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9. ABSTRACT

A bibliography intended to draw together what has been published or reported on grain storage losses/damage/estimation and detection. The main efforts toward increased food production have been directed toward greater agricultural production through better cultivation, high-yield varieties, and better fertilizers and insecticides. The necessity for good storage has not received sufficient recognition, partly because of a lack of understanding of the magnitude of losses occurring during harvesting and storage. Data on storage losses can be used as (1) a tool for directing future research and planning; (2) a basis for calculating justifiable expenditures on control; (3) a basis for estimating damage; (4) a means of evaluating the effectiveness of control measures; and (5) a basis for evaluating harvesting machines and machine components with respect to the damage they cause or produce. The bibliography is divided into four sections. The first included literature pertaining to internal infestation and detection procedures. The second concerns losses due to insects, rodents, and birds. The third concerns harvesting, handling, conditioning, and processing losses. The last section covers literature on nutrient, fungal, and germination losses. The four sections contain a total of 705 citations.

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Losses Which Occur During Harvesting and Storage of Grains: A Bibliography

FOOD & FEED GRAIN INSTITUTE
KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS 66506

LOSSES WHICH OCCUR DURING HARVESTING AND STORAGE OF GRAINS:

A BIBLIOGRAPHY

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AGENCY FOR INTERNATIONAL DEVELOPMENT
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Technical Assistance in Grain Storage, Processing and Marketing
and Agribusiness Development

at the
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PREFACE

Mr. A. N. Mphuru, Senior Lecturer in the Faculty of Agriculture, University of Dar es Salaam, Morogoro, Tanzania, spent four months at Kansas State University under a Fullbright-Hayes Fellowship, sponsored by the Council for International Exchange of Scholars. He was hosted at Kansas State University by the Food and Feed Grain Institute under contract AID/ta-C-1162, Technical Assistance in Grain Storage, Processing and Marketing and Agribusiness Development.

Prior to visiting Kansas State University, Mr. Mphuru had been active in grain storage work in Tanzania. He was principal investigator in a study to investigate the traditional grain storage methods in the rural Morogoro and Iringa Regions of Tanzania in which loss assessment was a major consideration. He also served as Director for the Second Course of the FAO/SIDA/Tanzania Sub-regional Training Center on Storage Pest Control held at the Faculty of Agriculture and Forestry of the University of Dar es Salaam, Morogoro, Tanzania May 26 - July 4, 1975.

During the time Mr. Mphuru was at Kansas State University he devoted most of his time to developing a bibliography on losses which occur during harvesting and storage of grains. He also took part in the 1976 AID Grain Storage and Marketing Short Course held at Kansas State University June 21 through August 6, 1976.

Over the past several years, considerable emphasis has been placed on increasing the production of the world's food supply to meet the needs of our growing population. Only recently has there been a realization, on a broad scale, that we need to increase our efforts in the area of harvest and post-harvest food loss reduction as a means of increasing the total available food supply.

Since the late 1940's, there have been various loss estimates published for various parts of the world. Some of these estimates are based merely on guesses, others on limited observations, and a few on well designed studies.

To put the harvest and post-harvest loss picture in proper perspective, there is a need to assess the information that is currently available. This Bibliography is an attempt to bring together in one publication a listing of the available literature on "Losses Which Occur During Harvesting and Storage of Grains." This effort should be of value to others persuing the subject of food losses.

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ATTENTION:

It should be noted that the reports quoted under reference numbers 183, 248, 299, 300, 343 and 349 are restricted TPI documents.

ACKNOWLEDGEMENT

The author acknowledges with gratitude the generous help of many persons and agencies who made this project possible.

The author is especially grateful to the Council for International Exchange of Scholars for financing this project and the University of Dar es Salaam for its willingness to release me for this period to carry out this project.

My sincere appreciation is expressed to Dr. J. R. Pedersen and Dr. R. Mills for their assistance, supervision, encouragement, transportation and other services while I was carrying out this project.

I am grateful to Prof. Knutson for the provision of office and office facilities. Last but not least I would like to express my sincere gratitude to Dr. W. J. Hoover and all others who made my stay fruitful and enjoyable.

INTRODUCTION

The main efforts towards increased food production havebeen directed towards greater agricultural production through efficient cultivation, using high yielding varieties, fertilizers, insecticides and good crop husbandry. The necessity for good storage of the harvest, won with such cost and difficulty, has not received sufficient recognition. The main problem has been due to lack of understanding of the magnitude of losses which occur during harvesting and storage. The nature and magnitude of these losses have been documented by several workers (Freeman, 1952; Herford, 1962; Howe, 1965; Parkin, 1956; Hall, 1970; Tygi and Girish, 1976; Jackson, 1976) and many others.

Most of these estimates have either been based on data from controlled experiments or from guesswork and as such have led to an over- or under-estimate of the extent of losses which occur under field conditions. Furthermore, most of these estimates give no information or clue on the progress of losses during storage.

There are several reasons why reliable qualitative and quantitative assessment of losses are important. Accurate assessment of losses is important and the data can be used: (i) as a tool for directing future research and agricultural planning, (ii) as a basis to calculate justifiable expenditure on control, (iii) in estimating damage that justifies control, (iv) in estimating the effectiveness of control measures and (v) as a basis for evaluating harvesting machines and machine components with respect to the damage they cause or produce.

Although many workers agree that there is a need for loss assessment there is no agreed method of storage loss assessment technique. Similarly, there is no agreed definition of grain "loss" or grain "damage". This is due to the fact that the storage losses are of a multiple nature, including losses in weight, quality, nutritive value, and market value. Each of these types of losses may have different significance that varies with people, time and place and in the face of existing methods, experts would proceed differently in estimating them (Harris, 1972). An agricultural engineer will be mostly interested in losses during combine harvesting, threshing, drying and handling. An entomologist would be mostly interested in losses due to insects while a nutritionist would be mostly interested in losses during processing.

Dobrovsky (1965) suggests that in order to overcome this problem, losses or damage should be expressed as an index. An index may be a ratio or another mathematical expression based on several factors and derived through a number of experimental observations whose relative values are assembled and placed in their logical positions in the body of the formulae. The computed damage index would preferably be a numerical expression which would indicate the current status of a given lot of grain. Since Dobrovsky suggested this procedure, very little work has been done along these lines. This bibliography is intended to draw together in one volume what has been published or reported on grain storage losses/damage/estimation and detection. The bibliography is arbitrarily divided into four sections. The first part includes literature pertaining to internal infestation and detection procedures. The second part includes losses due to insects, rodents,

and birds. The third section covers harvesting, handling, conditioning and processing losses and the last section covers literature on nutrient, fungal and germination losses.

DETECTION AND MICROANALYSIS

1. Adams, R. E., Wolfe, J. E., Milner, M.,and J. A. Shellenberger, (1953). Aural Detection of Grain Infested Internally with Insects. Science 118:163-164.

   Describes the use of a low noise level audio amplifier, suitable microphone and a loudspeaker for detection of insect infestation in grains.

2. Amman, A. D.and S.Tunnock (1971). Radiographic Detection of Agathis Punila Parasite of Larch Casebearer. J. Econ. Entomol. 64 (5): 1086-1088.

3. Anon (1950). Sectioning Technique Developed for Hidden Infestation Tests. Northwest Miller, 244 no. 7 November 1950.

4. Anon (1950). Determination of Hidden Insect Infestation in Wheat. Univ. of Wichita Foundation Ind. Res. Newsletter 5(2): 1,3,4.

5. Anon (1955). Official Methods of Analysis. 10th Ed. Assoc. Official Agric. Chem. Washington, D.C.

6. Anon (1959). United States Standards for Beans, 11 pp., Grain Div., U.S. Agr. Mktg. Serv., Washington, D.C.

7. Anon (1959). Sanitation Analysis. Cereal Science Today 4:301-302.

8. Anon (1965). Methods for the Determination of Infestation of Grain and Damage due to Pests in "State Standards of the USSR Grain and Pulse Crops." Translated by Dr. V. S. Kothekar.

9. Anon (1971). Magnets Detect Insects. Agric. Res. 20 (5) : 7.

   Describes a Simple Method of Detecting Internal Insect Infestation using the Principle of Nuclear Magnetic Resonance in which Magnetic Field Attracts Insects.

10. Apt, A. C. (1950). A Method for Detecting hidden Infestation in Wheat. Northwest Miller 242, No. 6; May 1950.

11. Apt, A. C. (1952). A Rapid Method of Examining Wheat Samples for Infestation. Northwest Miller 247, No. 24; June, 1952.

12. Ashman, F. (1966). Inspection Methods for Detecting Insects in Stored Grain. Trop. Stored Prod. Inf. 12 : 481-494.

13. Ashman, F., Elias, D. G., Ellison, J. F.,and R. Spratley, 1970. Ashman-Simon Infestation Detector: an Instrument for Detecting Insects within Food Grains. Trop. Stored Prod. Inf. 19: 15-19.

    Describes an Instrument which uses the Ninhydrin Technique for Detecting Insect Infestation.

14. Bailey, S. W. and J. B. McCabe (1965). The Detection of Immature Stages of Insects within Grains of Wheat. J. Stored Prod. Res. 1:201-202.

A non-destructive method of detecting insects in grains is described. Mechanical vibrations caused by the activity of the insects are amplified and the signal fed to an appropriate display system.

15. Banerjee, S. K. and A. Singh (1968). Radiographic Detection of Seed Abnormalities in some Horticultural Crops. Indian J. Agric. Sci., 39 (1): 27-31.

16. Bartchat, F. (1935). The Screening and Chloroform Tests as Aids in the Microscopic Investigation of Fodder Meals. Angew. Chem., 48: 549.

    Methods are given which isolate, among other things mites, mite eggs, and mite feces; Part of the material floats, and part sinks in the Chloroform.

17. Belcher, E. W. (1970). Radiography in tree Seed Analysis has new twist. Tree Planter's Notes 24 (3): 1-5.

    Describes the new radiographic paper that can produce image that can be viewed with reflected light. This has revolutionized the use of radiograph in insect detection; testing for seed viability; embryo development etc.

18. Berryman, A. A. and R.W. Stark (1962). Radiography in Forest Entomology. Ann. Ent. Soc. Amer. 55 (4): 456-466.

19. Bhattacharya, A. K. and G.P. Waldbauer (1969). Fecal Uric Acid as an Indication in the Determination of Food Utilization. J. insect. Phys. 15: 1129-1135.

20. Bhattacharya, A. K. and G. P. Waldbauer (1969). Quantitative Determination of Uric Acid in Insect Feces by Lithium Carbonate Extraction and the Enzymatic-Spectrophotometric Method. Ann. Ent. Soc. Amer. 62 (4): 925-927.

21. Blumberg, B. L. and C. W. Ballard (1940). Three Methods for Determining "Foreign" Matter in Flour. Food Ind. 12 (1): 36.

    Chemical and physical tests for flour beetle eggs and excreta are discussed.

22. Blumberg, B. L. (1939). Insect Infestation in Drugs and Flour with Special Reference to the Genus Tribolium MS Thesis Columbia Univ. College of Pharmacy.

    Describes a method of examination of foreign matter in flour which involves sifting, digestive with acid and staining with iodine.

23. Blumberg, B. L. and C.W. Ballard (1940). Further Studies on Foreign Matter in Flour. Food. Ind. 12 (8): 27.

24. Blumberg, B. L. and C. W. Ballard (1940). Three Methods for Determining "Foreign Matter" in Flour. Food Ind. 12 (1): 36.

Chemical and physical tests for flour beetle eggs and excreta are discussed.

25. Blumberg, B. L. and C. W. Ballard (1941). An Acid-Alkali Method for Staining Tribolium Eggs in Flour. Cereal Chem. 18: 355-358.

26. Bredemann, G. (1911). The Quantitative Determination of Smut Spores in Flour, Bran and Grain. Landw. Vers. Stat. 75: 134.

27. Bredemann, G. (1915). Determination of the Mildew-Spore Content of Flour, Bran and Grain. Landw. Vers. Stat. 87: 241.

28. Brindley, J. A. and H. J. Shipman (1920). Influence of Specific Gravity on the Separation of Weevil-Infested Peas. Seed World, Chicago, Feb. 28, 1920.

Describes the use of sodium chloride solution with specific gravity of 1·20 to 1·26 for separating weevil infested peas.

29. Brizi, U. (1908). Detection of Spoiled Maize by Means of the Microscope. Ric. Lab. Chi. Agr. r. Scuola Sup. Agr. Milano 3: 159.

Describes a technique for observing and identification of mold in maize.

30. Bruce, A. W. and M. W. Street (1974). Infra-red CO_2 Detection of Hidden Insects. J. Georgia Entomol. Soc. 9: 260-265.

A method is described which uses an intermittent flow of a carrier gas with alternating intervals for sample collection and sample readout in conjunction with bolus-activated infrared CO_2 analyzer.

31. Butcher, C. H. (1934). The Microscopy of Food Products. V. Flour Food 3: 415.

32. Chiang, B. Y., Miller, G. D., and J. A. Johnson (1973). Measuring Damaged Starch by Polarimetric Method. Cereal Chem. 50: 44-49.

