Parching Studies on Wild Rice[1]

R. A. ANDERSON, C. VOJNOVICH, L. L. NAVICKIS, and E. B. BAGLEY, Northern Regional Research Center, Federal Research, Science and Education Administration, U.S. Department of Agriculture, Peoria, IL 61604

Cereal Chem. 56(4):371-374

ABSTRACT

Development of methods for growing wild rice in paddies and the use of modern farm machinery and techniques are increasing production of this grain. This has placed some pressure on the wild rice processor to provide processing capacity for handling the increased volumes. Engineering studies directed toward improving the parching step of the process have resulted in the development of a continuous procedure for conducting this operation. This two-stage procedure involves a steaming and a drying stage, and yields a finished rice with processing characteristics similar to commercially processed rice.

Wild rice (*Zizania aquatica* L.) has been harvested by Indians in northern Minnesota, Wisconsin, Michigan, and southern Canada for many generations. A grass indigenous to North America, wild rice grows primarily in shallow lakes and slow-moving streams. A staple food for the Indians, wild rice today is a favorite of gourmet chefs because of its unique color and flavor characteristics. In addition, wild rice has been shown to possess some nutritional attributes not found in many other cereals. Wild rice has a higher protein content than most cereals, and a more adequate balance of essential amino acids (Anderson 1976, Lindsay et al 1975, Oelke 1976, Oelke et al 1973, Terrell and Wiser 1975).

Researchers at the University of Minnesota (Oelke et al, undated) have reported on the culture and production of wild rice. At the University of Wisconsin (Lund et al 1975), studies on drying (parching) and hulling characteristics of wild rice showed that the distribution of kernel fractions (whole, unhulled, and broken kernels) after processing was dependent on drying temperature, moisture content (both initial and final), and on the temperature of the rice at hulling. To eliminate the presence of undesired white centers, the grain should have an initial moisture content greater than 30% and be dried at temperatures of at least 80° C. Rice dried at too high a temperature, however, became scorched. In this work, Lund et al (1975) also determined that less kernel breakage occurred when the dehulling was done on cool wild rice, as opposed to rice dehulled directly from the dryer. In other investigations by Wisconsin workers (Lindsay et al 1975, Lund et al 1976), extended storage appeared to affect the processing of wild rice, since the color of the immature kernels darkened and hulling efficiency increased. However, their studies also showed that after one week of storage under ambient conditions, the yield of usable wild rice decreased appreciably. Our investigations have been directed toward improvements in the parching step. Largely a batch operation today, development of a continuous procedure, which will yield a final product with traditional flavor and color, will shorten the processing time and enhance the overall efficiency of the process. The objective of the study was to present the wild rice industry with a number of alternative procedures for parching wild rice, indicating the yield and breakage effects to be expected. To adapt these alternatives in practice, however, a more careful examination of statistical variation on the measured parameters would be needed, particularly to establish economics. For this report, replication was kept to a minimum so that some, but not all, of the tests were run in duplicate. Since the methods employed are simple and straightforward, it was felt that the occasional duplications were adequate for this study.

MATERIALS

Green wild rice harvested in 1975 and 1976 crop years was purchased from a commercial source. The grain, with approximately 45% moisture content, was frozen and kept at 0° C until used. No treatments were given to the rice during storage. The 1975 grain was cured or fermented by the processor for a six-day period. The 1976 rice was purchased without being fermented and, when desired, was fermented by allowing rice to stand under ambient conditions for seven days, with daily watering and turning of the sample. In experiments involving the 1975 wild rice, 1,300-g samples were used, and 2,400 to 3,000-g samples were used in tests on the 1976 rice.

EXPERIMENTAL PROCEDURES AND RESULTS

Current commercial practice involves processing of 300 to 400-lb lots of rice for periods of 1.5 to 2 hr at air temperatures up to 135–150° C. During the parching process, three different operations are thought to take place. Although in commercial practice parching is done in a single vessel, steaming, drying, and toasting occur at different times during the process. Steaming appears to be an integral part of the process and takes place during the initial phase of parching. The grain with 40 to 50% moisture is heated, thereby gelatinizing the starch. The wild rice kernels are cooked and the undesirable white, starchy centers become translucent. Steaming has been thought to toughen the kernel,

[1] Presented at the AACC 62nd Annual Meeting, San Francisco, CA, October, 1977.

