header losses with a cutterbar or combination header were not significantly lower than those from a standard header.

TUNNELL, J. C., NAVE, W. R. & YOERGER, R. R. **B21**
1973
Reducing soybean header losses with air
Trans. Am. Soc. Agric. Eng. **16** (6), 1020–1023.

Tests were made with air-jet nozzles on a standard header and a floating cutterbar header, reducing losses by 35 and 44% respectively.

UNITED KINGDOM MINISTRY OF AGRICULTURE, FISHERIES AND FOOD **B22**
1973
Combine grain losses
Short Term Leaflet 155, 11pp.

The leaflet demonstrates a simplified technique for measuring grain losses using cheap equipment.

WAELTI, H., BUCHELE, W. F. & FARRELL, M. **B23**
1969
Progress report on losses associated with corn harvesting in Iowa
J. Agric. Eng. Res. **14**, 134–138.

Pre-harvest, gathering, snapping-roll, separating and cleaning losses in five varieties of corn were examined. Ear drop losses before or during harvesting accounted for 85–95% of all losses, with large differences between varieties. For most varieties losses increased rapidly as grain moisture dropped below 25%.

WAELTI, H., TURNQUIST, P. K. & MATTER, V. E. **B24**
1971
Harvesting techniques for reducing grain sorghum losses
Trans. Am. Soc. Agric. Eng. **14** (5), 797–800.

Methods of reducing harvesting losses in sorghum grain in the Great Plains area were tested and evaluated. High-moisture combining followed by artificial drying, use of special header attachments to lift broken stalks and windrowing at high moisture with subsequent drying in the windrows were the techniques tested.

WAIT, J. J., NAVE, W. R. & BUTLER, B. J. **B25**
1974
Reducing soybean cutterbar losses with low-pressure air jets
Trans. Am. Soc. Agric. Eng. **17** (5), 817–820.

Low pressure air was directed over the cutterbar and toward the rear to carry potential losses into the header. Substantial loss reductions were obtained, eg a 52% reduction at 11% moisture with air velocity 1700 fpm at the cutterbar.

WILLIAMS, M. M. & RICHEY, C. B. **B26**
1973
A new approach to gathering soybeans
Trans. Am. Soc. Agric. Eng. **16** (6), 1017–1019, 1023.

Soyabean was harvested with an experimental unit designed to pull rather than cut the stalks. Substantial reductions in gathering losses were realised. Stubble loss, shatter loss and stalk and lodged losses were also reduced.

See also: A18:26
H11:17:18
K4:9:11:18:25

Threshing

Losses occur during threshing by spillage; by incomplete removal of grain from stalk; by damage to grain during threshing; by poor separation of grain during cleaning or winnowing after threshing.

Incomplete stripping usually occurs in regions of relatively high labour cost at harvest time, where the method of threshing used, leaves some grain unthreshed but labour is too expensive to justify final hand-stripping. TPI workers in Malaysia observed that 1.13% of paddy was lost by falling outside the threshing tub and it was also noted that up to 11.7% was left on the straw.

Certain mechanical threshers have cleaning equipment designed for only dry grain. A wet-season's harvest (eg of paddy) will clog the screens and grain will be lost with leaf and broken stalk (cleaning losses).

The use of oxen for threshing paddy provides a trodden straw said to be more easily digested. If the threshing floor is muddy or cracked, grain will be lost.

There is a 5% increase in cracked and broken kernels after combine-harvesting paddy compared to hand-harvesting and hand-stripping (Matthews, J. and Spadaro, J. J., 1975. *Rice J.* **78**, 59).

BORTHWICK, H. A. **C1**
1932
Thresher injury in baby lima beans
J. Agric. Res. **44**, 503–510.

DAVIES, A. C. W. **C2**
1964
The relative susceptibility to threshing damage of six varieties of wheat
J. Nat. Inst. Agric. Bot. **10**, 122–128.

Methods of measuring threshing damage in wheat are described, and in the six varieties studied, susceptibility to visible breakage was related to variety, but susceptibility to microscopic damage was not.

GARG, S. S. L., SINGH, J. & PRAKASH, V. **C3**
1966
Losses of wheat in threshing yards due to birds and rodents
Bull. Grain Technol. **4** (2), 94–96.

Losses of wheat in six randomly selected threshing yards was assessed by observation of duration and frequency of visits by birds, rats and squirrels.

GORBACHEV, I. V. **C4**
1975
Reducing grain damage during threshing
Doklady TSKhA (214), 168–170. (In Russian)

Results of threshing trials showed that wheat grain breakage was twice as high with ridged beaters as with smooth beaters.

KHAN, A. U. **C5**
1976
Harvesting and threshing: equipment and operations
In: *Rice Post-harvest Technology,* pp 85–104.
Ottawa: Ind. Dev. Res. Cent. (053e), 394pp.

Sources of paddy loss are reported as part of a general survey of mechanical and manual harvesting and threshing procedures.

KING, D. L. & RIDDOLLS, A. W. **C6**
1960
Damage to wheat seed and pea seed in threshing
J. Agric. Eng. Res. **5**, 387–398.

The effect was studied of different combinations of drum speed and concave clearance on wheat and pea seed threshed in a combine-harvester at fairly low moisture content. One conclusion drawn was that high drum speed was the chief factor in causing visibile damage in both seeds and invisible damage also in the case of wheat. Other results are included.

KING, D. L. & RIDDOLLS, A. W. **C7**
1962
Damage to wheat and pea seed in threshing at varying moisture content
J. Agric. Eng. Res. **7**, 90–93.

The effect of drum speed vs moisture content on pea and wheat seed during threshing (header-harvester) was studied. As drum speed was increased, wastage increased at all moisture contents within the range.

DE KONING, K. **C8**
1973
Measurement of some parameters of different spring wheat varieties affecting harvesting losses
J. Agric. Eng. Res. **18**, 107–115.

For normal threshing procedure, parameters of five spring wheat varieties were compared; the threshing of the kernels, loose ears and the amount of broken straw and chaff. Straw-shaker losses are fairly well characterised by the percentage threshed and the percentage of broken straw and chaff. Loose ears have an influence on the sieve losses.

SINGH, B. & LINVILL, D. E. **C9**
1977
Determining the effect of pod and grain moisture content on threshing loss and damage of navy beans
Trans. Am. Soc. Agric. Eng. **20**, 226–231.

Timely harvesting of navy beans is essential for low threshing loss, freedom from impact damage to the bean and good quality. Threshing loss depended on pod moisture content, and damage on combine cylinder speed and grain moisture content.

See also: A18
B18
E1

Shelling of maize (corn)

The stripping of maize grain from the cob is known as shelling. Losses occur whenever mechanical shelling is not followed by hand stripping of the grains remaining on the cob. Certain shellers damage the grain, making insect penetration easier, with increased storage loss subsequently. TPI has made a survey of sheller efficiency and grain damage.

AGNESS, J. B. **D1**
1968
Measuring mechanical damage to corn
Am. Soc. Agric. Eng. Pap. (68–620), 7pp.

In evaluating the performance of field shelling machines with respect to mechanical kernel damage, corn-breakage test results met most of the requirements as to the limited definitions needed, and correlated best with the actual kernel fragments created with the shelling machine.

BRASS, R. W. & MARLEY, S. J. **D2**
1973
Roller sheller: low damage corn shelling cylinder
Trans. Am. Soc. Agric. Eng. **16**, 64–66.

Quantitative damage comparisons between a laboratory roller sheller and a conventional cylinder type sheller showed reductions of up to 50% with the test machine.

BURKHARDT, T. H. & STOUT, B. A. **D3**
1974
Laboratory investigations of corn shelling utilising high-velocity impact loading
Trans. Am. Soc. Agric. Eng. **17** (1), 11–14.

Two cultivars of maize were used in tests on the influence of moisture content at shelling on the incidence of kernel damage.

BYG, D. M. & HALL, G. E. **D4**
1968
Corn losses and kernel damage in field shelling of corn
Trans. Am. Soc. Agric. Eng. **11** (2), 164–166.