A method based on polarimetric determination of starch in calcium chloride solution and on the fact that damaged starch is digested more easily by α-amylase is described.

33. Chung, D. S. and H. H. Converse (1970). Internal Damage of Wheat Analyzed by Radiographical Examination. Trans. ASAE 13 (3): 295-297.

34. Coombs, C. W. (1963). A Method of Assessing the Physical Condition of Insect Damaged Grain and its Application to a Faunistic Survey. Bull. Entomol. Res. 54: 23-35.

35. Cook, J. W. and A. W. Steers (1947). Detection of Fecal Matter in Food Products I. Investigations of the use of Trypsin and Alkaline Phosphatase Activity of Feces as a Measure of Contaminations. J. Assoc. Official Agric. Chem. 30: 168.

36. Cotton, R. T. (1962). How to Detect Hidden Insect Infestation in Grain. Northwest Miller 266 (1), Jan 8, 1962.

Cotton reviews various techniques available for detecting internal infestation.

37. Cotton, R. T. and D. A. Wilbur (1974). Insects In Storage of Cereal Grains and their Products. Am. Assoc. Cereal Chem. Ed. by C. M. Christensen.

38. de Carvalho, J. P. (1963). Contribution of the Radiographic Method for the Study of Sitotroga cerealella. Agriculture (Lisbon) 19: 22-25.

39. Dell' Orto, T. H. (1969). A Method of Determining the Presence of Infestation by Larvae of the Grain Moth Sitotroga cerealella in maize. Agriculture téc 29: 89.

A measured sample is boiled for 10-15 minutes in 10% NaOH. After cooling, water is added and the liquid is trained through gauze. Remains of larvae, cocoons, pupa etc. are then counted.

40. Dennis, N. M. (1953). A Technique of Grain Orientation for Radiographic Analysis. U.S. Dept. Agr. Bur. Entomol. Plant quarantine ET 256.

41. Dennis, N. M. and R. W. Decker (1962). A Method and Machine for Detecting Living Internal Insect Infestation in Wheat. J. Econ. Entomol. 55 (2): 199-203.

Describes a chemical indicator technique in which the body fluids of the insects produced a colour reaction with ninhydrin-inpregnated filter paper.

42. Douglass, J. R. and K. E. Gibson (1956). A Simple Device for Determining Insect Damage to Seeds. USDA Agric. Res. Serv. ARS-33-35.

Describes a visual technique of examination utilizing glass mirrors for better vision.

43. Dubois, D. (1952). Use of the X-ray in Milling Wheat Selection. Milling Prod. 248 (11): 1a, 18a.

44. Eighme, L. E. (1964). A Laboratory Device for Observing Insects and Mites Involved in Heating of Stored Grain. J. Econ. Entomol. 57 (6): 998-999.

Describes a technique which measures the temperature changes in infested grain.

45. Eisenberg, W. V. and K. L. Harris (1942). Method for Detection of Mammalian Urine Stains on cloth bags used as food containers. J. Assoc. Official Agric. Chem. 25: 772.

46. Enoch, C. (1929). Determination of Sand in Rice Fodder Flour. Chem. Ztg. 53: 891.

Describes a technique which involves boiling with 10% NaOH; wash with 1.25% H_2SO_4; ignite; and weigh.

47. Farrell, E. P. and M. Milner (1952). Insect Fragment Problem in the Milling Industry. Contribution No. 219, Department of Flour and Feed Milling Industries, Kansas Agric. Exp. Station, Manhattan, KS.

Describes a technique of removal of insects from wheat by cracking, aspirator and entoleter system.

48. Farrell, E. P., Milner, M., and R. Katz (1954). Separation of Grain by Projection into still air. Northwest Miller, 252 No. 15, October 12, 1954.

A Method of separating infested grains by projecting each grain at uniform velocity into still air is described.

49. Fesus, I. (1972). Detection and estimation of internal pest infestation in seeds by the Application of X-ray Techniques. OEPP/EPPO Bull. No 3: 65-76.

The radiographic process most appropriate to quarantine practice is presented.

50. Frankenfield, J. C. (1948). Staining Methods for Detecting Weevil Infestation in Grain. U.S. Dept. Agric. Bur. Entomol. Plant Quarantine ET 256.

Describes the use of Acid Fuchsin dye in staining egg-plugs.

51. Gier, H. T. (1949). Differential Stains for Insect Exoskeleton. J. Kansas Entomol. Soc. 22: 79-80.

Gives an account of the use of Giemsa stain (Azure II - Eosin) for staining the exoskeleton.

52. Gier, H. T., Wilbur, D. A. and G. D. Miller (1945). A Differential Stain for Identifying Insect Fragments in Flour. Milling Prod. 14, No. 4, April 1949.

The use of Azure I or Azure A or Methylene Azure for staining insect fragments is described.

53. Girish, G. K., Gopal, K., and K. Krishnamurthy (1971). Studies on the Detection of Latent Insect Infestation in the Food Grains. Bull. Grain Techn. 9 (4): 265-268.

Results on the studies of the development of Sitophilus oryzae using Ashman-Simon infestation detector (Ninihydrin) is described.

54. Girish, A. K., Goyal, R. K., Srivastava, P. K. and K. Krishnamurthy (1972). An Easy Method for Detection of the Eggs of Tribolium castaneum and Trogoderma granarium in milled products. Bull. Grain Techn. 10 (2): 97-99.

A flotation technique using supersaturated solution of sodium chloride with specific gravity 1·198 followed by centrifugation and microscope observations is described.

55. Goosens, H. J. (1949). A Method for Staining Insect Egg Plugs in Wheat. Cereal Chem. 26 (5): 419-420.

Goosens describes the staining of egg plugs using gentian violet.

56. Graham, H. M., Robertson, O. T. and D. F. Martin (1964). Radiographic detection of Pink bollworm larvae in cotton seed. J. Econ. Entomol. 57 (3): 419-420.

57. Greene, W. S. (undated). A method for the recovery of rodent hairs from flour. Food and Drug Admin. Mimeograph, 10-26-33.

Describes the use of salt solution to float insect and rodent filth.

58. Greenway, W. T. (1972). A fundamental and a rapid empirical test for dust in corn. Cereal Chem. 49: 151-157.

The fundamental procedure employs suction and mannual shaking to evacuate all dust from corn and to trap it in distilled water. The dust is filtered in to crucible, dried, and weighed to determine % dust.

59. Harein, P. K. (1960). Methods of detecting hidden infestations in grain. Pest Control. 28 (2): 35-36.

He summarizes the procedures for detecting internal insect infestation using staining methods, (acid fuchsin, gentian violet, berberine sulfate), cracking flotation method and simple flotation method.

60. Hart, J. R. (1970). A flotation method for determining extent of weevil infestation in peas. J. Econ. Entomol. 63: 1060-1062.

Damaged peas may be removed from a sample by flotation in a salt solution containing 300g of sodium chloride per litre of water.

61. Hart, H. V. and A. M. Heighton (1953). The separation of rodent hairs and insect fragments from oat products. Analyst 78: 439-440.

62. Harris, K. L. (1940). Proposed Rapid method for the separation of insects from wheat flour. Food & Drug Admin. Mimeograph 11-15-40.

63. Harris, K. L. (1941). General Principles for the study of insect and rodent filth in cereals. Food and Drug Admin. Mimeograph 12-18-41.

64. Harris, K. L. (1941). Foreign matter in corn meal. Cereal Chem. 18: 655-661.

65. Harris, K. L. (1943). Some application of insect separation methods to entomology. Proc. Entomol. Soc. Wash. 45: 1-

Reviews various insect extraction procedures and given current bibliography.

66. Harris, K. L. (1946). Annotated bibliography of methods for the examination of foods for filth. J. Assoc. Official Agric. Chem. 29: 420-439.

67. Harris, K. L. (1950). Identification of insect contaminants of foods by the micromorphology of the insect fragments. J. Assoc. Official Agric. Chem. 33: 898-911.

68. Harris, K. L. (1954). Symposium on extraneous materials in foods and drugs. J. Assoc. Official Agric. Chem. 37: 136-137.

69. Harris, K. L. (1955). Additional bibliography of methods for the examination of foods for filth 1946-1954. J. Assoc. Official Agric. Chem. 38: 1016-1019.

70. Harris, K. L. (1958). Insect infestation of grain and contamination of cereal products. Cereal Sci. Today 3: 12-15.

71. Harris, K. L. and R. T. Elliott (1943). Microscopic method for detection of insect excreta in flour meal. J. Assoc. Official Agric. Chem. 26: 257-259.

72. Harris, K. L. and O. L. Kurtz (1960). Diagnostic sanitation analyses in food and drug control. Food Technol. 14: 33-36.

73. Harris, K. L., Nicholson, J. F., Randolf, L. K. and J. L. Trawick (1952). An investigation of insect and rodent contamination of wheat flour. J. Assoc. Official Agric. Chem. 35: 115-158.

74. Harris, K. L. and H. L. Reynolds (1960). Microscopic-analytical methods in food and drug. Food and drug technical bulletin No. I. U.S. Dept. of Health, Education and Welfare.

75. Harris, K. L., Trawick, J. L., Nicholson, J. F. and W. Weiss (1953). An investigation of rodent and insect contamination of corn and corn meal. J. Assoc. Official Agric. Chem. 36: 1037-1064.

76. Hogan, J. T. et al (1954). X-ray and photomicrographic examination of rice. J. Agric. Food Chem. 2 (24): 1235-1239.

77. Holling, C. S. (1958). A radiographic technique to identify healthy parasitized and diseased sawfly prepupae within cocoon. Can. Entomol. 90 (1): 59-61.

78. Howard, B. J. (1922). A net micrometer for use in making mould counts. J. Assoc. Agric. Chem. 6: 50.

79. Howard, B. J. (1939). Estimation of insect excrets in flour. Food and Drug Admin. Mimeograph 1-7-39.

80. Howe, R. W. and T. A. Oxley (1944). The use of carbon dioxide production as a measure of infestation of grain by insects Bull. Entomol. Res. 35: 11-22.

81. Howe, R. W. and T. A. Oxley (1952). Detection of insects by their carbon dioxide production. Dept. of Sci. and Industries Research. Pest Infestation Research. H.M.S.O. Publications.

82. Hurlock, E. T. (1963). Detection of insects in dried peas. Food Manufacture 38 (7): 367-369.

83. Katz, R., Milner, M., and R. M. Lee (1956). X-ray grain inspection apparatus. U.S. Patent 2,737,594.

84. Katz, R., Farrell, E. P., and M. Milner (1954). The separation of grain by projection. Cereal Chem. 31 (4): 316-325.

A devise is described which effects a continuous separation of internally infested wheat from sound wheat. A stream of wheat is projected into still air by rapidly moving belts.

85. Katz, R., Lee, M. R. and M. Milner (1950). X-ray inspection of wheat. Kansas Agric. Exp. Station, Manhattan. Contribution No. 190, Dept. of Milling Industry.

86. Kent-Jones, D. W., et al. (1948). The micro-analytical test for purity in food with special reference to cereal. Analyst 73: 128-138.

87. Keppel, G. E. and K. L. Harris (1953). An evaluation of 5 procedures for the determination of internal insect infestation of wheat II. Gelatinization in sodium hydroxide. J. Assoc. Official Agric. Chem. 36: 140-144.

88. Khare, B. P. and R. B. Mills (1968). Development of Angoumois grain moths in kernels of wheat, sorghum and corn as affected by site of feeding. J. Econ. Entomol. 61 (2): 450-452.

89. King, J. and R. E. Weston (1950). Fluorescence microscopy as an aid to food and drug analysis. Analyst 75: 397-401.

90. Kirkpatrick, P. L., Niffenegger, D., and D. L. Yancey (1972). Detecting stored-product moths in a peanut warehouse by using light traps and larvae traps. USDA Marketing Res. Report No. 938.

The use of ultraviolet and greenlights for attracting moths is described. The green light traps were satisfactory for this purpose.

91. Kiteley, E. J. (1954). Some collaborative investigations of methods for isolating material from wheat flour. J. Assoc. Official. Agric. Chem. 37: 139-147.

92. Kurtz, O. L. (1965). Comparison of AACC and AOAC methods for extraeous materials in flour. J. Assoc. Official Agric. Chem. 48 (3): 554-558.

93. Kurtz, O. L. (1954). An approach to insect larval identification by structures isolated by fragments from cereal products. J. Assoc. Official Agric. Chem. 37:167-169.

94. Kurtz, O. L. and K. L. Harris (1960). Insect fragment contamination in cereals. Cereal Sci. Today 5:37-38.

95. Kurtz, O. L., Carson, N. A., and H. C. Van Dame (1952). Identification of cereal insects in stored grain by their mandible characteristics. J. Assoc. Official Agric. Chem 35:817-826.