Mention of firm names or trade products does not imply that they are endorsed or recommended by the USDA over other firms or similar products not mentioned.

making it more resistant to damage in subsequent milling (Lindsay et al 1975). Evidence will be presented to show this takes place. The second step of the parching process is the drying step where the moisture in the grain is reduced to 9–10%. Finally, the grain is slightly toasted when this particular type of flavor is desired.

The general properties of wild rice usually of concern are flavor, color, and cooking characteristics, but in this paper we will be concerned primarily with the recovery of whole wild rice and with its susceptibility to breakage during processing. Kernel breakage is of utmost importance to the wild rice industry. Kernel fragility (KF) has been designated as an indicator of rice breakage. KF is defined as the weight of whole kernels divided by the weight of total wild rice recovered. For the determination of KF, the finished rice sample is divided to provide a portion of from 100 to 200 g. This fraction is hand separated into whole and broken kernels. Our KF appears to be equivalent to the kernel hardness index reported by Wisconsin workers (Wirakartakusumah and Lund 1978). For comparative purposes, six commercial samples of finished wild rice collected from five different plants showed an average KF of 0.8.

Our investigations of the parching process included such approaches as direct hot air drying and combination steaming-drying procedures involving the use of the autoclave and microwave oven in conjunction with air drying, and a steam heated interrupted flight mixer-conveyor.

Direct Drying

Wild rice was exposed to a direct drying treatment to determine its effects on subsequent processing and product recovery. Wild rice from the 1975 and 1976 crops were dried from about 45% to 10% moisture in a laboratory Proctor-Schwartz forced hot air oven (Proctor-Schwartz Co., Philadelphia, PA) set at 85°C, with periodic stirring. The depth of the rice on a wire mesh tray was 1.5 to 2 in. After drying, the grain was dehulled by passing the material twice through a Satake laboratory rice huller (Satake Engineering Co., Ltd., Tokyo, Japan). Hulls were recovered by aspiration, and the remaining wild rice was hand separated into dehulled whole grain, broken kernels, and undehulled fractions. Operating conditions for the tests and recovery data are given in Table I. Product recovery from this type of processing was poor. A large amount of broken kernels was recovered from each of the tests (tests 1, 2, and 3), indicating that the rice was placed under considerable stress during the removal of moisture.

TABLE I
Operating Conditions and Recovery Data for Direct Drying of Wild Rice

Conditions and Recoveries	Test Number 1	2	3
Grain conditions			
Crop year	1975	1976	1976
Fermented	Yes	Yes	No
Moisture, %	49	47	42
Drying conditions			
Temperature, °c	85	85	85
Time, min	120	120	120
Final moisture, %	10.0	9.5	9.3
Product recovery			
Hulls and undehulled grain, %	23.1	21.0	22.0
Whole grain, %	39.9	27.8	38.2
Broken grain, %	37.0	51.2	39.8
Kernel fragility[a]	0.52	0.35	0.49

[a]Kernel fragility = wt of whole wild rice/wt of whole and broken wild rice.

TABLE II
Operating Conditions and Recovery Data for Autoclaving and Hot Air Drying Wild Rice (Autoclave conditions: 100–104° C, 20 min)

Conditions and Recoveries	Test Number 4	5	6	7
Grain conditions				
Crop year	1975	1975	1975	1976
Fermented	Yes	Yes	Yes	No
Moisture, %	52	50	51	45
Drying conditions				
Temperature, °C	37	85	94	94
Time, min	240	35	31	75
Final moisture, %	9.8	8.0	8.7	9.6
Product recovery				
Hulls and undehulled grain, %	25.4	27.0	27.3	21.0
Whole grain, %	69.8	67.9	66.5	68.7
Broken grain, %	4.8	5.1	6.2	10.3
Kernel fragility	0.94	0.93	0.92	0.87

TABLE III
Operating Conditions and Recovery Data for Microwave Treatment and Drying of Wild Rice