Laboratory studies were conducted to evaluate kernel damage due to different shelling techniques. The paper deals primarily with picker shellers and corn combines. Less ear loss was experienced with picker shellers than with corn combines, and the reasons for high combine losses are discussed.

CHOWDHURY, M. H. & BUCHELE, W. F. **D5**
1975
Effects of the operating parameters of the rubber roller sheller
Trans. Am. Soc. Agric. Eng. **18** (3), 482–486, 490.

A rubber roller sheller (Brass, 1970) was further evaluated to determine the effect of moisture content, cylinder inflation pressure and cylinder rpm on kernel damage, shelling efficiency and feed rate. A damage index was developed for quantitative as well as qualitative evaluation of kernel damage.

HALL, G. E. & JOHNSON, W. H. **D6**
1970
Corn kernel crackage induced by mechanical shelling
Trans. Am. Soc. Agric. Eng. **13** (1), 51–55.

Tables and figures demonstrate the kernel damage sustained by two Ohio corn hybrids in each of two sheller units operated under various conditions (cylinder speeds, concave clearance, cage sheller rate, etc).

MAHMOUD, A. R. & BUCHELE, W. F. **D7**
1975
Distribution of shelled corn throughput and mechanical damage in a combine cylinder
Trans. Am. Soc. Agric. Eng. **18** (3), 448–452.

Tests in a laboratory sheller made from conventional combine parts led to the conclusion, *inter alia,* that damage might be reduced if the repetitive impacts were reduced by modifying the shelling mechanism. Concave clearance and distance along the concave were significant; cylinder speed, moisture content and variety were statistically insignificant.

MAHMOUD, A. R. & BUCHELE, W. F. **D8**
1975
Corn ear orientation effects on mechanical damage and forces on concave
Trans. Am. Soc. Agric. Eng. **18** (3), 444–447, 452.

Selected ears (uniform weight and moisture) of deKalb XL66 corn were fed manually into a laboratory sheller. Results showed that a roll-in feeding produced least damage and tip-in orientation most damage. It was concluded that a roll-in orientation mechanism is a feasible addition to conventional shelling for damage reduction.

WAELTI, H. & BUCHELE, W. F. **D9**
1969
Factors affecting corn kernel damage in combine cylinders
Trans. Am. Soc. Agric. Eng. **12** (1), 55–59.

Five varieties of corn, planted on two dates, were used for field shelling, laboratory shelling and physical properties experiments at time intervals covering 35–15% kernel moisture content. The factors affecting kernel damage were determined as kernel detachment force, compressive kernel strength, kernel deformation and compressive cob strength.

See also: B8:17
G8:16

Conveying

BILANSKI, W. K. **E1**
1966
Damage resistance of seed grains
Trans. Am. Soc. Agric. Eng. **9** (3), 360–363.

The size, moisture content and position of the grain all influenced damage resistance in those tested (soybean, corn, wheat, barley and oats). High-moisture grain could be damaged by deflection. It was concluded that in actual threshing the hulls tend to act as shock absorbers and protect the kernels; hence the more covering matter or chaff and straw present, the greater the impact that can be absorbed.

CLARK, R. L. **E2**
1967
The effect of high velocity impact on the germination and damage of cottonseed
Am. Soc. Agric. Eng. Pap. (67–822).

FISCUS, D. E., FOSTER, G. H. & KAUFMAN, H. H. **E3**
1971
Physical damage of grain caused by various handling techniques
Trans. Am. Soc. Agric. Eng. **14** (3), 480–485, 491.

Handling procedures tested were grain dropping, grain throwing and bucket-elevation, which were carried out on corn, soybeans and wheat. It was found that corn incurred more breakage than soybeans, and soybeans more than wheat. Wheat damage was less than 0.4% in all tests. Dropping from more than 40 feet caused more damage than any other method tested. Other factors affecting breakage were impact surface, grain stream orifice and grain temperature and moisture.

FOSTER, G. H. & HOLMAN, L. E. **E4**
1973
Grain breakage caused by commercial handling methods
US Dep. Agric./ARS Mark. Res. Rep. (968), 23pp.

Simulated bin-filling and simulated railcar-filling, bucket-elevation and grain throwing tests were carried out on corn, wheat, soybeans and dry pea beans to determine resulting damage. Research data are illustrated and tabulated, and the report ends with a section on remedial measures.

HALL, G. E. **E5**
1974
Damage during handling of shelled corn and soybeans
Trans. Am. Soc. Agric. Eng. **17** (2), 335–338.

It is concluded that the most effective method of reducing damage to corn and soybeans in handling is to operate the equipment at full capacity and at or under the recommended speed. Artificial drying, if 'gentle', will not increase handling damage. Inclination angle of the screw had no significant effect on damage.

KELLER, D. L., CONVERSE, H. H., HODGES, T. O. & CHUNG, D. S. **E6**
1972
Corn kernel damage due to high velocity impact
Trans. Am. Soc. Agric. Eng. **15**, 330–332.

From this investigation it was concluded that factors affecting corn kernel damage were size, shape and velocity of kernel, moisture content, angle of impact and impact surface. Reduced damage was reported with urethane impact surface (vs concrete or steel), 45° angle of impact (vs 90°) and moisture contents over 15.25%. Velocity of kernel was the most important factor in kernel damage.

LOUVIER, F. J. & CALDERWOOD, D. L. **E7**
1972
Breakage of processed rice due to falling impact
Cereal Sci. Today **17** (4), 98–101.

1000 g lots of milled rice were dropped from varying heights onto simulated bin floors. Breakage was influenced by height of release, moisture content of grain, degree of milling, shape of grain (long or medium), parboiling, impact surface and angle of impact. Little or no effect was observed with variations in RH of ambient air or rice grain temperature.

MARTIN, C. R. & STEPHENS, L. E. **E8**
1977
Broken corn and dust generated during repeated handling
Trans. Am. Soc. Agric. Eng. **20** (1), 168–171.

Repeated handling of dry shelled corn produced a continuous increase in breakage and in segregation of broken grains from whole grains.

MITCHELL, F. S. & ROUNTHWAITE, T. E. **E9**
1964
Resistance of two varieties of wheat to mechanical damage by impact
J. Agric. Eng. Res. **9**, 303–306.

Results obtained by striking individual grains with a rotating hammer confirmed that breakage is highest at lower levels of moisture content, and germination most adversely affected at the higher levels of moisture.

PERRY, J. S. & HALL, C. W. **E10**
1966
Evaluating and reducing mechanical handling damage to pea beans
Trans. Am. Soc. Agric. Eng. **9**, 697–701.

SANDS, L. D. & HALL, G. E. **E11**
1971
Damage to shelled corn during transport in a screw conveyor
Trans. Am. Soc. Agric. Eng. **14** (3), 584–585, 589.

Factors contributing to corn damage were found to be one-fourth capacity charging of the screw conveyor, high-temperature drying and increased screw speed. Inclination had little effect on damage to the shelled corn.

See also: A2:17

Cleaning and winnowing

Cleaning is customary before milling. At the homestead hand-cleaning is a combination of hand winnowing with hand removal (eg of stones); losses are therefore very low. With correct equipment losses should be low in mills, but equipment undersized for the quantity of extraneous material (dirt etc) removed will cause a loss of grain, removed with the dirt etc or caused by the dirt being carried forward into the milling stages resulting in loss of grain or product. Loss assessment is difficult as losses are usually low: high losses are spotted by operators and the extraneous matter is 're-cleaned'.

CHRZANOWSKA, H. & STRUTYNSKA, K. **F1**
1969
Natural losses occurring during grain cleaning and drying
Biul. Cent. Lab. Technol. Przetworstwa i Przecho. Zboz w Warsawie **13** (4), 69–75. (In Polish)

In experiments with wheat, rye and oat cleaning, mean natural losses (other than real losses) are calculated as 0.026%. It is suggested that the relevant standards should include natural losses of 0.026% for cleaning and 0.44% for each drying operation.