96. Laakso, J. W., Ferrigan, M. O., Schultze, M. O. and W. F. Geddes (1956). A simple method for detecting contamination of wheat by rodent urine. Cereal Chem. 33:141-145.

This is a staining technique in which the kernels are first treated with urease solution (pH 6.8) for 5 minutes followed by addition of Nesslers reagent which forms a yellow to orange complex with rodent urine. Acuity of differentiation between normal and contaminated kernels is increased by examination with ultraviolet light.

97. Loschiavo, S. R. and J. M. Atkinson (1967). A trap for the detection and recovery of insects in stored grain. Can. Entomol. 99(11): 1160-1163.

This is a small trap that excludes grain kernels but permits the entry of grain beetles.

98. McCormack, T. H. (1954). Extraneous materials in spices. J. Assoc. Official Agric. Chem. 37:157-161.

99. Microanalytical Division, U. S. Food and Drug Admin. (1944). Microanalysis of Food and Drug Products. Food and Drug Circula. No. 1. Superintendent of Documents, Washington, D.C.

This is a compilation of filth separation and identification as used by Food and Drug Admin. Plant sanitation, rodent contamination, etc.

100. Mills, E. M. (1944). Ultra-violet light: An aid to the pest control operator. Pests 12 (6): 25.

Describes the ultraviolet light to determine presence of rodent urine. The rodent urine fluorescent in ultraviolet light.

101. Mills, R. B. and D. A. Wilbur (1967). Radiographic studies of Angoumois grain moth development in wheat, corn, and sorghum kernels. J. Econ. Entomol. 60(3):671-677.

102. Milner, M. (1958). New methods to detect and eliminate insect infested grain. Adv. Food Res. 8:111-131.

A very comprehensive review of various techniques of detecting insect infested kernels.

103. Milner, M., Barney, D. L. and J. A. Shellenberger (1950). Use of selective fluorescent stains to detect insect egg plugs on grain kernels. Science 112:791-792.

Describes the use of alkaloid berberine sulfate for staining egg-plugs.

104. Milner, M.,Lee, M. R. and R. Katz (1950). Application of X-ray technique to the detection of internal insect infestation of grain. J. Econ. Entomol. 43 (6): 933-935.

105. Milner, M.,Katz, R., Lee, M. R., and W. B. Pyle (1953). Application of the Polaroid-hand process to radiographic inspection of wheat. Cereal Chem. 30(2):169-170.

106. Milner, M., Farrell, E. P., and R. Katz. (1953). Use of a simple blowing device to facilitate inspection of wheat for internal infestation. J. Assoc. Official Agric. Chem. 36(4):1065-1070.

107. Milner, M., Lee, M. R., and R. Katz (1952). Radiography applied to grain and seeds. Food Technol. 6(2): 44-45.

A radiographic method for the detection of internal insect infestation in grain by means of low energy radiation from a cobalt-target berylium-window x-ray tube is described.

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109. Milner, M., Farrell, E. P. and R. Katz (1954). The separation of grain by projection II. Systematic differences in physical properties and composition of wheat fractions. Cereal Chem. 31(4):326-352.

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111. Nicholson, J. F. (1954). Some application of radiography to the examination of Food and Drugs. J. Assoc. Official Agric. Chem 37:148-153.

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115. Nicholson, J. F., Kurtz, O. L. and K. L. Harris (1953). An evaluation of 5 procedures for the determination of insect infestation of wheat VI. Investigations of the x-ray inspection of wheat. J. Assoc. Official Agric. Chem. 36:156-159.

116. Nicholson, J. F., Kurtz, O. L., and K. L. Harris (1953). X-ray examination for the detection of internal insect infestation in corn. J. Assoc. Official Agric. Chem. 36:993-1001.

117. Oxley, T. A. (1944). A simple gasometric apparatus for estimation of carbon dioxide. Chem. Ind. (London) 3:24-25.

118. Pedersen, J. R. and R. A. Brown (1960). X-ray microscope to study behavior of internal infesting grain insects. J. Econ. Entomol. 53(4):678-679.

119. Pesho, G. (1954). Detection of immature rice weevils Sitophilus oryzae by audio amplification. MS thesis, Kansas State College.

120. Peters, R. W. and R. Katz (1962). Using a density gradient column to determine wheat density. Cereal Chem. 39(6):487-494.

121. Pixton, S. W. (1965). Detection of insect infestation in cereals by measurement of uric acid. Cereal Chem. 42(3):315-322.

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124. Potter, G. C., Shellenberger, J. A., and M. Miller (1952). The effect of cleaning on the detection of insect egg plugs in wheat. Tras. Am. Assoc. Cereal Chem. 10(3):181-187.

Noted that the egg-plug count decreased as the grain was washed or subjected to abrasion.

125. Radley, J. A. (1951). Ultraviolet radiation in the food industry Part II. Food 20, February 1951.

126. Reed, G. L. and K. L. Harris (1953). An evaluation of five procedures for the determination of internal insect infestation of wheat. I. Berberine sulphate fluorescent stain for weevil egg plugs. J. Assoc. Official Agric. Chem. 36:138-143.

127. Schoenhem, W. H. (1954). Identification of insect fragments in Cereal products. J. Assoc. Official Agric. Chem. 37:154-155.

128. Sharifi, S. and R. B. Mills (1971). Developmental activities and behaviour of the rice weevil inside wheat kernels. J. Econ. Entomol. 64 (5):1114-1118.

129. Sharifi, S. and R. B. Mills (1971). Radiographic studies of Sitophilus zeaviais in wheat kernels. J. Stored Prod. Res. 7:195-206.

130. Shchastny, N. (1940). Determination of mites and mite eggs in flour. Chem Zentr. 1:1284.

Flour is treated with alcohol, centrifuged, treated with sodium chloride solution-glycerol solution, stirred and centrifuge eggs to surface.

131. Shellenberger, J. A., et al (1953). An investigation of insect fragment production in milling using radioactive rice weevils. Contribution No. 234, Dept. of Flour and Feed Milling Industries, Kansas State University.

132. Shevchenko, M. I. (1937). Revealing seed pests by means of X-rays (Rus.) Plant Prot. 14:14-25 Eng. summ.

133. Sica, S. J. and R. A. Nanz (1950). Identification of insect fragments in spices and other food materials utilizing differential stains. J. Assoc. Official Agric. Chem. 33:895-897.

134. Singh, A. and S. K. Banerjee (1968). Use of radiography in seed and grain technology. Bull. Grain Techn. 6(2):96-101.

135. Singh, A. and S. K. Banerjee (1968). Detection of mechanical damage in soya bean (Glycine max) seed by radiographic analysis. Current Sci. 37(11):322-323.

136. Smith, H. R. (1954). Instruction in microanalytical methods. J. Assoc. Official Agric. Chem. 37:170-177.

137. Smirnov, A. M. (1938). The antiformin method for detection of mites in flour and bread-stuffs (RUS). Chem. Zentr. 2:2181.

Food treated with antiformin is centrifuged and the sediments are examined.

138. Solomon, M. E. (1945). Tyroglyphid mites in stored products; methods for the study of population density. Ann. Appl. Biol. 32 (1):71.

139. Street, M. W. (1971). Nuclear magnetic resonance for detecting hidden insect infestation in stored grain. J. Georgia Entomol. Soc. 6(4): 249-254.

140. Stedman, H. (1950). Wheat selections for fragmentation count. Bulletin Assoc. Operative Millers, Feb., 1950.

141. Stermar, R. A. (1972). An automated x-ray inspection system for measuring "hidden" insect infestation in grain. Paper presented at the Corn Refiners Association "Grain Seminar" held at the Grain Marketing Research Center, USDA, Manhattan, Kansas, March 7-8, 1972.

142. Strivastava, B. K. and S. K. Bhatia (1958). Detection of injury by germination test. Indian J. Entomol. 20:157-158.

143. Turner, W. K. and L. F. Charity (1971). Determining response of insects to radiation by continuous monitoring of their carbon dioxide output. Ann. Entomol. Soc. Am. 64:419-424.

144. Venkat Rao, S. et al. (1959). An improved method for the determination of uric acid in insect infested foodstuffs. Ann. Bioch. Exp. Med. 19:187-190.

A new improved system for the determination of uric acid using the enzyme uricase is described.

145. Venkat Rao, S. et al. (1957). The relation between the uric acid content and the extent of kernel damage in insect infested grain. Food Sci. 6(12): 273-275.

146. Venkat Rao, S., Nuggehalli, R. N., Swaminathan, M., Pingale, S. V. and V. Subrahmanyan (1957). A simple method for assessing the extent of insect damage in commercial samples of food stored grains. Food Sci. 6(5):102-103.

147. Wallis, T. E. (1923). Analytical microscopy. Edward Arnold and Company, London.

148. Walkden, H. H. (1957). Detecting hidden infestation. Grain and Feed Journ. consolidated 114(6):37-38.

Reviews several techniques for detecting hidden infestation. These include visual, egg-plug stain, carbon dioxide production, sectioning, flotation, x-ray etc.

149. Walker, N. H. and G. Dalby (1947). Extraneous materials in ground spices and chocolate. Cereal Chem. 24:283-290.

150. Weak, E. D., Miller, A. D. Farrell, E. P. and C. A. Watson (1972). Rapid determination of germ damage in cereal grains. Cereal Chem. 49(6): 653-663.

151. White, G. D. (1949). An apparatus for rapidly inspecting both sides of small objects. USDA Agric. Res. Admin. Bureau Ent. Plant Qua. ET-265.

152. White, G. D. (1954). The detection of insect infestation in wheat by immersion in fluids of different gravity. USDA Agric. Marketing Service. Marketing Research Division. Special Report A-114.

153. White, G. D. (1956). Studies on separation of weevil-infested from noninfested by flotation. USDA Agricultural Marketing Service. Marketing Research Division AMS-101.

154. White, G. D. (1957). The practicability of flotation as a means for detecting interval insect infestation in wheat. Down to Earth, Summer 1957, p. 8-9.

155. White, G. D. (1970). Radiography to facilitate bagworm egg counts. J. Econ. Entomol. 63(3):910-911.

156. White, G. D. (1956). Studies on separation of weevil-infested from noninfested wheat by flotation. Milling Prod. 21(4):1,24.

157. Whitney, W. K., and E. E. Ortman (1962). Gas chromatography for measuring insect respiration. J. Kansas Entomol. Soc. 45(3):323-332.

158. Wildmann, J. D. (1932). A simple method for separating certain insects from food products. Science 75:168.

159. Winburn, T. F. (1940). Insect infestation in farm-stored grain in Kansas. Trans. Kansas Acad. Sci. 43:289-290.

160. Wirtz, A. L. and J. A. Shellenberger (1963). A rapid method to determine insect infestation in grain using electrcity. Cereal Sci. Today 8(9):305-306.

161. Wojcik, D. P. (1968). Tests for audible and ultrasonic sound production by stored products insects. J. Econ. Entomol. 61(5):1414-1417.

162. Yate, O. H. (1967). Radiographic detection by Rhyacionia larvae pupae, parasites and predators within pine shoots. J. Georgia Entomol. Soc. 2(3):81-85.

163. Yuasa, H. (1926). On the advantage of the x-ray examination of certain classes of materials and insects subject to plant quarantine regulations. Proc. 3rd Pan-Pacific Sci. Congress, Tokyo. Vol 1. p. 1141.

ESTIMATE OF LOSSES DUE TO INSECTS

RODENTS AND BIRDS

164. Adams, J. M. and G. W. Harman (1976). The evaluation of losses in maize stored on a selection of small farms in two areas of Zambia with particular reference to methodology. Tropical Products Institute. (to be published).

165. Adams, J. M. (1976). Report on post harvest loss assessment in durable produce, with particular reference to methodology. Paper prepared for the meeting of GASGA, Montpellier, France, 23-25 June 1976.

Gives progress report on: data and literature collection on postharvest loss assessment; questionnaire survey to identify all people working on storage loss assessment; laboratory testing some methods to assess losses during storage.

166. Adams, J. M. (1976). A guide to the objective and reliable estimation of food losses in small scale farmer storage. Draft paper: to be submitted for publication in Trop. Stored Prod. Inf.

Noted that losses in storage are of different types and hence the ultimate use of any estimate must be considered when conducting loss assessment. In arriving at the total loss, the pattern of consumption and grain disposal must be taken into account.

167. Adams. J. M. (1972). Storage loss assessment techniques: A biologists view. Mimeograph paper 10pp. Tropical Stored Products Institute.

The author reviews the important factors involved when planning a project to estimate losses in stored grain at the village level. Both planning and technique methodology are discussed with reference to problems likely to be encountered.

168. Adesiyun, A. A. (1973). Bird damage to cereals grown in the dry season in some parts of Northern Nigeria. Samaru Agric. Newsl. 15(1):34-37.

169. Ahi, F. N. (1956). Wings over the Congo. Boston Publishing Company 1956. p. 148.

Losses of the order of 20-30% are reported in the Congo basin

170. Ahmad, M. R. and M. Ahmed (1969). Evaluation of losses caused by bruchids. Pakistan J. Sci. Res. 21:117-122.

Under laboratory conditions Callosobruchus maculatus caused a loss in weight of the order of 22·8%, 48·58% and 61·14% in grain, Phaseolus munge, and wash respectively after a 4 week storage.