Conditions and Recoveries	Test Number 8	9	10	11	12
Grain conditions					
Crop year	1975	1975	1976	1976	1976
Fermented	Yes	Yes	Yes	No	No
Moisture, %	51	51	57	45	49
Microwave treatment					
Anode current, mA	0.3	0.3	0.5	0.3	0.3
Time, min	8	8	6	8	8
Drying conditions					
Type	Micro-hot air				Interrupted flight
Temperature, °C	88	121	121	121	154
Time, min	. . .	8	. . .	8	14
Final moisture, %	17.0[a] (8.6)	13.0	22.0[a] (9.0)	14.0	10.0
Product recovery					
Hulls and undehulled grain, %	27.1	26.4	17.2	22.2	22.0
Whole grain, %	68.0	67.7	69.5	69.0	69.2
Broken grain, %	4.9	5.9	13.3	8.8	8.8
Kernel fragility	0.93	0.92	0.84	0.89	0.88

[a]Drying in a hot oven was necessary to reduce moisture for processing and storage. Final moisture of rice was 8.6% in test 8 and 9% in test 10.

Direct Steam Treatment and Air Drying

Autoclaving is a direct method of steaming; similarly, using the forced hot air dryer is a direct method of drying. This combination process was studied to establish operating parameters and a laboratory procedure for parching wild rice. A similar procedure has been reported by Lund et al (1977).

Fermented green wild rice from the 1975 crop and unfermented green wild rice from the 1976 crop were autoclaved for 20 min at 100–104° C. Moisture content of the grain ranged from 45 to 52%. The treated wild rice was air dried in the Proctor-Schwartz dryer at temperatures varying from 37 to 94° C and for periods varying from 31 to 240 min, depending on the drying temperature. After drying, the grain was dehulled and separated as already described.

Operating and product recovery data are given in Table II. The best overall results were obtained when fermented wild rice from the 1975 crop was steamed and then gently dried (test 4). More whole kernels were recovered, which indicated less stress and less breakage than during direct drying. When the same wild rice, after steaming, was dried at higher temperatures for shorter periods of time, essentially the same results were obtained (tests 5 and 6). A sample of 1976 nonfermented wild rice (test 7), when processed under similar conditions to test 6, gave a slightly lower KF than did the other samples under test. Because a larger sample was used in test 7, the drying time was greater than in test 6. There appeared to be slightly less hulls and unhulled rice from the 1976 crop than from that of the previous year. Covering all tests, the amount of unhulled rice was in the range of 0.5 to 1.5%, but generally less than 1%.