See also: B23
N5:7

Drying (crops other than rice)

Two losses occur frequently during drying: removal of grain from the drying system and damage to the grain leading to a subsequent loss.

Grain which is dried in yards or on warehouse floors or on roads will be consumed by birds, rodents. Wind, either natural or from passing vehicles in the case of road drying, will blow some grain away. Very little grain is removed on vehicle tyres.

ADAMS, S. L., STARK, W. H. & KOLOCHOV, P. **G1**
1943
Reduction of the fermentable carbohydrate content of corn by kiln drying
Cereal Chem. **20**, 260–266.

BERTELMANN, L. **G2**
1975
Problems in the drying of maize and maize products
Getreide, Mehl und Brot **29** (6), 149–153. (In German)

Factors affecting drying processes with maize and methods of reducing the number of broken grains are discussed, and specific drying conditions for obtaining maize products are reported.

BERTELMANN, L. **G3**
1975
Heat treatment of wet-harvested maize grain
Mullerei **28** (18), 275–278. (In German)

Maize is harvested at 30–45% moisture in Central Europe. The method of drying and the pattern of air movement during drying are illustrated. A standing period of up to 10 hours improves the product, short standing times producing more surface cracks.

CHUNG, D. S. & CONVERSE, H. H. **G4**
1971
Internal damage of wheat kernels by successive wetting and drying cycles
Cereal Chem. **48** (3), 108–118.

A substantial increase in internal cracks or fissures in the kernels of two varieties of HRS wheat was observed as a result of repeated wetting and drying cycles. The related effect on kernel breaking strength was evaluated.

FOSTER, G. H. **G5**
1973
Dry aeration: heated air drying and corn quality
Ann. Technol. Agric. **22** (3), 233–244.

Three drying systems were tested and the percentage kernel breakage is given for each system and for conventional continuous flow drying.

FRENCH, R. C. & KINGSOLVER, C. H. **G6**
1964
Effect of excessive heat during artificial drying of corn on reducing sugar content and diastatic activity
Cereal Chem. **41**, 47–58.

Of the chemical and physical changes in corn grain examined as possible indices of damage by high temperatures during artificial drying, diastase activity was the property having the greatest differential between unheated and heated (200° F) samples, showing an inverse correlation with increasing drying temperature, significant at the 1% level.

GHALY, T. F., EDWARDS, R. A. & RATCLIFFE, J. S. **G7**
1973
Heat-induced damage in wheat as a consequence of spouted bed drying
J. Agric. Eng. Res. **18** (2), 95–106.

Viability of grains, dough properties and baking quality were used to assess thermal damage in an Australian wheat variety. It was established *inter alia* that spouted bed drying of wheat grains at moisture contents over 15% resulted in some damage.

HALL, G. E. **G8**
1972
Test weight changes of shelled corn during drying
Trans. Am. Soc. Agric. Eng. **15** (2), 320–323.

The applicability of test weight as a measure of corn quality was studied. Hand-shelled samples, ie undamaged, reached a higher test weight during drying than combine-harvested samples. Variety had marked effect on test weight. The usefulness of test weight as a quality indicator is questionable however.

HOLADAY, C. E. **G9**
1964
Electronic method for the measurement of heat damage in artificially dried corn
Cereal Chem. **41**, 533–542.

A method based on measurement of moisture distribution in the corn kernel proved to be both accurate and rapid as an indication of drying damage. Moisture was indirectly measured by electrical capacitance and d.c. resistance of the corn.

McGUIRE, T. A. & EARLE, F. R. **G10**
1958
Changes in the solubility of corn protein resulting from the artificial drying of high-moisture corn
Cereal Chem. **35**, 179–188.

Solubility of proteins in water and in 0.01N KOH solution at 23.9 ± 2.8° C decreased more or less continuously with increasing drying temperatures ranging from 48.9 to 93.3° C. There was no indication of any critical damage occurring at any particular temperature.

MENSAH, J. K., HERUM, F. L. & BLAISDELL, J. L. **G11**
1976
Impact fracture resistance of selected corn varieties due to drying conditions
Am. Soc. Agric. Eng. Pap. (76–3042).

Shear impact to failure tests were used to evaluate varietal differences in the mechanical strength of corn kernels. Genetic differences were significant. Moisture content and drying temperature influenced the kernel strength.

RAGHAVAN, G. S. V. & HARPER, J. M. **G12**
1974
High temperature drying using a heated bed of granular salt
Trans. Am. Soc. Agric. Eng. **17** (1), 108–111.

Low quality corn was used in a study of salt-bed drying at high temperatures. Effect on bulk density, colour, stress-cracking and nutritive value are given.

ROSS, I. J. & WHITE, G. M. **G13**
1971
Discoloration and stress cracking of white corn as affected by overdrying
Technical Pap. Am. Soc. Agric. Eng. M1–71–321.

The results are reported of studies of the colour changes and stress cracking in white corn dried with heated air, as affected by various initial and final moisture contents. Stress cracking was most severe (70–90% checked kernels) in grain dried to 10–14% moisture in air temperatures of 130–220° F. Samples dried at 100° F had less than 50% checked kernels.

SMIT, C. J. & DE BEER, A. G. **G14**
1970
Cracking in artificially dried maize
Farming in South Africa **46** (5), 3, 19.

The effects of a) moisture removal rate, b) initial moisture content and c) stress reduction before cooling on the incidence of cracking in artificially dried maize were examined. a) proved to be the most potent factor in crack formation; increasing b) from 15 to 17% increased cracking from 15 to 75%; c) reduced cracked kernels by up to 75%.

THOMPSON, R. A. & FOSTER, G. H. **G15**
1963
Stress cracks and breakages in artificially dried corn
US Dep. Agric. Mark. Res. Rep. (631).

VOJNOVICH, C., ANDERSON, R. A. & GRIFFIN, E. L. **G16**
1975
Wet milling properties of corn after field shelling and artificial drying
Cereal Foods World **20** (7), 333–335.

Extreme artificial drying of corn reduces yields of oil and starch. Picker-sheller damage during harvest can affect recovery of prime milling products.

WALL, J. S., JAMES, C. & DONALDSON, G. L. **G17**
1975
Corn proteins: chemical and physical changes during drying of grain.
Cereal Chem. **52**, 779–790.

Proteins were solvent-extracted from defatted grain or endosperm meals during forced air drying to 15% moisture of corn harvested at 25% moisture. Air temperatures between 15 and 143°C were used. Among other findings, it is reported that proteins extracted with 0.5 NaCl were markedly reduced in meals heated to 143°C; yield of zein dropped (70%—ethanol—0.5% Na acetate extraction); the number of sulfydryl groups (and grain viability) decreased in whole grain; lysine and available lysine were reduced at the highest heating temperature.

WESTERMAN, P. W., WHITE, G. M. & ROSS, I. J. **G18**
1973
Relative humidity effect on the high-temperature drying of shelled corn
Trans. Am. Soc. Agric. Eng. **16** (6), 1136–1139.

In the conditions prevailing in the study, colour changes from heated air had no significant effect on the quality of corn for wet or dry milling. Drying air of 50% RH or higher will significantly reduce stress cracking in temperatures of 100–160°F.

WHITE, G. M. & ROSS, I. J. **G19**
1970
Discoloration and stress cracking in white corn as affected by drying temperature and cooling rate
Am. Soc. Agric. Eng. Pap. (70–831).

Results indicated no apparent relationship between post-drying treatment and the value of a sample's colour parameters. Slow cooling of both white and yellow corn after drying resulted in a dramatic reduction in the number of cracked kernels.

See also: A19
B17:24
E5:11
F1
M2

Drying (rice)

The principal loss occurring during drying is caused by kernel cracking ('checking') of grains such as rice which are eaten whole. Angladette has reviewed the subject (FAO Informal Working Bulletin No. 23, 1964). The greatest damage occurs through re-wetting which happens when grains of different types are mixed in a dryer, and when rain or dew re-wets grain in a yard. The damage manifests as broken grains during milling, especially in the polishers.