171. Anon. (1945). Famine enquiry. Govt of India, Famine Enquiry Commission, 1945, Final Rept. pp. 158-164.

Noted that the normal losses to crop in India from diseases, pests, vermin, etc. may be placed at 10% of the total produce.

172. Anon,(1950). Pyrenone prevents grain insect damage to stored wheat. U.S. Industrial Chemical Co. publications.

Observed that wheat graded "weevily" had increased from 3.45% in 1948 to 4.28% in 1952. With light infestation,(2%), the total loss was about 6¢ per bushel while with heavy infestation (10%) the loss increased to 45¢ per bushel.

173. Anon, (1954). Losses from pests --- A new evaluation. NACA News and Pesticide Rev. May-June, 1954 p. 8.

In this popular article it is estimated that rats destroy 359 million dollars worth of stored crops and insects cause value decreases of 218 million dollars. The total post-harvest losses are put at 38 billion annually.

174. Anon, (1954). Southern PCO Conference told economic importance of rat control. Pest Control 22(3):28, 42.

It is indicated that in the U.S.A. the losses due to insects amount to about 4 billion annually. It was estimated that there was two rats to every person on farms and one rat for every five city dwellers.

175. Anon, (1954). Losses in Agriculture. U.S.D.A. Bull. A25-20-1.

Attempt is made to assemble the information available on the various types of losses to agricultural crops and livestock for the year 1942-1951. Corn losses were estimated to be about 51,947,000 bushels, wheat losses 58,211,000 bushels and sorghum losses 24,223,000 bushels.

176. Anon, (1958). Report on meeting of specialist on stored food products. Sci. Council for Africa. South of Sahara. Publication no. 31. pp. 200.

Work in Congo showed that after one year's storage the loss of weight resulting from insect attack was: for sorghum 50%; for beans 20%; and for groundnuts 15%.

177. Anon (1959). African agriculture in Nyasaland (Malawi). Dept. Agric. Zomba, Malawi p. 75.

It is estimated that the loss of the order of 20-30% occur annually during storage of grains.

178. Anon, (1969). "Storage problems in developing countries: The role of storage in world food supplies." World Food Problems No. 9. FAO, Rome.

Estimate of losses in USA and India are given. Discusses the shortcomings of the estimates so far reported. Noted that at farm level a farmer will constantly be withdrawing supplies for his own consumption and consideration should be taken into account when one is estimating losses.

179. Anon (1969). Rapport d'activite de la commission d'evaluation des pertes dans les denrees stockees crie a l'issue du congress de Marseille la protection des cultures tropicales. L'Agron. Tropicale, Paris 24(a):872-876.

Describes a simple method of estimating losses. The grain is separated into damaged and undamaged categories. The damaged sample is further subdivided according to cause and the loss in weight calculated according to a given formulae.

180. Anon (1970). Economic losses in Gambian Groundnuts. Trop Stored Prod. Inf. 20:1-2.

In Gambia by comparing the weight of insect-damaged and sound grains it was estimated that for the year 1968 the apparent loss in weight was 2,500 tons, while the cash losses were £180,000.

181. Anon (1970). Sorghum storage survey (MN 1978). Ann. Rept. Dept. Agric. Zambia, p. 141.

The survey to assess losses in rural areas showed that at harvest the damage is about 1% which rose to 7% damage in 5 months storage.

182. Anon (1971). Maize storage survey (NRDC). Ann. Rept. Res. Branch. Dept Agric.- Zambia, 1970-1971.

183. Andrews, W. H. and J. M. Adams (1971). A short review of the information on the economic of storage losses. TSPC Int. Rep. dupl. 45 pp.

A comprehensive account on various projects going on on estimate of losses with particular reference to Africa. For each project an account is given on purpose, sampling procedure, methodology of assessing losses and results.

184. Back, E. A. (1919). Conserving corn from weevils in the gulf coast states.

Back estimated that weevils destroy 1,260,000 bushels annually, 10% of Florida's crop. In South Carolina the losses were estimated to range from 2% to 75% with an average of 14%.

185. Barnett, S. A. (1951). Damage to wheat by enclosed populations of Rattus norvegicus. J. Hyg. (Cambr) 49:22-27.

Small enclosed populations of the common rat (10 to 26 rats) each with access to one ton of sacked wheat for 12-28 weeks caused a loss in weight of 4.4% of the wheat. 70.4% of the wheat was fouled.

186. Barnett, S. A. (1967). Rats. Sci. Am. 216:79-85.

Discusses the biology, ecology and population dynamics of rats and their potential as pests of storage and field crops.

187. Beckley, V. A. (1948). Protection of grain against weevils. East Afr. Agric. For. J. 14(2):71-76.

Records that in Germany in 1948 losses caused by insects was worth 10 mill. R.M. while in Kenya the level of damage could be as high as 50%.

188. Brooker, R. H. (1967). Observations on three bruchids associated with cowpea in northern Nigeria. J. Stored Prod. Res. 3: 11-15.

Noted that field infestation was about 2%. In laboratory observations one bruchid can cause a 3-5% weight loss in a cowpea seed. The decrease in weight loss per individual insect is lower when there are several larvae per seed.

189. Brooke, C. (1967). Types of food shortages in Tanzania. Georgr. Rev. 57(3):333-357.

190. Brooker, D. B., Arkena, F. B. and C. W. Hall (1974). Grain Losses. In: Drying Cereal Grains. The Avi Publishing Company Inc., Westport.

Estimate losses of 5-50% from the time reaches maturity to the time of their consumption. He categorizes the type of losses into: Field losses, harvesting losses, shelling losses, handling losses, drying losses and storage losses.

191. Brower, J. H. and E. W. Tilton (1973). Weight loss of wheat infested with gamma radiated Sitophilus oryzae and Rhyzopertha dominica. J. Stored Prod. Res. 9:37-41.

The possible use of radiation to control pests is described. The radiated species caused less damage than normal insects. After 5 weeks storage the loss in weight was 3-11% as compared with control.

192. Bull, J. O. (1973). Rodents and food spoilage. Chem. Ind. (London) 1056-1057.

Reviews the type and extent of damage caused by rodents. Noted that there are few accurate estimate of losses. May estimates are guess work; few from experimental work.

193. Bull, J. O. and M. E. Solomon (1958). The yield of Lasioderma serricorne from a given quantity of food stuffs. Bull. Entomol. Res. 49:193-200.

194. Calhoun, J. B. (1962). The ecology and Sociology of the Norway rat. U.S. Public Health Serv. Publication 1008.

195. Campbell, A. and R. N. Sinha (undated). Damage of wheat by feeding of some stored products beetles. Unpublished manuscript.

196. Caswell, G. H. (1961). The infestation of cowpeas in Western regions of Nigeria. Trop. Sci. 3(4):154-158.

197. Caswell, G. H. (1968). The storage of cowpeas in the Northern states of Nigeria. Proc. Agric. Soc. (Nigeria) 5:4-6.

Gives results of estimate of losses of cowpeas from monthly samples from the market. Noted that there was a correlation between the number of bruchids per seed and extent of damage. By extrapolation using this technique he found out that about 24,000 tons are being lost annually which are worth £ 840,000.

198. Caswell, G. H. (1973). The impact of infestation on commodities. Trop. Stored Prod. Inf. 25:19.

199. Chahal, B. S. (1973). Avoid grain losses in storage. Progr. Farming 9(9):19.

200. Chambon, R. and A. Leruth (1954). Monographs des bena Muhona, Territoire de Kongolo-District du Tanganyika. Bull. Agric. Congo:Belge, June 1954.

Gives estimates due to various storage pests, 20 to 30%.

201. Chester, K. S. (1950). Plant disease losses: Their appraisal and interpretation. Plant Dis. Rep. Suppl. 193:196-208.

Discusses in detail the value of reliable crop loss data.

202. Chiareppa, L., Chiang, H. C. and R. F. Smith. Plant pests and diseases: Assessment of crop losses. Science 176:769-773.

Reviews the value and need for crop loss information.

203. Christensen, C. M., Mirocha, C. J. and R. A. Meronuck (1971). Some biological and chemical characteristics of damaged corn. J. Stored Prod. Res. 7:287-291.

Data is given on effect of different sowing dates on field infestation by cowpea weevil. The weight loss caused by the weevil was closely correllated with the level of infestation.

204. Cleare, L. D. (1962). Damage and loss caused by insects to stored rice and paddy in British Guiana. Rice Storage Investigations. Publication No. 4. Dept. Agric. British Guiana.

Cleare has published some interesting data concerning the weight losses caused by pests to stored rice and has attempted to translate these losses into monetary losses.

205. Cockbill, G. F. (1953). Investigations on the control of insect pests of stored grains and pulses. Rhod. Agric. J. 50:294-323.

From insecticide trials the loss in gross weight of beans over a 5 month storage was 11%: for maize 4.9%; and for sorghum 2.1%.

206. Coombs, C. W. (1963). A method of assessing the physical condition of insect damaged grain and its application to a faunistic survey. Bull. Entomol. Res. 54:23-35.

207. Coon, R. A. (1974). Corn losses from birds reduced with repellent. Pennsylvania Agric. Exp. St. Sci. Agric. 21(4):13.

208. Cotton, R. T. (1948). Storage losses of grain - The world picture. Trans. Am. Assoc. Cereal Chem. 6(2):100-107.

He estimates that on a world basis the losses due to insects, fungi and rodents is of the order of 10%. He lists the results from the FAO survey which cover 27 countries. The total loss in estimated about 25,750,000 metric tons, without considering farm losses. Taking farm losses into account the total loss would be about 65,000,000 tons which is enough to supply caloric value for more than 360,000,000 people.

209. Cotton, R. T. (1950). Insect damage to stored grain and its prevention. Pest control 18(10):8-16.

Estimates that wheat in the Great Plains of USA may suffer a loss of 10% in one season and corn in the deep south may be destroyed at the rate of 9% per month while in storage.

210. Cotton, R. T. and P. A. Wilbur (1974). Insects. In: Storage of cereal grains and their products. Am. Assoc. Cereal Chem. Ed. by C. M. Christensen.

211. Cotton, R. T. (1963). Rodent and bird pests of stored grain. In: Pests of stored grain and grain products. Burgess Publishing Company.

It is estimated that the rat population equals the human population and in some communities may be twice as great. Their young are produced at the rate of 3½ million everyday. It is estimated that they destroy as much food as 200,000 american farmers can produce.

212. Coyne, F. P. and B. M. Henley (1970). Farm storage project Kenya. Rep. FFHC project. TPI file OMI7.

By comparison of treated and untreated grain in the farm cribs in Kenya it was observed that with sorghum the loss in weight after 9 months storage was 18% and about 36% after 12 months storage.

213. Coyne, F. P. (1945). Principles of Cereal Storage. Dept. of Food Booklet, India, 45 pp.

Estimates that India loses 1 million tons of grain annually due to pests.

214. Cramer, H. H. (1967). Plant protection and world crop production. Pflanzenschutznachrichten 20(1):1-524.

On a worldwide basis, Cramer estimates that losses to pests is about 35%. These losses include destruction by insects, weeds, and pathogens.

215. Cranham, J. E. (1960). Insect infestation of stored raw cocoa in Ghana. Bull. Entomol. Res. 51:203-222.

216. Crombie, A. C. (1943). The effect of crowding upon the natality of grain infesting insects. Proc. Zool. Soc. (Loud.) A, 113:77-98.

217. Daniels, N. E. (1956). Damage and Reproduction by the flour beetles Tribolium confusum and T. castaneum in wheat and three moisture contents. J. Econ. Entomol. 49(2):244-247.

218. Darling, H. S. (1947). Report of the Entomologist. Ann. Rept. Dept. Agric. Tanganyika 1945-1946.

Darling observed that the percent damage after a 9 months of storage was 84% and the loss of weight was 14% for maize. The extent of damage rose to 98.4% and loss of weight to 27% after 15 months storage.

219. Davis, D. E. (1953). The characteristics of rat populations. Quart. Rev. Biol. 28(4):373-401.

220. Davies, J. D. (1959). A note on the control of bean pests in Uganda. East Afr. Agric. For. J. 24(3):174-175.

Working with beans in Uganda, Davies observed a positive correlation between the extent of damage and loss in weight. A 50% damage gave a weight loss of 6.4%. From experimental work loss in weight after 6 months storage was 5%.

221. Davies. J. D. (1960). Experiments on the crib storage of maize in Uganda. East Afr. Agric. For. J. 26(1):71-75.

222. de Lima, C. P. F. (1973). A technical report on twenty-two grain storage projects at the subsistance farmer level in Kenya. Kenya Dept. Agric. Proj/Res/AG 21.

223. de Luca, Y. (1962). Considerations on the determination of amount of bruchid damage to leguminous seeds (FR.)Parasitica 18(13):221-225.