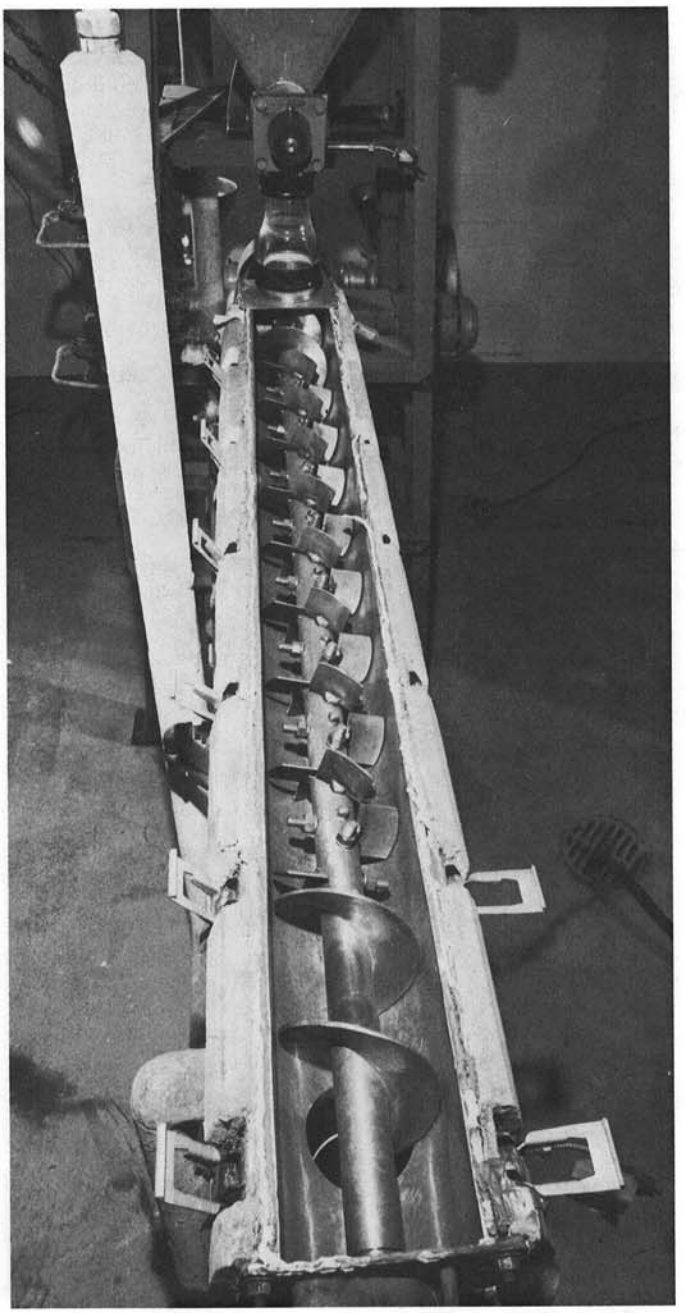

Fig. 1. Interrupted flight mixer-conveyor for processing wild rice.

Microwave Treatment and Alternate Drying Methods

Several tests were conducted in which the rice was subjected to microwave treatment for a few minutes to complete the steaming process and then was dried, either in the microwave oven using forced hot air or in a continuous conveyor-type dryer. The microwave unit used was a Despatch model SMC-1-33H (Despatch Oven Company, Minneapolis, MN) operating at an output frequency of 2,450 MHz at a power output of 1.2 kw. The unit was equipped with a forced-air convection heating device that can be used separately or in combination with the microwave power. After treatment, the wild rice was dehulled and separated by procedures already described. Results of these tests are shown in Table III. Use of the microwave oven reduced the time required to conduct the steaming operation. Drying in the microwave oven from 8 to 13 min reduced moisture content from 45–57% to 10–22%. Extended drying in the Proctor-Schwartz oven was done on samples with moistures in excess of 14% to permit processing and storage of rice. Final moisture of rice in test 8 was 8.6% and in test 10, 9%. In tests 8 and 9, comparable results were obtained when the two rice samples from the 1975 crop were steamed in the oven with the anode current set at 0.3 mA for 8 min, but one dried at 88° C (test 8) and the other dried at 121° C (test 9). The yield of products and KF were about the same for the two tests. The amount of broken kernels was quite low. Results also were similar to those obtained when the same rice was autoclaved and hot air dried. Grain from the 1976 crop, steamed at 0.5 mA for 6 min (test 10), and 0.3 mA for 8 min (test 11), dried and processed, gave recoveries of broken kernels slightly higher than the 1975 grain. There was a smaller hull and undehulled fraction from the 1976 wild rice than obtained from the 1975 grain. This parallels the results from the test on 1976 grain that was autoclaved and hot air dried. In test 12, following the steaming in the microwave oven, the grain was dried in the interrupted flight conveyor dryer for 14 min at 154° C. Essentially the same product yields and KF value were obtained as noted in the parallel test (test 11) using the microwave for drying.

Continuous Processing in an Interrupted Flight Mixer-Conveyor

Green wild rice was processed in an interrupted flight mixer-conveyor (Fig. 1). The apparatus was heated by circulating steam in the mixer-conveyor jacket. Grain was passed through the equipment twice. No air was blown through the conveyor. In the first pass, the grain was essentially steam-cooked. During the second pass, the wild rice was dried and lightly toasted or parched. Residence times for wild rice in mixer-conveyor were 14–16 min for the first passage and 11–14 min for the second.

Unfermented wild rice from the 1976 crop containing from 44 to 47% moisture was processed using steam pressures of 70, 90, and 110 psig (tests 13, 14, and 15, respectively). Operating and product recovery data are given in Table IV. Increasing the steam pressure in the mixer-conveyor, which in turn increased the conveyor surface temperature, affected the ultimate processing by increasing recovery of hulls and undehulled wild rice and broken kernels and decreasing the amount of whole grain rice. In test 16, wild rice from the 1976 crop was fermented for seven days and then treated in the same manner as nonfermented wild rice, ie, 90 lb steam pressure in conveyor jacket (test 14). Slightly less whole kernels were recovered but there were also less broken kernels, so the KF was about the same in both tests.