ARBOLEDA, J. R., MANALO, A. S. & KHAN, A. U. **H1**
1973
Accelerated drying of paddy
Ann. Technol. Agric. **22** (3), 257–273.

A review of progress in work on accelerated paddy drying at the International Rice Research Institute, discussing tests on:
(1) Conduction drying-parboiling of paddy with heated sand;
(2) Direct-flame drying;
(3) Development of a small batch dryer with a rice husk furnace.

BAN, T. **H2**
1971
Rice cracking in high rate drying
Japan Agric. Res. Q. **6** (2), 113–116.

The effect of variety, moisture content, drying rate, etc on percentage crackage of rice during forced air drying is discussed. Maximum crackage occurred at drying temperatures circa 80°C, decreasing at higher temperatures. Below 80°C, crack ratio increased with higher initial moisture content, the reverse being true at temperatures above 80°C (probably as a result of gelatinisation).

BEENY, J. M. & CHIN SHIN NGIN. **H3**
1970
Multipass drying of paddy (rice) in the humid tropics
J. Agric. Eng. Res. **15** (4), 364–374.

Using a tropical rice strain, this work showed that multipass drying of wet paddy (with limited moisture content removal per pass, and a period of tempering between each pass) greatly improves milling head yields.

BHASHYAM, M. K., SRINIVAS, T. & DESIKACHAR, H. S. R. **H4**
1975
Controlled sun drying of freshly harvested paddy for improved milling quality
J. Food Sci. Technol. (India) **12** (3), 124–127.

When drying temperature was high and humidity low (40–45°C and $<$ 45%), sundrying caused high damage. Stirring and covering of the paddy at intervals was highly beneficial. Under milder weather conditions covering may not be necessary, and other procedures are described.

BHATTACHARYA, K. R. & ALI, S. Z. **H5**
1970
Improvement in commercial sun-drying of parboiled paddy for better milling quality
Rice J. **73** (9), 3, 4, 9–15.

Long grain Kalma rice was parboiled and dried, moisture and temperature being measured during drying, and samples were examined for milling damage. 1-stage and 2-stage drying operations followed. Results are reported and directions for a 2-stage drying and tempering process are given.

BHATTACHARYA, K. R. & INDUDHARASWAMY, Y. M. **H6**
1967
Conditions of drying parboiled paddy for optimum milling quality
Cereal Chem. **44** (6), 592–600.

Paddy drying trials showed that a period of conditioning after hot-air drying reduced milling breakage. Drying in two passes with tempering in the moisture range 15–19% followed by hot conditioning after the final drying was satisfactory and convenient in practice.

CALDERWOOD, D. L. **H7**
1975
Rice drying and storage studies
Rice J. **78** (7), 77.

Results are given of trials in field drying, deep bed drying and continuous heated-air drying of rice, as related to milling yield.

CHANCELLOR, W. J. **H8**
1965
An experiment on sun-drying of paddy
Malaysian Agric. J. **45** (1), 65–75.

The drying history and weather conditions for the experiment are shown by tables and figures, and a method is described for predicting drying performance.

CRAUFURD, R. Q. **H9**
1962
Moisture changes in raw and parboiled paddy in West Africa and their influence upon milling quality. II. Changes during drying
Emp. J. Exp. Agric. **30** (120), 321–329.

A higher percentage of whole grains, and a less critical moisture content at milling are obtained with slow drying of both raw and parboiled paddy.

INTERNATIONAL RICE RESEARCH INSTITUTE **H10**
1969
Drying and processing research: accelerated drying of paddy
Ann. Rep. Int. Rice Res. Inst., p 208.

Results are given for accelerated drying of high moisture paddy, where an increase in head rice yield was due to parboiling.

JAYAWARDENA, S. D. G. **H11**
1973
Effect of grain moisture content, time of harvest and method of drying on milling quality of rice
Trop. Agriculturist **129** (3/4), 103–118.

Investigations in Sri Lanka showed that optimum harvest-time for rice was 28–36 days after 50% flowering. Harvesting after more than 36 days gave 1–2% more broken rice per day. Yield was higher with shade-drying than with sun-drying immediately after threshing.

KHAN, A. U. **H12**
1974
Accelerated drying of rice using heat conduction media
Trans. Am. Soc. Agric. Eng. **17** (5), 949–955.

Results are given of experiments in the use of heated sand and liquid petroleum gas flame as paddy drying media. Gelatinisation of starch and consequent reduction of breakage in milling occurred with both conduction media. Direct flame drying in combination with heated-air or shade drying can increase head rice yield.

KORATEV, I. G. **H13**
1975
The influence of hot dehydration on rice grain quality
Izv. Vyssh. Uchebn. Zaved. Pishch. Teknol. **4**, 58–61. (In Russian)

The effect of rate of heating of rice grain on technological properties was examined during alternate heating and cooling.

LOCKWOOD, L. M. **H14**
1975
Small scale storage and drying of paddy in Bangladesh — the scope for reducing losses
IVS/CORR Grain Storage Project, 19pp. Available from: Int. Voluntary Services Inc., 549F—Road 14, Dhanmandi, Dacca.

Village-scale practices in post-harvest treatment of paddy are described, with discussion of possible improvements and loss-reduction.

POLITI, A. **H15**
1970
Influence of mechanical drying on milling yield
Il Riso **19** (1), 73–85. (In Italian)

PRASAD, S. **H16**
1975
Natural drying of harvest paddy in the field and its influence on milling quality
Rice Process. Eng. Cent. Rep. **1** (1)

Available from: Indian Inst. Technol., Kharagpur,

The effect of moisture in three varieties of paddy on milling quality (total and head yields) during natural drying (> 20%–< 15%) is shown by tables.

RANGANATH, K. A., BHASHYAM, M. K., BHASKAR RAO, Y.
& DESIKACHAR, H. S. R. **H17**
1970
Influence of time of harvest and environmental factors on grain yield and milling breakage of paddy
J. Food Sci. Technol. (India) **7** (3), 144–147.

In investigations on four rice varieties, increases in milling breakage were found to be related to moisture contents below 19–21%, field drying over several days and wetting by dew. Field drying for one day had little effect. Yield increased as moisture content dropped to 17%.

SAMY, S. J. & PHANG, C. C. **H18**
1975
Harvesting and drying studies with padi Bahagia and padi Jaya
Malaysian Agric. J. **50** (1), 31–38.

Total and head yields of polished rice were examined in relation to moisture content at harvesting (15–25%) followed by either sun-drying or oven drying.

SHCHERBAKOV, V. et al. **H19**
1977
Effect of warm-air drying on the protein and lipid complex of rice
Mukomolno Elevatornaya Prom-st. **2**, 30–31. (In Russian)

Rice was experimentally dried from 24.5% to 13.5–14% by air at temperatures from 35 to 120°C. Warm air drying caused changes in the composition of fatty acids and in the fractional composition of lipids. Higher temperatures were conducive to a decrease in protein fractions and an increase of non-protein compounds.

STIPE, D. R. & MILLER, M. F. **H20**
1975
Effects of steaming, drying and tempering conditions on mill yields of rough rice
Rice J. **78** (7), 58.

A combined steaming, drying and tempering system increased head yields of rice by up to 8% over shade-dried, unsteamed controls. The system calls for steaming, drying to 16%, tempering, drying to 14%, tempering, drying to 12.5%. Poor quality rice was most benefited by the treatment.

UCHIYAMA, Y. **H21**
1969
Prevention of the occurrence of broken rice in Cambodia
Japanese J. Trop. Agric. **13** (1), 12–17. (In Japanese)

Paddy drying in Cambodia was studied in wet and dry seasons in efforts to reduce incidence of broken grains.

VORONTSOV, O. S. & KONDRATEV, A. I. **H22**
1974
Influence of grain drying temperatures on the technological and culinary properties of rice
Zb. Kazakhskii Politek. Inst. imeni V. I. Lenina **3**, 19–27. (In Russian)

Samples of two varieties of Bulgarian rice were sprayed to give moisture contents from 17–30% and were subsequently dried at 30–45°C. Yield and quality of polished rice were reduced at the higher temperatures. Recommended treatment is given for the two varieties as a result of the tests.