224. de Luca, Y. (1967). Reflexions sur l'estimation des pertes ulimentaires dues suix bruchides. Rev. Zool. Agric. App. 66(10-12):152-154.

225. de Luca, Y. (1969). On losses due to pests of stored products (fr). Rev. Zool. Agric. Appl. 68(4-6):67-74.

The author outlines the main types of direct and indirect damage together with the terminology in general use. He distinguishes quantitative, qualitative and socio-economic type of losses.

226. de Luca, Y. (1969). Analysis of the representativeness of the amount of depreciation of stored products (FR). Anns. Soc. Hort. Hist. Nat. Herault 109(4):203-207.

227. de Luca, Y. (1969). A weighted rate of bruchid damage. Faba No. 30, 4 pp.

He points out the serious disadvantages of estimating the loss of stored grains by mere reference to the % damaged and discusses the various factors that ought to be taken in arriving at a true estimate.

228. de Monte, Aino (1958). The enemies of stored grains: Insects: damaged caused; and the principal injurious species. FAO Grain Storage Newsl. 2(1) Jan 1960.

The author reviews the subject of losses in stored products and states that it is not easy to convert in a meaningful figures the economic, hygienic and nutritional losses. He classifies losses into direct and indirect losses and subdivide them into smaller categories.

229. Decker, G. C. (1955). Wanted - an evaluation of insect losses. J. Econ. Entomol. 48:226-227.

230. Deoras, P. J. Some observations on the probable damage caused by rats in Bombay. Indian J. Entomol. 28:543-547.

231. Dobrovsky, T. M. (1960). What is damage. Grain Storage Newsl. 2(2): 1-2, FAO Rome.

He classifies damage into 3 categories notably direct damage; indirect damage and economic damage.

232. Durden, J. C. and J. R. Cutler (1957). The storage of groundnuts under tropical conditions. I. The effect of storage of undecorticated and decorticated groundnuts. J. Sci. Food Agric. 8:600-604.

Noted that there was little difference in extent of damage between undecorticated and decorticated nuts, but there were large differences in the build up of free fatty acids.

233. Dykstra, W. W. (1954). Rodent filth in food. Pest Control 22(7):9-10.

Rodents not only consume food but contaminate it. Rats eat about 20g food daily; void about 20 droppings daily; and 16 ml. of urine per day. Each rat deposits enough droppings daily to render one bushel of grain unfit for milling.

234. Dykstra, W. W. (1959). Food contamination by rodents and birds. Cereal Sci. Today 4(10):303-304.

235. Eden, W. G. (1953). Control of rice weevil in corn with protectant dusts and sprays. J. Econ. Entomol. 46:1105-1107.

In Alabama corn stored in shuck after a period of storage of 9 months showed a mean value of damaged kernels of 37.7% while the shelled corn showed a mean damage of 86%.

236. Eden, W. G. (1967). Insect damage to corn in three southeastern states at time of harvest and in farm storage. U.S. Dept. Agric. Mktg. Res. Rep. 792.

During the year 1962 loss from insect damage to farm stored crop in Alabama, Georgia and Mississippi was about $10 million. After one year storage at harvest the loss was already $4 million.

237. Eden, W. G. (1974). A study of insect damage to corn in the southern states at time of harvest and storage. USDA-AMS-MQRD Final Rep.

A summary of the research conducted in Georgia, Alabama and Mississippi is given. Using x-ray detection technique he noted that damage to ear corn increased from initial of 11.6% to 37.5% after a year of storage. He estimates a total loss of about $9,875,332 for the year 1964 in the three states.

238. Ekbom, P. (1958). Viewpoints of pest control. Agric. Res. Centre Dop. Bull. 5 (Finish).

In Finland it has been estimated that grain pests cause a loss of about 2% in imported bread corn.

239. Floyd, E. H., Oliver, A. D. and J. D. Powell (1959). Damage to corn in Louisiana caused by stored-grain insects. J. Econ. Entomol. 52(4): 612-615.

The average damage was approximately 10% at harvest time. This gradually increased to 17% in May. Attempts to separate damage according to pest involved showed that Sitophilus was the most destructive.

240. Floyd, E. H. (1961). Effectiveness of malathion dust as protectant for farm-stored corn in Louisiana. J. Econ. Entomol. 54(5):900-904.

In the control threatment it was noted that the percentage ears infested increased to 100% in 10 months storage while the percentage kernel damage increased to 72%.

241. Fraenkel, A. and M. Blewett (1943). The natural food and Food requirements of ····· stored products insects. Tras. Roy. Entomol. Soc. (Lond) 93:457-490.

The average number of kernels of grain damaged by one larva during its development for seven different species of insects is reported.

242. Freeman, J. A. (1952). Damage and loss to stored products from attack by insects and mites. Trans. Int. Congr. Entomol. 9th, 1:823-824.

Freeman classifies damage into various categories including; reduction in weight, heating, reduction of food value, loss in germination, tainting of food, contamination etc.

243. Freeman, J. A. (1960). Stored Products pests and international trade. Rept. 7th Commonwealth Entomol. Conf. 6th-15th July 1960.

244. GASGA (1973). Methodology of evaluating grain storage losses. Agron. Trop. (Paris) 28(5):563-566.

245. Gerberg, E. J. and S. L. Golheim (1957). Weight loss in stored corn and beans caused by the insect feeding. J. Econ. Entomol. 50:391-392.

Attempt is made to corrolate the number of insects per bean and the percent loss of weight. The average weight loss caused by one bean weevil in 60 days was 3.5%.

246. Giles, P. H. (1964). The storage of cereals by farmers in Northern Nigeria. Trop. Agric. (Trin) 41(3):197-212.

From the result of survey work it is estimated that about 4% of the total sorghum and millet crop is lost to stored product insects every year.

247. Giles, P. H. (1964). The insect infestation of sorghum stored in granaries in Northern Nigeria. Bull. Entomol. Res. 55(3):573-588.

From the results of long term storage trial it was observed that damage increased from 0% to 89.3% after 21.5 months in store while the % weight loss increased from 0 to 24.3%.

248. Gilman, G. A. (1968). Storage problems in Ethiopia with special reference to deterioration by fungi. Trop Prod. Inst. Report R48.

249. Girish, G. K., Arora, K. K. and K. Krishnamurthy (1974). Studies on rodents and their control. X. Storage losses in food grains by rats. Bull. grain Techn. 12(2):139-148.

Girish et al. gives a very comprehensive review of the type and extent of losses and damage caused by rodents.

250. Girish, G. K., Goyal, R. K., Tomer, R. P. S. Srivastava, P. K. and K. Krishnamurthy (1972). Studies on preservation and losses of food grain in underground pits "khatties" in U.P. Uttar, Pradesh, India. Bull. Grain Technol. 10(1):11-21.

251. Girish, G. K., Tripathi, B. P., Tomer, R. P. S. and K. Krishnamurthy (1974). Studies on the assessment of losses. IV. Conventional grain storage practices and losses in rural areas in Uttar, Pradesh, India. Bull. Grain Techn. 12(3):199-210.

A survey on storage losses in India 1973/74 showed that the % losses in weight after 6 months storage range from 0.06 to 9.7%. A formulae used in calculating losses is given.

252. Gloria, R. B. (1972). Informacion preliminar sobre las principales de los granos almacenados en la costa. Peruane (SP). Rev. Peru. Entomol. 15(2):219-224.

The author gives information about the most important pests, their magnitude of their damage and their distribution in Peru. He estimates that about 10% is lost during storage.

253. Golebiowska, Z., Nawrot, J. and A. Pradzynska (1971). Characteristics of wheat grain damaged by some storage beetles (Pol.) Przegl Zbozowo Mlynarski 15:107-109.

254. Gouveia, J. A. A. (1970). Statistical analysis of nutritional preferences of Sitophilus oryzae with corn varieties and value of losses produced (Por.) Nova Lisboa 26 p. illus. (1970). Monograph.

255. Granham, J. E. (1960). Insect infestation of stored raw cocoa in Ghana. Bull. Entomol. Res. 51:203-222.

Attempt was made with very small numbers of defective beans to estimate quantitative losses.

256. Gray, H. E. (1948). The biology of flour beetles. Milling Prod. 13(12):7,18-22.

257. Green, A. A. (1967). Cutting the cost of insect damage. Farm and Country. 222(4158):341-343.

258. Green, V. E. (1972). Birds injurious to the world rice crops: species, damage, and control. I. Western Hemisphere. Riso 21(3): 281-292.

259. Hafiz, A. and Hussein, S. (1961). Good seed storage reduces losses and increases production. Agric. Pakistan 12(3):368-385.

The author points out that losses due to insects is about 5.6%; that due to rats 6-10% and due to moulds 1.2%.

260. Hall, D. W. (1955). Problems of food storage in tropical territories. Ann. Appl. Biol. 42:85-97.

Hall reviews storage losses in various tropical countries.

261. Hall, D. W. (1954). The quality of groundnuts from the Gambia with special reference to insect infestation. Col. Pl. Anim. Prod. 4(3):227-235.

262. Hall, D. W. (1956). Insect damage observed in stored groundnuts. East Afr. Agric. For. J. 22(2) : 11-15.

263. Hall, D. W. (19). Storage of produce in the Gambia. Tropical Sci. 1:193-199.

Groundnuts is the major cash crop in Gambia accounting for about 97% of the export crop. Average loss was estimated about 3% equivalent to £90,000. The reduction in available oil accounted for a loss of £ 175,000.

264. Hall, G. E. and L. D. Hill (1971). Changes in test weight of corn during drying. Illinois Univ. Ext. AE-4268, 4pp.

265. Halliday, D. (1967). Insect damage to foods on sale in Kano Market. Rep. Niger. Stored Prod. Res. Inst. 1966 pp. 103-107.

Cowpeas losses due to bruchids was 8%.

266. Harris, K. L. (1972). Methodology of assessment of storage losses of food grains in developing countries. International Bank for reconstruction and development. 43 pp.

A comprehensive review of storage losses and methods of assessment.

267. Harris, W. V. (1935). Report of the entomologist. Ann. Rept. Dept. Agric. Tanganiyika, 1937. P. 1-8.

268. Harris, W. V. (1950). Report of the entomologist. Ann. Rept. Dept. Agric. Uganda 1947-1948. pp. 1-5.

269. Hawthorne, R. M. (1970). Estimated damage and crop loss caused by insect/mite pests, 1969). Rep. U.S. Calif. Dept. Agric. No. E82-12; 12pp.

270. Hayward, L. A. W. (1955). Losses associated with groundnuts infested with Trogoderma granarium. J. Sci. Fd. Agric. 6(6):337-340.

271. Herford, G. V. B. (1961). Losses resulting from the infestation of stored products by insects. Proc. Nutr. Soc. 20(1):11-15.

Attention is drawn to the scale on which foodstuffs may be damaged by insects. Figures are cited to show the worldwide nature of the problem. Problems attendant upon assessment of storage losses are discussed.

272. Hindmarsh, P. S. (1968). Economic losses in the 1968 Gambian groundnut crop as a result of infestation by the groundnut seed beetle Carynedon serratus. Mimeographed 6 pp.

273. Howe, R. W. (1952). Entomological problems of food storage in Nigeria. Bull. Entomol. Res 43:111-144.

274. Howe, R. W. (1965). Losses caused by insects and mites in stored foods and feed stuffs. Nutr. Abstr. Rev. 35:285-293.

A very comprehensive review covering various aspects on storage losses.

275. Hurlock, E. T. (1965). Some observations on the loss in weight caused by Sitophilus granarius to wheat. J. Stored Prod. Res. 1:193-195.

An investigation into the weight of grain eaten by a small population of sitophilus at three different temperatures is described. Assessment of damage caused was made by weighing and radiography. The average of grain consumed by each larvae was about 28.7mg. and the mean weight of each adult was 2.7 mg.

276. Hurlock, E. T. (1967). Some observations on the amount of damage caused by Oryzaephilus surinamensis. J. stored prod. Res. 3:75-78.

277. Huysmans, A. A. C. (1970). Storage of food grains: Problems and prospects. Bull. GrainTechn. 8:92-97.

Huysman reports some of the results on estimateof losses which have been made by a committee on losses of food grains during post harvest handling. According to the committee more than 50% of the total loss was due to rodents. For the whole India an average loss of nearly 2 million tons of grain per year for the period of 1962-1965 is reported.

278. Ibrahim, M. M. (1972). Damage and control of the field or the nile rat, Arvicanthis niloticus.

Proc. 1st Sci. Symposium Rodents and their control in Egypt; Assiut. Univ.

279. Irabigon, T. A. (1959). Rice weevil damage to stored corn. J. Econ. Entomol. 52:1130-1136.

Investigations showed that weevils coused 74.7% loss in weight in single kernels and 12.9 and 25.9% in 20 and 250 g samples respectively. Chemical analysis showed an increase in protein content with increasing infestation.