WASSERMAN, R. E., FERREL, R. E., BROWN, A. H. & SMITH, G. S. **H23**
1957
Commercial drying of Western rice
Cereal Sci. Today, **2** (9), 251–254.

Commercial practices can be improved by applying information from laboratory studies on effects of air temperature and number of drying stages on rice breakage and drying time. The results are summarised in a diagram suitable for guiding dryer operators.

See also: A18:26
J18
K11:25
R2

Parboiling

Though easily quantifiable losses of soluble materials occur during the parboiling of paddy, these losses are more than offset by the improvement in nutritional value of the kernel (see Gariboldi, F. 'Rice Parboiling', FAO Agricultural Paper No. 97, Rome, 1974).

BHATTACHARYA, K. R. & SUBBA RAO, V. P. **J1**
1966
Processing conditions and milling yield in parboiling of rice
J. Agric. Food Chem. **14** (5), 473–475.

BHATTACHARYA, K. R. & SUBBA RAO, V. P. **J2**
1966
Effect of processing conditions on quality of parboiled rice
J. Agric. Food Chem. **14** (5), 476–478.

DESIKACHAR, H. S. R., BHASHYAM, M. K. & PARIPA, H. A. B. **J3**
1967
Relative yields of total and head rice from raw and parboiled paddy
J. Food Sci. Technol. (India) **4**, 156–158.

DIMOPOULOS, J. S. & MULLER, H. G. **J4**
1972
Effect of processing conditions on protein extraction and composition and on some other physico-chemical characteristics of parboiled rice
Cereal Chem. **49** (1), 54–62.

In three varieties of rice, even light parboiling practically eliminated breakage after milling. Parboiling slightly increased protein in milled rice and altered protein solubility in various solvents. Grain length and soluble starch were increased.

FEILLET, P. & ALARY, R. **J5**
1975
Parboiling of rice: effects of processing conditions and varietal differences on quality
Ann. Techn. Agric. **24** (11).

GARIBOLDI, F. **J6**
1970
Modern parboiling processes
Il Riso **19** (3), 265–276.

The use of hot water (vs cold), steam injection and artificial drying in parboiling processes have led to better yield, keeping quality and nutritional value of rice.

GUSEV, P. & KUZMINA, Q. **J7**
1972
Hydrothermal processing of rice
Mukomolno-Elevatornaya Prom. -st. **38** (9), 19–20. (In Russian)

Increases in the pressure and duration of steam treatment of rice gave higher yield of grits and reduction in crushed grains.

JONES, J. W. **J8**
1946
Effect of parboiling and related treatments on the milling, nutritional and cooking quality of rice
US Dep. Agric. Circ. (752), 15pp.

Three varieties of rice were pre-treated before milling by twelve different methods. All the treatments increased head yields, and increased the thiamine content while improving the cooking quality of milled samples.

JONES, J. W. & TAYLOR, J. W. **J9**
1933
Effect of parboiling rough rice on milling quality
US Dep. Agric. Circ. (340), 14pp.

KURIEN, P. P., RADHAKRISHNAMURTHY, R., DESIKACHAR, H. S. R. & SUBRAHMANYAN, V. **J10**
1964
Effect of parboiling on the swelling quality of rice
Cereal Chem. **41**, 16–22.

Swelling rates and expansion ratios during cooking of parboiled rice were lower than those of raw rice. The importance of an optimum steaming period to obtain a balance between swelling quality and increased yield of head rice is emphasised.

MAZUMDER, A. C., BOSE, A. N., GANGULI, N. C. & GUHA, B. C. **J11**
1960
Pilot plant studies on parboiling of rice: I. Soaking and gelatinization. II. Effect of hot soaking and mechanical drying on the nutritive value of parboiled rice
J. Biochem. & Microbiol. Technol. & Eng. **2** (4), 431–451.

Alternative processes of paddy parboiling to those in general use in the Orient were tested in an attempt to produce parboiled rice of superior quality. Results indicated that the improved parboiling processes followed by mechanical drying produced rice of improved digestibility and significantly higher thiamine value.

NAWAB ALI & OJHA, T. P. **J12**
1976
Parboiling — technology
In: *Rice Post-harvest Technology*, pp 163–204.
Ottawa: Ind. Dev. Res. Cent. (053e), 394pp.

In a general review of parboiling techniques, the effect of parboiling on milling properties, nutritional value and cooking quality is dealt with.

NURUNNABI, B. I. & HUQ, M. M. **J13**
1975
Effect of parboiling and storage on the total nitrogen, non-protein nitrogen, fat, acid value, peroxide value and iodine value of some varieties of Bangladesh rice
Bangladesh J. Sci. & Ind. Res. **10** (1–2), 20–31.

Fifteen varieties of rice were stored for one year, either raw or after parboiling. The effect of parboiling was examined and comparisons are made between raw and parboiled stored samples.

OCKER, H. D., BOLLING, H. & EL BAYA, A. W. **J14**
1976
Effect of parboiling on some vitamins and minerals of rice: thiamine, riboflavin, calcium, magnesium, manganese and phosphorus
Il Riso **25** (1), 79–82.

Polishing of raw brown rice resulted in pronounced loss of some vitamins and minerals. This loss can be avoided by soaking and steaming paddy rice.

PADUA, A. B. & JULIANO, B. O. **J15**
1974
Effect of parboiling on thiamine, protein and fat of rice
J. Sci. Food Agric. **25**, 697–701.

While parboiling reduced the thiamine content of rice, milled parboiled rice contained more thiamine than milled raw rice. Bran-polish of parboiled rice contained more fat and protein and less starch than raw rice bran-polish. Milled parboiled rice tended to contain less protein than milled raw rice.

ROBERTS, R. L., POTTER, A. L., KESTER, E. B. & KENEASTER, K. K. **J16**
1954
Effect of processing conditions on the expanded volume, colour and soluble starch of parboiled rice
Cereal Chem. **31**, 121–129.

An increase in severity of heat treatment during parboiling increased expansion of dry milled rice, darkened the colour and increased soluble starch content. Steaming temperature rather than duration of steaming or steeping conditions had greatest influence on these factors.

SHIVANNA, C. S. **J17**
1976
Leaching losses during commercial parboiling of paddy by the hot soaking method
J. Food Sci. Technol. (India) **13**, 94–95.

Losses of rice solids by leaching during hot-soaking were found to be higher for paddy procured at high moisture and stored in silos and godowns as compared with those procured at lower moisture content.

STIPE, D. R. & MILLER, M. F. **J18**
1974
Rice drying and processing
Rice J. **77** (7), 55–56.

Exploratory tests were conducted to determine the effect of steam treatment on milling quality of medium and long grain varieties, both rough and brown rice. Results obtained are discussed in relation to future larger-scale experiments.

SUBBA RAO, V. P. & BHATTACHARYA, K. R. **J19**
1966
Effect of parboiling on thiamine in rice
J. Agric. Food Chem. **14** (5), 479–482.

Parboiling causes thiamine loss in paddy but protects against loss of the remaining thiamine in milling. Soaking *per se* causes no loss unless paddy splits during soaking. Thiamine is protected against milling loss by mere high-temperature soaking of paddy or by soaking and steaming, but not by soaking alone at lower temperatures, which would indicate embedding of the inner bran and scutellum layers in the endosperm due to gelatinisation, rather than inward diffusion of the vitamin.

See also: A26
E7
H5:6:9:10
K3

Hulling and polishing (rice)

Removal of the outer husks from a grain may take place in one or more stages. In the case of paddy rice (also red sorghum and oats), a considerable mechanical effort is needed to remove these layers; any weakness in the kernel, caused previously, or inherent, will manifest at this stage. Even with grain in perfect condition, only the best process with correctly set machinery will yield an out-turn of whole polished grains approaching 100% of that attainable. In the case of rice, broken grains command lower prices and finely shattered material ceases to be human food, some leaving the mill in the husk (fuel or waste), most with the bran (feed). With the consumer demanding rice with a high degree of polish, the stage which causes most loss cannot be omitted, and the loss must be measured and then minimised.