280. Iranova, Z. V. (1960). The protection of stored grain (RUS.) Zashchita Rastenly 5(12):10-12.

He reports that losses caused by grain storage pests totals 5% of the crop in U.S.A. In West Germany, the granary weevil alone caused a 2% loss which is equivalent to 120,000,000 marks. In Mexico he reports losses of the order of 15% which is equivalent to 5 million tons.

281. Jackson, W. B. (1976). Bird and Rodent depredations to crops and damage stored crops. A World View.

FAO/WHO/EPPO conference on rodents of agric. and public health concern, Geneva, Switzerland, June 15-18; 1976.

282. Kahlon, A. S. (1970). Impact of changing conditions on grain marketing institutions and the structure of grain markets in the Erstwhile, Punjab. Punjab Agric. Univ. Ludhiana.

In the appendix he lists extent of losses which have been reported by various workers.

283. Kahlon, A. S. and S. S. Grewal, (1966). A study of marketing of wheat in Punjab. Commodity Report No. 2:P.A.V. Ludhiana 54 pp.

284. Kapoor, K. N., Rawat, R. R., Luckmann, W. H. and M. L. Purohit (1972). Damage to soybean grain by the almond moth in Mahhya Pradesh. J. Econ. Entomol. 65 (3):902-903.

285. Khare, R. M., Krishnamurthy, K. and S. V. Pingale (19). Milling losses of food grains, Part II. Studies on losses of peas during milling Bull. Grain Techn. 4(4):169-176.

286. Khare, G. B., Sengar, C. S., Singh, K. N., Agrawal, R. K., and H. N. Singh. (1972). Losses in grain due to insect feeding I: wheat. Indian J. Agric. Res. 6(2):125-133.

Loss in weight during storage due to insect feeding under different geophysic and rainfall conditions ranged from 4.3% at maximum and 1.5% minimum. Loss in weight was directly related to storage method, design and local climatic conditions.

287. Kirk, L. E. (1948). Preservation of grains in storage, FAO, Agric. studies No. :2, 2-3.

288. Kirkpatrick, R. L. and D. A. Wilbur (1965). The development and habit of the granary weevil, Sitophilus granarius within the kernel. J. Econ. Entomol. 58 (5):979-985.

289. Kondo, M. (1941). Storage of rice in concrete silos III. Storage of insufficiently dried rice for over 4 years after dessication by heating. Rep. Ohara Agric. Inst. Japan. 32:95-113. (Jap.)

Losses of the order of 8.6% were experienced after the storage period.

290. Krishnamurthy, K., Uniyal, V., Singh, J. and S. V. Pingale (1967). Studies on rodents and their control I. Studies on rat populations losses of food grains. Bull. Grain Techn. 5(3):147-153.

The rat populations was higher in the vallages than in the towns. Losses of food grains due to rodents are estimated to range from 1.36 to 3.59 tons per year. A comprehensive account of populations, ecology and damage is given.

291. Le Cato, G. L. (1975). Species composition influencing insect population growth and weight loss of stored rice, wheat and corn. J. Kansas Entomol. Soc. 48(2):224-231.

292. Lepigre, A. L. (1965). The assessment and comparison on a worldwide scale of damage to stored products. C. R. Trav. Congress Prot. Cultures Trop. 23-27. Mars Chambre Comm. Ind. Marseilles pp. 81-84.

Describes a methodology of estimating losses by comparison of damaged and undamaged grains.

293. Lepigre, A. L. and J. G. Pointel (1971). Protection of stored maize stored in traditional Togolese granaries. Trop. Stored Prod. Inf. 21:7-12.

294. Ling, L. 1961. Man loses a fifth of the crops he grows. Atlantis (Special FAO-FFH issue):1-68.

295. Link, D. (1970). Differentiation between damage caused by the cereal moth and that of the weevils in attacking unhulled rice grains in our warehouses (Por.). Lav. Arrozeira23(256):8-9.

296. Lipton, M. (1971). Research into the economics of food storage in less developed countries. Inst. Dev. Studies. Univ. sussex Communication series no. 61, 15 pp.

297. Majumder, S. K. and H. A. B. Parpia (1966). Possible losses of food grains in India. Vijan Karmee 18:4.

298. Mascarenhaus, A. (1966). Aspects of food shortages in Tanganyika (1925-1945). Geography Dept. Univ. College Dar es Salaam Research Paper 6643.

299. McFarlane, J. A. (1964). Wheat storage investigations in Kenya. 1962-1964. Trop. Stored Prod. Inst. Rept. R 211.

300. McFarlane, J. A. (1969). A study of storage losses and allied problems in Ethiopia. Trop. Stored Prod. Inst. Rep. R41, 67 pp.

301. Michelmore, A. P. C. (1952). Annual report of the Entomologist. Ann. Rept. Dept. Agric. (Uganda) 1949-1950. pp. 4-22.

302. Miracle, M. P. (1958). Maize in Tropical Africa. Trop Agric. (Trinidad) 35:1-15.

303. Mookherjee, P. B., Jotwani, M. G., Sircar, P. and T. D. Yadav. (1968). Studies on the incidence and extent of damage to insect pests in stored seeds: I. Cereal seeds. Indian J. Entomol 30:61-65.

304. Mould, H. A. (1973). Grain Storage in Ghana. Trop. Stored Prod. Inf. 25:44.

305. Mphuru, A. N. and M. A. Maro. (1975). Grain storage and handling in the Morogoro and Iringa regions of Tanzania. Trop. Stored Prod. Inf. 38:35-40.

306. Nyanteng, N. K. (1972). Tech. Pub. Series 18, Inst. Stats. Social and Econ. Res. Accra., 1972.

307. Oxley, T. A. (1948). Losses in storage In: Grain storage in East and Central Africa HMSO Colonial Res. Publication No. 5:11-12.

308. Parkin, E. A. (1959). Insects and stored food. World losses and control measures surveyed. Food Manuf. 34:164-168.

309. Parkin, E. A. (1956). The assessment and reduction of losses caused by insects to stored foodstuffs. Ann. Rev. Entomol. 1:223-239.

A critical review on grain storage losses and allied problems.

310. Parkin, E. A. (1959). Insect and stored Food: World losses and control measures surveyed. World Crops 11:405-407 and 439-441.

311. Parpia, H. A. B., et al (1967). Report of the study group on food losses and their prevention of National Nutrition Advisory Committee Part I: Food grains.

Reviews some estimate losses which have been reported in India. These reports mention a 30% loss of the total subsistance agricultural production during handling and storage. Cereal and pulse losses were put at 20%. Paddy losses during storage showed an average loss of 11%.

312. Parrack, D. W. (1967). A bibliography of rodent literature with emphasis on India. John Hopkins Centre for Medical Res. and Training, Calcutta, India.

313. Pimental, D. W., Dritschilo, W., Krummel, J., and J. Kutzaman. (1975). Energy and land constraints in food protein production. Science 190:754-761.

Pimental et al. reports that post-harvest losses may be about 20%, ranging from about 9% in U.S.A. to 40% in some developing countries. When post-harvest losses are added to preharvest losses, total food losses due to pests are estimated about 48%.

314. Pingale, S. V. (1970). Prevention of losses in storage. Bull. Grain Techn. 8:3-13.

315. Pingale, S. V. (1972). Storage losses prevention. Green Revolution pp. 127-132.

316. Rahman, K. A., Sohi, G. S., and S. Amarnath (1947). Studies on stored grain pests in Punjab IV. Biology of Trogoderma granarium. Indian Agric. Sci. 17:85-92.

Storage losses due to Khapra beetle was estimated to vary from 2.25 to 5.47%

317. Ramasivan, T., Singh, J., and K. Krishnamurthy (1966). Losses of wheat seed during storage. Bull. Grain Techn. 4(3):117-124.

318. Rao, S. B. P. and D. U. H. Rao (1953). Bird damage in Jowar. Madras Agric. J. 40:466-467.

319. Rawnsley, J. (1969). Ghana: Crop Storage. UN:FAO Technical Rep. SF/GHA 7.

Storage losses for Ghana are put at 15% for maize, 20% for beans, 15% for yams, and 5% for cassava.

320. Richards, O. W. and N. Waloff (1946). The study of a population of Ephestia elutella on bulk grain. Trans. Roy. Entomol. Soc. London 97:253-293.

Richards et al. found out that one larvae of Ephestia consumed about 47 embryos of wheat.

321. Richards, O. W. (1947). Observations on grain weevils.V. General biology and oviposition. Proc. Zool Soc. (London) 117:1-43.

It was observed that one rice weevil larvae turns about 15 mg of grain into carbon dioxide and water and produces 14 mg of feces while developing into a weevil weighing 2.4 mg. About 2/3 of the endosperm of a wheat kernel is consumed by a weevil.

322. Rodionov, Z. S. (1943). Qualitative and quantitative damage caused by grain mites (Ger). Rev. Appl. Entomol. 31A:70.

323. Russell, M. P. (1961). Effects of sorghum varieties on the lesser rice weevil I. Oviposition, immature mortality, and size of adults. Ann. Entomol. Soc. Amer. 55:678-685.

324. Russell, M. P. and M. M. Rink (1965). Some effects of sorghum varieties on the development of a rice weevil, Sitophilus zeamais. Ann. Entomol. Soc. Amer. 58:763.

325. Salmond, K. E. (1957). Investigations into grain storage problems in Nyaraland. HMSO Colonial Res. Studies No. 21.

326. Schulten, G. G. M. (1975). Losses in stored maize in Malawi and work undertaken to prevent them. EPPO Bull. 5(2):113-120.

Schulten estimated that in 1971 about 1% of the maize harvest was lost during storage. He indicates that from the survey results the losses of maize can be estimated accurately provided the following date is known: total production and how it is made up by the different varieties, the pattern of disposal, etc.

327. Schulten, G. G. M. (1973). Storage loss assessment techniques. Paper presented at the "GASGA Technical Seminar on Storage Loss Assessment". 6-7 February, 1973.

328. Schruben, L. W. (1954). Farming for profit: Do insects eat your wheat profit. Kansas Farmer, Feb. 20th, 1954.

Noted that 3% insect damage in 1,000 bushels of wheat would cost a farmer $15 in wheat destroyed. A chart is presented which translates insect damage to dollar loss per 1,000 bushels.

329. Shahjahan, M. (1974). Extent of damage of unhusked stored rice by Sitotroga cerealella in Bangladesh. J. Stored Prod. Res. 10(1): 23-26.

330. Sinha, R. N. and A. Campbell (1975). Energy loss in stored grain by pest infestation. Canada Agric, Spring 1975.

Sinha proposes a new technique of assessing losses due to insects by calculating energy budgets of several major stored product insects. By measuring the exact amount of food consumed by each insect it is possible to tell the exact and potential caloric loss of food. Using this technique they found out that 58.2% of the caloric content of wheat kernel was consumed per Sitophilus during its development from egg to adult.

331. Singh, K., Agrawal, N. S. and G. K. Girish (1972). Studies on the loss in weight caused by Sitophilus oryzae to various high yielding varieties of wheat. Bull. Grain Techn. 10(4):271-275.

The average amount of grain damage by weight, by number and amount of grain per larvae during development varied in different varieties. The average loss of weight varied from 1.5% to 3.7% while the % damage varied from 13.2 to 22.7.

332. Srivastava, P. K., Tripath, B. P., Girish, G. K. and K. Krishnamurthy (1973). Studies on the assessment of losses. III. Conventional grain storage practices and losses in rural areas in Western Utah, Pradesh, India. Bull. Grain Techn. 11(2):129-139.

333. Spensley, P. C. (1975). Post-harvest losses and ways of reducing them. Proceedings 2nd Latin American Congress Fd. Sci. and Techn., Campinas, Brazil, August, 1975.

334. Spencer, D. A. (1954). Rodents. In: Storage of Cereal grains and their products. Edited by Anderson J. A. and A. W. Alcock. Amer. Assoc. Cereal Chem., St. Paul, Minn.

335. Solomon, M. E. (1959). Pest in packaging: Weight loss from infestation. Food, February, 1959.

336. Srivastava, P. K., Singh, K., Tomer, R. P. S., Girish, G. K. and K. Krishnamurthy (1971). Storage losses in cooperative seed stores in U.P. India. Bull. Grain Techn. 9(3):177-185.

337. Stone, C. P. (1973). Bird damage to agricultural crops in the United States - a current summary. Proc. 6th Bird Control Seminar, Bowling Green University.

338. Surtees, G. (1963). Site of damage to whole wheat grains by five species of stored-products beetle. Entomol. Mon. Mag. 99:178-181.

Sitophilus granarius bores mainly into the dorsal surface of the moist grain but around the germ end of the dry grain. Rhizopertha dominica spread dorso-ventrally in the damp grain but also prefers the germ end when the grain is dry.

339. Swanson, C. O. (1934). Some factors involved in damage to wheat quality. Cereal Chem. 11(2):173-199.

Describes various indices for measuring damage of wheat. These include decrease in viability, development of fat acidity; test weight, baking tests etc.

340. Taylor, K. D. (1968). An outbreak of rats in agricultural areas of Kenya in 1962. East Afr. Agric. For. J, 35:66-77.