ARBOLEDA, J. R. **K1**
1975
Improvement of the kiskisan rice mill
Int. Rice Res. Inst. Saturday Seminar Paper, July 7.

Results are tabulated and reported of milling runs with different modifications to Engelberg huller mills. Higher yields of total and head rice were obtained as compared with the unmodified Engelberg mill and two commercial huller mills.

AUTREY, H. S., GRIGORIEFF, W. W., ALTSCHUL, A. M. & HOGAN, J. T. **K2**
1955
Effects of milling conditions on breakage of rice grains
J. Agric. Food Chem. **3** (7), 593–599.

Figures and tables illustrate the sites and percentages of losses in rice milling, and it is recommended that the mill room atmosphere be maintained at 70–80% RH for maximum head yield.

BHATTACHARYA, K. R. K3
1969
Breakage of rice during milling and effect of parboiling
Cereal Chem. **46** (5), 478–485.

Factors relating to breakage of rice kernels during milling were studied. Most breakage occurred in the early stages of milling, increased little at later stages and was quantitatively related to the percentage of cracked and immature kernels. The advantages of parboiling in salvaging damaged paddy is emphasised.

BRANDÃO, S. S., GALVÃO, J. D. & DE OLIVIERA, L. M. **K4**
1970
Relationship between moisture content of rice grain at harvest and total and whole grain yield at milling
Rev. Ceres **17** (91), 35–46. (In Portuguese)

CHILDERS, R., SORENSEN, J. W. & STERMER, R. A. **K5**
1972
Evaluation of two laboratory rice shellers
Cereal Sci. Today **17** (8), 212–215.

A rubber roll sheller and a steel roll sheller were compared for performance. The quantitative and qualitative performance of the rubber roll sheller was superior to the steel roll sheller in all but one instance in each case.

DESIKACHAR, H. R. S. **K6**
1973
Effect of differential maturity of paddy grains in a panicle on their milling quality
J. Sci. Food Agric. **24**, 893–896.

Branches of paddy panicles were divided into four equal parts and the grains from each part separately were compared for moisture content and milling quality.

ENGRACIA, R. L. **K7**
1977
A study on the milling recovery of cone type rice mill at varying huller clearance in correlation to the physical characteristics of paddy
Rome: FAO Action Oriented Field Workshop for Prevention of Post-Harvest Rice Losses, Alor Setar, Malaysia, WPPL/17.

Preliminary results indicate that for the rice varieties used in the study, the optimum huller clearance was 3.5 mm, and a higher milling recovery occurred with the paddy at 14—15% moisture than at 13—14% moisture.

INTERNATIONAL RICE RESEARCH INSTITUTE **K8**
1972
Rice-processing systems
Ann. Rep. Int. Rice Res. Inst. 82–83.

The milling efficiency of Engelberg hullers as compared with conco-type mills is illustrated.

LANGFIELD, E. C. B. **K9**
1957
Time of harvest in relation to grain breakage on milling in rice
J. Austr. Inst. Agric. Sci. **23** (4), 340–341.

Long and short grain rice varieties were examined and results indicated that delayed harvest leads to increased breakage on milling.

LAWRENCE, E. **K10**
1975
Grain gains
Nature **256**, 453.

The article deals with the percentage losses in rice crops in Asian countries and it is suggested that official milling recovery figures are over-optimistic. Introduction in Indonesia of small, efficient local mills for rural rice-growers is dealt with.

MAHADEVAPPA, M., BHASHYAM, M. K. & DESIKACHAR, H. S. R. **K11**
1969
The influence of harvesting date and traditional threshing practices on grain yield and milling quality of paddy
J. Food Sci. Technol. (India) **6** (4), 263–266.

Experiments on two rice varieties to determine optimum moisture content for harvesting showed that greater milling breakage resulted from post-harvest drying than from delaying harvesting for the same period of time. For both varieties shade drying was preferable to sun-drying.

MALABUYOC, J. A., MAMICPIC, M. G., CASTILLO, P. S., MIRANDA, R. M. & CALLAO, H. P. **K12**
1966
Grain characters, yield and milling quality of rice in relation to dates from heading
Philippine Agric. **49** (8), 696–710.

MATTHEWS, J., ABADIE, T. -J., DEOBALD, H. J. & FREEMAN, C. C. **K13**
1970
Relation between head rice yields and defective kernels in rough rice
Rice J. **73** (10), 6–12.

Percentage of cracked paddy was found to be correlated with percentage broken kernels after shelling and after milling. Hand shelling confirmed that in medium-grain paddy, some cracked kernels were resistant to breakage, but that cracked long-grain paddy was very fragile. It is concluded that breakage in the McGill miller is due to mechanical stress, and that cracked kernels are not necessarily broken during shelling and milling.

MATTHEWS, J., HOGAN, J. T., MOTTERN, H. H. & DEOBALD, H. J. **K14**
1971
Southern Laboratory is studying rice milling
Rice J. **74** (6), 28–30, 34.

Rice breakage research work at USDA Southern Research Laboratory is outlined. The relative importance of grain defects in rice breakage was studied, as was mechanical damage during milling. Methods which could modify the breakage characteristics of rice are discussed.

MATTHEWS, J., VEAL, D. M. & DEOBALD, H. **K15**
1971
Comparative head rice yields from commercial and laboratory milling equipment
Rice J. **74** (4), 5–9.

Rice kernel breakage in eight long and four short grain lots was compared using laboratory and commercial husking and milling equipment. Results are given. It was concluded that improved bran removal would be more effective in reducing breakage than improved husker design.

MATTHEWS, J. & SPADARO, J. J. **K16**
1976
Breakage of long-grain rice in relation to kernel thickness
Cereal Chem. **53** (1), 13–19.

Six lots of paddy were separated into four fractions according to thickness of kernels, and X-ray photographs were used to estimate the percentage of cracked and broken grains. Breakage in the milled rice was related to breakage in the unmilled grains. In general breakage in the milled rice was greater for the thinner fractions.

MAUNG MAUNG, U. **K17**
1977
Shelling efficency of rubber roll shellers
Rome: FAO Action-Oriented Field Workshop for Prevention of Post-harvest Rice Losses, Alor Setar, Malaysia, WPPL/15, 8 + vi pp.

Figures are given for the efficency of rubber roll shellers as compared with disc shellers.

MORSE, M. D., LINDT, J. H., OELKE, E. A., BRANDON, M. D. & CURLEY, R. G. **K18**
1967
The effect of grain moisture at time of harvest on yield and milling quality of rice
Rice J. **70** (11), 16–20.

Present and past work indicated that total grain yield per acre increased as grain moisture dropped to about 20% at time of harvest. The percentage head rice generally peaked as moisture declined to 30–26%. Total milled rice per acre continued to increase as grain moisture dropped to 12%, but slowly after reaching 26%.

RAGHAVENDRA RAO, S. N., NARAYANA RAO, M. N. & DESIKACHAR, H. S. R. **K19**
1972
Pattern of change in silica, ash, crude fibre, whiteness and bran pigmentation with progressive polish in rice varieties
J. Food Sci. Technol. (India) **9** (2), 51–56.

For checking under-polishing below 3–4% and over-polishing above 3–4%, silica content and whiteness or reflectance value of rice grains may serve as useful parameters with least varietal variations.

RAO, M. N. & SWAMINATHAN, M. **K20**
1952
Nutritive value of undermilled rice
Bull. Cent. Food Technol. Res. Inst. Mysore, India **2** (10), 262.

Raw husked rice, raw undermilled rice and parboiled undermilled rice are reported on the basis of rat growth studies to have a higher nutritive value than raw milled rice.

RHIND, D. **K21**
1962
The breakage of rice in milling
Trop. Agric. Trin. **39** (1), 19–28.

This review assembles the information on the causes of breakage of rice grains during milling which are inherent in the grain itself rather than in the milling machinery used.