341. Taylor, K. D. (1972). The rodent problem. Outlook on Agriculture 7(2):60-66.

342. Tyagi, A. K. and G. K. Girish (1975). Studies on the assessment of storage losses of food grains by insects. I. Quantitative assessment. Bull. Grain Techn. 13(2):84-102.

A very comprehensive review in a tabulated form under the following headings: place, kind of storage, commodity, loss in weight, major pest, period of storage, country, investigator and remarks.

343. Tyler, P. (1969). Survey of native grain stores in Botwana. Trop. Prod. Inst. File 0149.

Reports damage losses, weight losses and germination losses of various crops in Botwana. Maximum weight losses encountered were 46% for sorghum, 55% for maize, 6% for millets and 23% for beans.

344. Venkatrao, S., Nuggehalli, R. N., Swaminathan, M., Pingale S. V. and V. Subrahmanyan (1968). Effect of insect infestation on stored grain. III. Studies on Kaffir corn (Sorghum vulgare) J. Sci. Fd. Agric. 12:837-839.

Changes and losses which occur during storage are described. The results after 5 months storage indicate that the weight loss increased from 0.9 to 31.5% ; the weight volume ratio decreased from o.85 to 0.59; the insect population increased from 0 to 7,650 per 500 g. sample and the viability decreased from 85% to 5%.

345. Vishwambharan, P. R. (1966). Benefits of warehousing scheme. Bull. Grain Techn. 4:136-139.

Reports on the population dynamics of rodents and their potential as pests of stored products.

346. Walker, D. W. and M. Sather (1957). Survey on the cost of controlling insect in commercial storage. Mimeographed paper 5 pp.

This paper describes the results of the work aimed in determining the cost of preventing insect damage to wheat in commercial stores in U.S.A. Control costs varied roughly with the number of bushels stored. Individual operations ranged from 0 to 2.25 cents per bushel, averaging 0.45 cents per bushel.

347. Ward, P. (1973). A new strategy for the control of damage by queleas. Pans 19(1):97-106.

348. Ward, P. (1966). Queleas, the scourge of Africa. Geogrl. Mag. Lond. 39:182-189.

349. Westwood, D. (1970). Losses in village grain stores in Malawi. Trop. Stored Prod. Inst. File oM5.

350. Wheatley, P. E. (1972). The maize storage problem in the less developed countries of Africa. Proc. Soc. Chemical Industry (London); 20th Nov. 1972.

351. White, G. D. (1953). Weight loss in stored wheat caused by insect feeding. J. Econ. Entomol. 46:609-610.

Weight losses caused by Sitophilus oryzae during the developmental period in wheat is described. The mean loss in weight per infested wheat kernel was found to be 0.67% after the first week of larval development; 2.36% after the second week; 6.52% after the third week, 13.59% after the forth week and 20% upon the completion of emergence.

352. Wilbur, D. A. (1968). Damage and losses to stored grain resulting from insect infestation. Mimeographed paper 3 pp. Kansas State University.

He outlines the nature and type of losses caused by pests. Estimates that on a world-wide basis the losses due to pests range between 5-10% This equals to the quantity of food required to feed 130 million people for one year.

353. William, J. G. (1954). The Quelea threat to Africa's grain crops. East Afr. Agric. For. J. 19(3):133-136.

354. Worthington, E. G. (1946). A development plan for Uganda. Govt. Printer, Entebbe, Uganda (1946).

Worthington estimates that in Uganda under the present storage arrangements, about ¼ of the food crop is lost annually through ravages of insect pests and rodents.

HARVESTING, HANDLING, CONDITIONING AND PROCESSING LOSSES

355. Agnes, J. B. (1968). Measuring mechanical damage to corn kernels. Amer. Soc. Agr. Engin. Paper No. 68-620, 7 pp.

356. Agnes, J. B. (1968). How do you measure grain damage? Symposium on the grain damage held under the auspices of the ASAE. Iowa State University, April, 1968.

One of the reasons for measuring kernel damage is to evaluate harvest machines and machine components with respect to the damage they cause or produce. Methods described for measuring damage include:1. counting damaged vs sound (visual). 2. Sieving. 3. Comparing the H_2^o absorption characteristics of 100 sound of 10% damaged corn.

357. Alderson, L. L. (1968). Analysis of combine kernel damage. M.S. Thesis, Kansas State University, Manhattan, Kansas.

358. Anderson, D. E. (1975). Importance of physical damage in export corn. In: Corn. Quality in World Markets L. D. Hill ed.pp. 151-167.

359. Anon (1973). Combine grain losses. Short term leafl. Minist. Agr. Fish. Food, 155 11th March 1973.

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The project was intended to find the levels of damage during:

(i) Elevating and discharging
(ii) Filling bins
(iii) Sprouting into a rail car or ship
(iv) Trimming a car or ship

Free drop was the most severe treatment tested and caused the worst breakage.

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Gives a detailed account of the factors affecting bean damage in soya. Noted that damage beans have a lower % germination and are highly susceptible to fungal attack.

Noted that the major factors affecting damage were M.C., pod moisture.

NUTRIENT LOSSES, FUNGAL DAMAGE

AND LOSSES IN GERMINATION

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Heating of grain was attributed to biological oxidation of dextrose and similar sugars, mainly in the embryo. Respiration increased to maximum at 55°C. but enzymes were largely inactivated at 65°C.

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The fatty acids in the oil is related to the degree and type of damage present in the grain. From the work above it was found that there was no marked difference among the free acids, released by damage grains.

594. Baker, D., M. H. Neustadt and L. Zeleny. (1957). Application of the fat acidity test as an index of grain deterioration. Cereal Chem. 34:226-233.

A rapid and simple method for determining fat acidity in grain utilizing a grinder-extractor to shorten the extraction time is described. This method gave slightly lower values. The maximum fat acidity values accepted for little or no deterioration are 10 for beans, 22 for soybeans, 20-25 for cereals.

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Reviews critically various types of changes of rice during storage. These changes include changes in color, odor, eating quality, physiochemical changes, changes in carbohydrates and nitrogenous compounds, lipids, enzymes and vitamins. This publication is a must for anybody interested in this topic.

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599. Bautista, B. M. (1962). A study of methods to detect storage deterioration of corn and wheat. M.S. Thesis. Kansas State University.

600. Bautista, B. M., et.al. (1964). Glutamic acid decarboxylase activity as a viability index of artifically dried and stored rice. Cereal Chem. 41:188-191.

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602. Berjak, P. and T. A. Villiers (1972). Ageing in plant embryos II. Age induced damage and its repair during early germination. New Phytol. 71(1):135-144.

603. Borker, E., Insalata, N. E., Levi, C. P. and J. S. Witzeman (1966). Mycotoxins in feeds and foods. Advan. Appl. Microbiol. 8:315-351.

604. Bottomley, R. A., Christensen, C. M. and W. F. Geddes (1950). Grain storage studies IX. The influence of various temperatures, humidities and O_2 concentration on mold growth and biochemical changes in stored yellow corn. Cereal Chem. 27:271-296.

Bottomley et. al has demonstrated that there is a marked disappearance of non-reducing sugars in corn stored under conditions favoring deterioration i.e. high R. H. etc. under high T^o and R.H. the total water soluble nitrogen and reducing sugars increased. Viability decreased. Changes in non-reducing sugars were considered the best index of deterioration.

605. Bottomley, R. A., Christensen, C. M. and W. F. Geddes (1952). Grain storage Studies X. The influence of aeration, time and M. C. on fat acidity, non-reducing sugars and mold flora of yellow corn. Cereal Chem. 29:53-64.

Both aerated and sealed corn was stored at humidities of 80-100%. An increase in free fatty acids, a decrease in non-reducing sugars, and a drop in viability were found to be associated with high moisture content.

606. Brett, C. C. and W. W. A. R. Dillion (1941). Loss of vitality during storage of grain treated with organomercury seed disinfectants. J. Agric. Sci. (England) 31: 500-517.

Grains treated with mercurial fungicides at the rate of 2 oz. per bushel were not injured when stored for 12 months; but at the end of 24 months the speed of germination was reduced. With a treatment of 3 oz. per bushel, a greater reduction occurred.

607. Burlison, W. L., vanDoren, C. A. and J. C. Hackleman (1940). Eleven years of soybean investigations. Varieties, seeding, storage. Ill. Agric. Expt. Sta. Bull. 462. pp 121-167.

When stored in metal cans soybeans dropped only 2% in germination the first year. Over an 8-year period the germination percentages were 58, 46, 33, 17, 8, 5 and 1.

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Under laboratory storage conditions, at Norwood, England, the small grains tested deteriorated slowly over a 5- to 9-year period, followed by a rapid drop. Longevities were: wheat and barley, 10 yrs; oats, 14 to 16 years; legumes, 10 to 15 years.

609. Christensen, C. M. (Editor). Storage of Cereals and Their Products. American Assoc. of Cereal Chem. St. Paul, Minnesota. (1974).

610. Christensen, C. M. and H. H. Kaufman(1974). Microflora. In: Storage of Cereal Grains and their products. 2nd. edition. Edited by Christensen. Am. Assoc. Cereal Chem., St. Paul, Minnesota.

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612. Christensen, C. M. and H. H. Kaufman(1969). Grain storage. The role of fungi in quality loss. University of Minnesota Press, 153 pp.

613. Cooper, P. J. and P. W. Hammond (1964). Decrease of soluble oil in animal feedstuffs during storage. J. Sci. Food Agric. 15(19): 639-645.

The oil contents of samples of compound feeding stuff when determined by simple solvent extraction appear to decrease progressively as the age of the sample increases. These losses can be substantial,even over short periods.

614. Crocker, W. and J. F. Groves (1915). A method of prophesying the true duration of seeds. Nat'l Acad. Sci. Proc. I: 152-155.

Loss of viability was attributed to the precipitation of proteins. Formulae was given for the prediction of longevity.

615. Crocker, W. and L. V. Barton (1957). Physiology of seeds., Waltham, Mass. 1957, 267 pp.

A review covering most phases of seed physiology including anatomy, chemical composition, water relations, respiration, germination, dormancy storage and metabolism.

616. Crocker, W. (1948). Growth of plants: 20 years research at Boyce Thompson Institute. pp. 28-66., New York.

A review of a number of reports in regard to seed deterioration. Particular attention is given to seed storage and deterioration. Precipitation of proteins is advanced as a likely cause of loss of viability.

617. Crocker, W. (1938). Life-span of seeds. Bot. Rev. 4:235-274.

A review of work related to seed longevity up to 1938, concluded that the most plausible cause of seed deterioration with age is the degeneration of the nucleus, preventing normal mitotic division.

618. Dadswell, I. W. and W. B. Wragge. (1940). The autolytic digestion of flour in relation to variety and environment. Cereal Chem. 17:584.

619. Danley, M. M. and R. L. Vetter (1974). Artifically altered corn grain harvested at three moisture levels. I. Dry matter and nitogen losses and changes in the carbohydrates fractions. J. Anim. Sci. 38(2):417-423.

620. Darsie, M. L. et. (1954). A study of the germinating power of seeds. Botanical Gazette 58; 101-136.

621. Davey, P. M. (1961). The acceptability and fitness of maize meal for human consumption. Trop. Sci. 3(4):163-173.

622. Davies, W. L. (1928). The cause of deterioration of maize and maize meal. Fert. Feed. Stuffs and Farm Supplies Jour. (London) 13:784-785.

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Observed changes in the concentrations of certain individual free amino acids during storage at 19.5% moisture.

624. Donelson, J. R. and W. T. Yamazaki (1969). Note on the application of the Donelson-Yamazaki damage-starch procedure to high-damage wheat flour and starch. Cereal Chem. 46(5):567-568.

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626. Dubois, M., Geddes, W. F. and F. Smith (1960). The carbohydrates of the germinae. X. A quantitative study of the carbohydrates of wheat germ. Cereal Chem. 37:557-568.

627. Forgacs, J., and W. T. Carll (1962). Mycotoxins. Advan. Vet. Sci. 7: 273-382.

628. Foss, J. O. (1945). Mouldy grain can cause livestock losses. North Dakota Agricultural Experiment Station, Bimonthly Bulletin 7,(6).

629. Fowler, W. L. (1975). Performance expected from lower germinating seed. Rep. Minutes meet North Centr. Corn Breed Res. Comm. p.15-16.

630. Fraenkel, G. and M. Blewett (1943). The natural foods and food requirements of.....stored products insects. Trans. Roy. Entomol. Soc. (London) 93:457-490.

631. Garcia, W. J. and M. J. Wolf, (1972). Polarimetric determination of starch in corn with dimethyl sulfoxide as a solvent. Cereal Chem. 49:298-306.

Polarimetric starch analyses in which starch is extracted from the corn kernel with 90% dimethyl sulfoxide (DMSO) at room T^{o} is described.

632. Geddes, W. F. (1958). The chemistry, microbiology and physics of grain storage. Food Technol. 12(11):7-14.

633. Gili, N. S. (1969). Deterioration of corn (Zea mays) seed during storage. Mississippi State University. Ph.D. Dissertation.