RHIND, D. & TIN, U. **K22**
1933
The effect of temperature on the breakage of rice in milling
Indian J. Agric. Sci. **3**, 658–662.

Results of tests on the relationship of temperature to milling breakage in rice indicated that the control of temperature during polishing is of practical importance to millers and may be a source of serious error in laboratory tests.

ROBERTS, R. L. & WASSERMAN, T. **K23**
1977
Effect of milling conditions on yields, milling time and energy requirements in a pilot scale Engelberg rice mill
J. Food Sci. **42** (3), 802–803, 806.

Pilot scale studies were conducted into the effect of optimum settings and various additives on total and head yield and energy consumption during rice milling. Tables show the results obtained with different pressure bar settings, gate settings and additives (which included 1% H_2O alone and in combination with whole hulls; $CaCo_3$ alone and in combination with 1% H_2O or 5% paddy).

SIDHU, J., GILL, M. S. & BAINS, G. S. **K24**
1975
Milling of paddy in relation to yield and quality of rice of different Indian varieties
J. Agric. Food Chem. **23** (6), 1183–1185.

The effect of extended milling of six varieties of Indian rice was studied for yield, rice breakage, grain dimensions, protein content and amylose content in relation to water uptake and cooking quality.

STAHEL, G. **K25**
1935
Breaking of rice in milling in relation to the condition of the paddy
Trop. Agric. Trin. **12** (10), 255–261.

Results of tests in Surinam indicated that the optimum moisture content for milling was 10.5% or less; that the drier the season the shorter the optimum harvesting period; that re-moistening the paddy at 14% moisture or below causes 'sun-cracks'; that stacking of hand-harvested paddy (grain and straw together) in stooks allows a longer period of field drying before milling quality is reduced.

TAINSH, J. A. R. **K26**
1975
Farmers need mini-mills. 2. For the rice-grower
World Crops **27** (5), 198–199.

Methods of small-scale rice processing in tropical Asia are reviewed, and the nature and magnitude of losses are discussed in relation to the development of 'mini-mills' for use by local farmers, providing a higher degree of processing efficiency and thus higher product yields.

VICHEV, V. **K27**
1974
Effect of moisture content of paddy on processing quality of rice
Khranitelna Prom-st. **23** (3), 31–32. (In Bulgarian)

Moisture content (natural and added moisture) was studied as related to grain cracking, dehulling percentage, whole grain yield and broken grain yield in two cultivars of rice.

See also: A6:26
E7

Hulling and de-branning (other crops)

In the case of grains such as sorghum which will be ground to flour, the bran should be removed as completely as possible before grinding to prevent contamination of ground endosperm with the less desirable bran.

DREWS, E. & REIMERS, H. **L1**
1971
Husking experiments with native oats
Getreide und Mehl. **21** (9), 83–86. (In German)

Wet husking (22% moisture) gave higher kernel yields than dry husking (9% moisture) and white oats generally gave higher kernel yields than yellow oats.

KURIEN, P. P. **L2**
1977
Grain legume milling technology
Rome: FAO/AGS:GLP/77/11, 17 + xii pp.

The author describes traditional and modern methods of dehulling and grinding of grain legumes, in particular improved technology developed at the Central Food Technological Research Institute, Mysore, with a view to efficient processing and higher yields. Tables and diagrams show the results of pilot trials employing the various processing methods.

NARAYANA RAO, M., GOWRI SUR, SWAMINATHAN, M. **L3**
& SUBRAHMANYAN, V.
1958
Effect of milling on the nutritive value of jowar *(Sorghum vulgare)*
Ann. Biochem. & Exp. Med. **18** (1), 27–32.

Polished jowar was found to contain less fibre, calcium, phosphorus, iron and thiamine than unpolished jowar. Rat-feeding trials showed a higher rate of growth and retention of larger amounts of nitrogen and phosphorus with diets of unpolished jowar.

REICHERT, R. D. & YOUNGS, C. G. **L4**
1976
Dehulling cereal grains and grain legumes for developing countries. I. Quantitative comparison between attrition and abrasive type mills
Cereal Chem. **53** (6), 829–839.

Two commercial mills were compared with a laboratory model Strong-Scott barley pearler in the dehulling of pigmented Nigerian sorghums and millets. Study of the reflectance values of the flours and kernel cracking analysis indicated that the abrasive type mill was more suitable for dehulling Nigerian sorghum and millet.

REICHERT, R. D. & YOUNGS, C. G. **L5**
1977
Dehulling cereal grains and grain legumes for developing countries. II. Chemical composition of mechanically and traditionally dehulled sorghum

Cereal Chem. **54** (1), 174–178.

Nigerian sorghum and millet grains were dehulled mechanically in a laboratory barley pearler, and in abrasive and attrition type mills, for comparison with traditionally dehulled grains (pestle and mortar). At 75% extraction, losses of oil, ash and protein were greater in the mechanically dehulled grains. Removal of crude fibre was more efficient in the pearler and abrasive mill.

ROONEY, L. W., FRYAR, W. B. & CATER, C. M. **L6**
1972
Protein and amino acid contents of successive layers removed by abrasive milling of sorghum grain

Cereal Chem. **49** (4), 399–406.

Grain from six varieties of sorghum with different endosperm textures were subjected to controlled, stepwise abrasive grinding until 45% of the kernel remained. Protein content and amino acid content of the fractions were estimated.

Grinding (milling)

In some processes such as wheat milling the removal of an edible part of the grain is deliberate and desired by the consumer. No loss occurs within the definitions used for this document. However, mechanical losses of desired ground products frequently occur, often caused by maloperation of the process, worn equipment etc. Common processes are pounding in a mortar, grinding between horizontal stones (quern), grinding between mechanically driven vertical stones or steel plates.

ADRIAN, J., GOUSSAULT, B., ARNAL-PEYROT. F., SAMSON, M.-F. & SEPIAL **M1**
1975
Milled millet and the protein value of the semolina and flour
Agron. Trop. **30** (1), 43–51. (In French)

Three techniques of millet milling were compared: hand-grinding, Stramil process and Sepial process. Results indicated that the industrial milling yielded flours of similar nutritive value to those produced by hand-grinding.

BREKKE, O. L., GRIFFIN, E. L. & SHOVE, G. C. **M2**
1973
Dry milling of corn artificially dried at various temperatures
Trans. Am. Soc. Agric. Eng. **16** (4), 761–765.

Dry milling quality of artificially dried corn generally decreased as temperature of the drying air increased from ambient to 290° F. While ambient air drying gave corn of the best dry-milling quality, air-drying temperatures up to 140° F in an experimental fluidised-bed dryer produced corn of reasonable quality except for a high percentage of stress cracks.

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE **M3**
1977
Pulses in India – production, agriculture, processing and consumption
Mysore: *Cent. Food Technol. Res. Inst. Rep.* 38 + xii pp.

Chapter IV, pp 9–27, 'Milling technology' contains estimates of losses in processing of legumes and reviews research into improved methods of milling. Average yields of pulses processed by different methods are tabulated.

KURIEN, P. P. & DESIKACHAR, H. R. S. **M4**
1966
Preparation of a refined white flour from ragi (*Eleusine coracana*) using a laboratory mill
J. Food Sci. Technol. (India) **3**, 56–58.

A refined, branfree white flour was obtained from ragi in a laboratory mill. The protein content was low (4%). The shorts and husk fractions were rich in protein, and were wet-processed to yield an edible fraction containing 10.5% protein.

KURIEN, P. P. & DESIKACHAR, H. S. R. **M5**
1962
Studies on refining of millet flours — Ragi *(Eleusine coracana)*
Food Sci. **11** (5), 136–137.

Wet and dry ragi milling processes were studied to determine the composition of various fractions and the percentage extraction of nutrients. Wet processing of the residue of dry milling was also studied.

Wheat milling

BAKER, C. W. & DOTY, N. C. **N1**
1977
Microwave conditioning of durum wheat. II. Optimization of semolina yield and spaghetti quality
J. Agric. Food Chem. **25** (4), 819–822.

Crosby durum wheat was conditioned with microwave energy at 2450 MHz before milling to increase semolina yield and improve spaghetti quality. Semolina and semolina + flour yield could be increased by 1.8 and 2.5% respectively, and cooked spaghetti firmness was increased significantly.

COSTIN, I. **N2**
1974
Means of increasing yield of white wheat flour
Ind. Aliment. **25** (6), 286–290. (In Romanian)

Optimum yields of white wheat flour resulting from experience and experiment in Romanian mills are quoted.

FARRAND, E. A. **N3**
1972
Controlled levels of starch damage in a commercial United Kingdom bread flour and effects on absorption, sedimentation value and loaf quality
Cereal Chem. **49** (4), 479–488.

A UK grist was milled at three levels of starch damage while other measurable parameters were kept constant. Relationships between flour absorption, dough properties, starch damage, yeast levels and loaf quality are discussed.

HOPF, L. **N4**
1974
The amount of yield reduction occurring with worn down flutes
Mullerei **27** (17), 265–266. (In German)

Degree of wear on fast and slow rolls as affecting flour yields is demonstrated.

LISCOMBE, E. A. R. **N5**
1962
Milling losses caused by insect infestation of wheat
Cereal Chem. **39**, 372–380.

The consequences of insect infestation of wheat endosperm on milling yields, and the current US Standard requirements are discussed. The use of an Entoleter-scourer aspirator for cleaning infested wheat prior to milling reduced the number of infested kernels by 40%.

NIKOLENKO, A. **N6**
1971
Influence of mechanical and technological factors on husking efficiency during milling of wheat

Mukomolno-Elevatornaya Prom-st. **37** (1), 15–18. (In Russian)

The relation of technological indicators of husking systems to yield of flour, and of the specific load to the circumferential speed of the high-speed roll were determined under laboratory and commercial conditions.

SEBESTYEN, E. **N7**
1977
How to improve the extraction rate of flour from wheat

J. Flour & Anim. Feed Milling **160** (5), 40–41.

Various methods of improving the extraction rate of wheat flour during milling are briefly reported; grain cleaning, use of coarser plan-sifters etc are discussed.

WASSERMAN, T., FERREL, R. E. & PENCE, J. W. **N8**
1970
Mechanical debranning of whole kernel wheat. I. Engelberg and McGill rice mills

Cereal Sci. Today **15** (5), 134–138, 151.

The effect on debranning efficiency and grain yield of certain milling variables is described. Variables were as follows: number of debranning passes, amount of water sprayed on grain pre-milling, time lapse between spraying and milling, amount and kind of abrasive added, moisture content before spraying, debranning time and mill pressure. Optimum results were obtained on HRW wheat in four passes, with 2% water spray, 1% abrasive ($CaCO_3$), 5 minute temper and moderate milling pressure.

ZWINTELBERG, H. **N9**
1973
Flour and protein yields in milling of single and mixed wheats

Getreide Mehl und Brot **27** (2), 54–58. (In German)

Wheats of different varieties from different areas were milled singly and mixed. Flour and protein yields were estimated at intermediate stages in the milling process. Flour yields differed with variety and area. Both flour yields and moisture content must be taken into account when determining protein loss and yield.

Separation

Whether the separation of edible from less desired products is carried out in the homestead (eg winnowing hulls and bran from rice) or mill (eg sieving flour from bran), a complete separation is desired but rarely achieved. In the case of rice, it is quite difficult to separate the more finely broken grain from bran. In the case of wheat, flour adheres to bran and special equipment is used to remove most of this flour.

See: B23

Secondary processes (cooking, baking, fermenting, etc)

BARANYUK, L. A., ZALESSKAYA, E. V., KARCHIK, S. N., LOKTEVA, T. V. & MELNIKOV, E. M. **R1**
1975
Effect of hydrothermal processes on content of sugars in buckwheat groats and porridge
Izv. Vyssh. Uchebn. Zaved. Pishch. Tekhnol. **4,** 81–83. (In Russian)

Steam treatment reduced the glucose and fructose content of the groats, the reduction increasing with increasing steam pressure. Maltose content showed virtually no change at low pressures, but decreased with increasing pressure. Sugar content was stable after domestic cooking.

BATCHER, O., LITTLE, R. R., DAWSON, E. H. & HOGAN, J. T. **R2**
1958
Cooking quality of white rice milled from rough rice dried at different temperatures
Cereal Chem. **35**, 428–434.

Panel evaluation of colour, cohesiveness and absence or presence of off-flavour in two varieties of rice cooked after drying at different temperatures led to the conclusion that forced air drying of rough rice at elevated temperatures did not cause any marked change in the cooking quality of milled rice.

DESIKACHAR, H. S. R. & SUBRAHMANYAN, V. **R3**
1961
The formation of cracks in rice during wetting and its effect on the cooking characteristics of the cereal
Cereal Chem. **38**, 356–364.

Formation of cracks during wetting took longer in parboiled than in raw rice. After soaking, both raw and parboiled rice required shorter cooking time and cooked grains were longer than in unsoaked samples. Mode of water penetration is described. Grains cracked prior to wetting absorbed water quite fast.

DESIKACHAR, H. S. R., SOWBHAGGA, C. M., VIRAKTANATH, C. S., INDUDHARASWAMY, Y. M. & BHASHYAM, M. K. **R4**
1969
Steaming of paddy for improved culinary, milling and storage properties
J. Food Sci. Technol. (India) **6** (2), 117–121.

KOZMINA, E. P., NAGAICHENKO, L. I. & ANISIMOV, B. N. **R5**
1975
The effect of heat treatment on fatty acids in hulled millet
Izv. Vyssh. Uchebn. Zaved. Pishch. Tekhnol. **3,** 38–41. (In Russian)

Seven fatty acids were determined in lipids and lipid fractions of hulled millet. Unsaturated fatty acids tended to increase on boiling of hulled millet and to decrease in high pressure treatment.

NECHAEV, A. P., MELNIKOV, E. M., ZALESSKAYA, E. V., KORALEV, A. I. & BAIKOV, V. G. **R6**
1975
Changes in lipid and fatty acid contents of buckwheat grain during hydrothermal treatment
Izv. Vyssh. Uchebn. Zaved. Pishch. Tekhnol. **6**, 55–58. (In Russian)

Steam treatment of buckwheat grain changed the composition of fatty acids. Saturated fatty acids content and free fatty acids content decreased; that of unsaturated fatty acids increased.

PAI, M. L. **R7**
1958
Influence of cooking on the nutritional values of foods. Part III. Vitamin A content of some cooked foods
Indian J. Med. Res. **46** (3), 481.

Analysis before and after cooking or baking of several foods composed of cereals, pulses and vegetables showed losses in Vitamin A of up to 70%. Raw milled rice lost in washing and cooking 23% Vitamin A. Different methods of preparation and cooking influenced the loss.

PAI, M. L. **R8**
1958
Influence of cooking on the nutritional values of foods. Part IV. Further data on thiamine, riboflavin and nicotinic acid content of cooked foods.
Indian J. Med. Res. **46** (4), 609.

Thirty-seven foods composed of cereals, pulses and vegetables were analysed before and after cooking. Results showed thiamine, riboflavin and nicotinic acid losses of up to 23, 48 and 30% respectively due to washing, and losses of up to 55, 36 and 38% respectively due to cooking. Direct heat caused higher losses than steam cooking or pressure cooking.

YAROVENKO, V. A., MANERAKI, V. V. & STAVITSKAYA, G. A. **R9**
1974
Effect of hydrothermal processing of the grain on the proteins of millet and buckwheat groats
Izv. Vyssh. Uchebn. Zaved. Pishch. Tekhnol. **1**, 55–57. (In Russian)

Buckwheat and millet grains were moistened, drained, steamed at 1.5 and 2.5 atm. and dried to 14.0 ± 0.5% moisture. Total N content was unaffected but all the individual protein fractions were reduced in both millet and buckwheat, with the exception of the alkaline-soluble fraction in buckwheat, which showed an increase.

See also: A6
J12
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