634. Girish, G. K., Goyal, R. K., Tomer R. P. S., Srivastava, P. K., and K. Krishnamurthy, (1972). Studies on preservation of foodgrains in rural storage sturctures. Part I. Losses in food grains. Bull. Grain Techn. 10(1):11-21.

Studies to determine losses in food stored in underground pits revealed decrease in % germination; increase in free fatty acid and increase in damaged beans.

635. Glass, R. L. and W. F. Geddes (1960). Grain Storage Studies XXXI. Changes occurring in low molecular weight compounds in deteriorating wheat. Cereal Chem. 37:568-572.

636. Goldblatt, L. A. (1965). Aflatoxin. Assoc. Food Drug Officials Quarterly Bull. U.S. 29:58-69.

637. Goldblatt, L. A. (1969). (Editor). Aflatoxin - Scientific background, control, and implications. Academic Press, New York and London.

638. Groves, J. F. (1917). Temperature and life duration of seeds. Bot. Gaz. 63:169-189.

Life expectancy of Turkey Wheat was determined by a formulae based on the rate of coagulation of proteins at different temperatures and temperature durations. Predicted life of wheat with 9% moisture stored at 0°C. was 938 years and with 12% moisture 393 years.

639. Gupta, V. K., Ram, B., Palmer, L. T., and L. M. Joshi (1973). Post-harvest fungal damage to wheat due to rains. Indian Phytrpathol. 26(1):156-157.

640. Hesseltine, C. W., Shotwell, O. L., Ellis, J. J. and R. D. Stubblefield (1966). Aflatoxin formation in Aspergillus flavus. Bacteriol. Rev. 30:795-805.

641. Hinton, J. J. C. (1953). The distribution of protein in the maize kernel in comparison with that in wheat. Cereal Chem. 30:441-445.

Using flinty maize it was found that 70% of the total protein was found in the endosperm in which conc. gradient exists from the outer to the inner layers.

642. Houston, D. F., Straka, R. P., Hunter, I. R. and others. (1957). Changes in rough rice of different M. C. during storage and controlled T°s. Cereal Chem. 34:444-456.

During storage there was an increase in reducing sugars and fat acidity and a decrease in non-reducing sugars. Loss in germination was associated with increases of reducing sugars and fat acidity.

643. Howe, R. W. (1951). Miscellaneous experiments with grain weevils. Entomologists Monthly Magazine. 88:252-255.

Effect of insect damage on germination is described. It was observed that heavily infested samples reached a maximum of 78% germination while sound kernel reached as high as 90%.

644. Howe, R. W. (1963). The prediction of the status of a pest by means of a laboratory experiment. World Rev. Pest Control. 2(1):30-40.

645. Howe, R. W. (1973). Loss of viability of seeds in storage attributable to infestations of insects and mites. Seed Sci. Technol. 1:563-586.

Howe provides excellent review on loss of viability of seeds in storage attributable to infestations of insects and mites.

646. Hummel, B. C. W., Cuendet, L. S., Christensen, C. M. and W. F. Geddes (1954). Grain Storage studies. 13: Comparative changes in respiration, viability, and chemical composition of moldfree and mold-contaminated wheat upon storage. Cereal Chem. 31:143-150.

Mold-free grain respired at a uniform rate whereas the inoculated seeds showed a rapid rise. Germination of seed stored 19 days was injured by moisture content at 14.9%, as was also mold-contaminated wheat with M. C. at 14.9%.

647. Hunter, I. R., Houston, D. F. and E. B. Kester (1951). Development of free fatty acids during storage of brown (husked) rice. Cereal Chem. 28:232-239.

Rice was stored 22 wk. with moisture at 3.9, 6.6, 9.5, 11.8, and 14.1% at T^os of 0° to 2°, 25°, and 35^oC. Free fatty acids increased as both moisture content and T^o increased.

648. International Seed Testing Association. (1972). Seed bibliography. Proc. Int. Seed Test. Assn. 37(4):1001-1199.

Bibliography covering all aspects of seed technology including morphology, physiology, chemistry, germination, seed treatment, seed testing, etc.

649. International Seed Testing Association (1970). Seed bibliography. Proc. Int. Seed Test. Assn. 35(4):831-1053.

A bibliography covering all aspects of seed technology.

650. International Seed Testing Assn.(1971). Seed bibliography. Proc. Int. Seed Test. Assn. 36(4):578-785.

651. International Seed Testing Assn. (1966). International rules for seed testing. Proc. Int. Seed Test Assn. 31(1):49-91.

Describes the standard method used for seed testing.

652. Irabagon, T. A. (1959). Rice weevil damage to stored corn. J. Econ. Entomol. 52(6):1130-1136.

653. James, E. (1961). An annotated bibliography on seed storage and deterioration. U. S. Dep. Agric. Res. Serv. ARS 34-15-1.

Gives an annotated bibliography on seed deterioration - with about 500 citations. The bibliography covers different types of seeds including forest tree seeds.

654. Jones, D. B. and C. E. F. Gersdorff (1941). The effect of storage on the protein of wheat, white flour and whole wheat flour. Cereal Chem. 18:417-434.

Jones and Gersdorff observed that prolonged storage of wheat and milled wheat products decreases protein nitrogen and increases free amino acid nitrogen.

655. Jones, D. B., Divine, J. P. and C. E. F. Gersdorff (1942). Effect of storage of corn on the chemical properties of its proteins and on its growth promotive value. Cereal Chem. 19:819-830.

The results show that there is a decrease in the solubility of the proteins (2) A partial breakdown of the proteins - indicated by a decrease in true protein content (3) a decrease in digestibility. The extent of the alterations were influenced by T^o, type of container, duration of storage; changes in ground corn were greater than sound corn. Significant decreases in feeding were also found.

656. Johnson, A. G. (1948). The role of fungi in the deterioration of grains in storage. In "Preservation of Grains in Storage" FAO Agricultural Studies. No. 2, pp. 88-91.

Estimates that about 1% of the world's supply of grain and oilseed is lost due to fungi attack.

657. Jotwani, M. G., Sircar, P. and T. D. Yavar (1967). Studies on extent of damage and germination of seeds II. Germination of some leguminous seeds damaged by Callosobruchus maculatus. Indian J. Ent. 29:309-311.

658. Jotwani, M. G. and P. Sirca, (1964). Studies on the extent of insect damage and germination of seeds. I. Germination of pea seeds damaged by Callosobruchus maculatus. Indian J. Entomol. 26:130-133.

He noted that average weight of seeds damaged by different number of bruchids developing within each seed is reduced by about 2.4, 4.5, 6.2, and 7.1 gm. respectively; the loss in wt. being about 12.0, 22.5, 32.0 and 35.5% respectively - the amount of food taken by each grub during its developmental period gets gradually reduced depending in the number of grubs developing in each seed.

659. Karper, R. E. (1928). Longevity and viability of Kafir seed. J. Amer. Soc. Agron. 20:527. Kafir seed stored under atmospheric conditions at College Station, Texas, lost only 12% viability in 7 years and 23% in 10 years.

660. Karper, R. E. and D. L. Jones (1936). Longevity and viability of sorghum seed. J. Amer. Soc. Agron. 28:330-331. Sorghum seed stored under prevailing conditions at Lubbock, Texas; dropped gradually in germination over a 9 year period, then in the following 10 years dropped rapidly to 0.5%.

661. Kik, M. C. (1943). Thiamine in products of commercial rice milling. Cereal Chem. 20:103-109. Losses of thiamine due to the process of parboiling of rice may be as high as 45%.

662. Kondo, M. and T. Okamura (1930). On the influence of various temperatures in duration of storage and various moistures of rice upon the preservation of germination power of hulled rice. O'Hara Inst. f. Landw. Forsch. Ber. 4:(315)-341.

Rice with a moisture content of no more than 12% maintained germination when stored at normal granary temperatures.

663. Kondo, M. (1926). The storage of rice and change of its physical properties during this period. O'Hara Inst. f. Landw. Forsch. (Kurashiki, Japan) Ber. 3:153-175.

Hulled rice stored in straw bags lost its flavor and viability rapidly.

664. Kondo, M. and Okamura, T. (1932). Storage of rice. VI. Physical and biochemical studies of hulled rice stored in straw bags. Ber. O'hara Inst. 5:395-406 (Japan). (Chem. Abstr. 27:4284).

Losses in thiamine may be as high as 75% when stored in bag depending on physical conditions prevailing during the storage of rice.

665. Kraybill, H. F. and Shimkin, M. B. (1964). Carcinogenesis related to foods contaminanted by processing and fungal metabolites. Advan. Cancer Res. 8:191-246.

666. Krishnaswamy, P. (1952). Storage and germination of millet seeds. Madras Agr. Jour. 39:485-490.

8 varieties of millet, including spp. of sorghum Pennisetum, Eleusine, Setaria, etc. were dried and stored in sealed bottles. Germination of 70% was maintained for 26 months for sorghum spp. When seed was stored in gunny sacks germination dropped to 4 to 38% in 1½ years.

667. Lichtwardt, R. W. and G. L. Barron (1959). Quantitative deterioration rating scale for shelled maize. Iowa St. College Jour. Sci. 34: 139-146.

A rating scale is proposed for experimental use for expressing the degree of deterioration in samples of shelled maize. The scale ratings are assigned to appropriate combinations of % germination and amount of infection by spp. Aspergillus and Penicillium.

668. Lindgren, D. L. and Vincent, L. E. (1962). Fumigation of food commodities for insect control. Adv. Pest Control Res. 5:85-152.

Provides excellent review on the effect of fumigants on the viability of seed.

669. Linko, P. (1960). Zone electrophoresis pattern of free amino acids as an index of storage condition of wheat. Cereal Chem. 38:187-194.

Paper Electrophoresis of free amino acids provided a rapid simple and convenient method to detect changes in the free amino acids of wheat during storage. Using 0.025M potassium-hydrogen-phthalate solution (pH 4.0) as a buffer a good resolution of amino acids was obtained. Electrophoresis of good quality wheat was characterized by a high glutamic acid peak. Glutamic acid peak decreases with deterioration.

670. Linko, P. (1961). Quality of stored wheat. Simple and rapid manometric method for determining glutamic acid decarboxylase activity as quality index of wheat. J. Agr. Food Chem. 9:310-313.

671. Linko, P. (1963). The significance of glutamic acid decarboxylase activity of wheat in evaluation of storage deterioration and quality. Suomen Komislilehti. 36:93-97.

672. Linko, P. and L. Sogn. (1960). Relation of viability and storage deterioration of glutamic acid decarboxylase in wheat. Cereal Chem. 37:489-499.

673. Lynch, B. T., R. L. Glass, and W. F. Geddes. (1962). Quantitative changes occurring in the sugars of wheat deteriorating in the presence and absence of molds. Cereal Chem. 39:256-262.

Changes in sugar content and viability are described.

674. Lynch, B. T., Glass, R. L. and W. F. Geddes (1962). Grain Storage studies. XXXII. Quantitative changes occurring in the sugars of wheat deteriorating in the presence and absence of molds. Cereal Chem. 39:256-262.

675. Marth, E. H. (1967). Aflatoxins and other mycotoxins in agricultural products. J. Milk. Food Technol. 30:192-198.

676. Montgomery R. and Smith F. (1956). A review of carbohydrates of wheat and other cereal grains. Agr. Food Chem. 4:716-720.

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Mookherjee found out that the question of damage as a result of continuous breeding of the pest in various grains was as follows: Rice suffered mostly with 100% damage after 4 months. The damage was restricted to nibling in the germ points and no other portion of the grain were eaten up. Feeding on other seeds was not restricted to the germ but extended to other parts.

678. Moreno-Martinez, E. and C. M. Christensen (1971). Difference among lines and varieties of maize in susceptibility to damage by storage fungi. Phytopathology 61(12):1498-1500.

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681. Owen, E. B. (1956). The storage of seeds for maintenance of viability. Commonwealth Bur. Pastues and Field Crops (Hurley, Berkshire, England) Bul. 43, 81 pp.

A well documented bulletin of 10 chapters covering longevity of seed, hygroscopicity, drying, change in composition during storage, dormancy, and treatment in relation to storage.

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683. Peers, F. G. (1967). Aflatoxin - a summary of recent work. Trop. Sci. 9:186-203.

684. Pingale, S. V. (1953). Effect of damage by some insects in the viability and weight of stored grain. Bull. cent. Food. Tech. Res. Inst. Mysore 2:153-154.

685. Pixton, S. W. and S. T. Hill (1967). Long term storage of wheat II. J. Sci. Fd. Agric. 18(3):94-98.

686. Pixton, S. W., Hyde, M. B. and G. Ayerst (1964). Long-term storage of wheat. J. Sci. Fd. Agric. 15(3):152-161.

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(1) Oxidation of unsaturated fatty acids
(2) Decrease in lipids due to oxidation
(3) Decrease in nonpolar lipids
(4) Rapid disappearance of glycolipids and phosolipids.

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