DISCUSSION

Present commercial methods of parching wild rice are far from the efficient combination of the steaming, drying, and toasting processes needed to handle potential increased volumes of grain.

TABLE IV
Operating Conditions and Recovery Data for Processing Wild Rice in a Continuous Interrupted Flight Mixer-Conveyor (1976 Crop Wild Rice)

Conditions and Recoveries	Test Number 13	14	15	16
Grain conditions				
Fermented	No	No	No	Yes
Moisture, %	44	47	44	58
Operating conditions				
Steam pressure on equipment, psig	70	90	110	90
Surface temperature, °C	144	154	~158	154
Residence time, steaming, min	14	14	14	15
Residence time, drying, min	12	12	11	14
Final moisture, %	12.4	10.1	9.2	7.5
Product recovery				
Hulls and undehulled grain, %	17.8	22.7	21.8	24.7
Whole grain, %	71.3	65.4	63.5	63.6
Broken grain, %	10.9	11.9	14.7	11.7
Kernel fragility	0.87	0.85	0.81	0.84

While traditional methods are quite effective considering the slow growth of the industry, a more efficient parching process must be implemented if the processing industry is to grow with anticipated greater production of wild rice.

This work has established that steaming of the moist green wild rice is critical to subsequent processing, confirming preliminary results of Wisconsin studies (Lindsay et al 1975, Lund et al 1977). Steaming gelatinizes the starch and gives the wild rice kernel its translucent appearance. The amount of broken kernels recovered was generally lower after steaming regardless of the method of drying and toasting.

Use of the interrupted mixer-conveyor offers a means of continuously steaming, drying, and slightly toasting wild rice. Slightly greater breakage occurs in this machine than with the batch systems of autoclave or microwave steaming followed by hot air drying. The amount of breakage, however, is less than is generally found in commercial operations.

There are undoubtedly other continuous systems for parching wild rice to produce a finished product with traditional characteristics. One such system could involve the use of a commercial corn roaster. In a preliminary test, wild rice was processed in such a machine with fair results. KF of 0.73 was obtained. There was a considerable amount of broken kernels, but dehulling was about the same as in other tests. More work is necessary to establish proper operating parameters for conditioning wild rice so that less breakage results. The corn roaster could speed up the overall process considerably, since residence time is only 6 to 9 min.

To complete this study, physical, chemical, cooking, and organoleptic analyses will be conducted on the finished rice from the various tests.

LITERATURE CITED

ANDERSON, R. A. 1976. Wild rice: Nutritional review. Cereal Chem. 53:949.

LINDSAY, R. C., LUND, D. B., MARTH, E. H., and STUIBER, D. A. 1975. Report of Wild Rice Research Activities. Univ. Wis.: Madison.

LUND, D. B., HEIDEMANN, R., LINDSAY, R. C., JOHNSON, C. E., MARTH, E. H., and STUIBER, D. A. 1976. Extended storage of wild rice. Trans. ASAE 19:332.

LUND, D. B., LINDSAY, R. C., MARTH, E. H., and STUIBER, D. A. 1977. Methods to extend the storage life of green, wet wild rice. Univ. Wis.: Madison.

LUND, D. B., LINDSAY, R. C., STUIBER, D. A. JOHNSON, C. E., and MARTH, E. H. 1975. Drying and hulling characteristics of wild rice. Cereal Foods World 20:150.

OELKE, E. A. 1976. Amino acid content in wild rice (Zizania aquatica L.) grain. Agron. J. 68:146.

OELKE, E. A., ELLIOTT, W. A., KERNKAMP, M. F., and NOETZEL, D. M. (undated). Commercial Production of Wild Rice. Ext. Folder 284, Agric. Ext. Serv. Univ. Minn., St Paul.

OELKE, E. A., ELLIOTT, W. A. KERNKAMP, M. F., NOETZEL, D. M., and PETERSON, A. G. 1973. Progress Report on Wild Rice Research. Univ. Minn.: St. Paul.

TERRELL, E. E., and WISER, W. J. 1975. Protein and lysine contents in grains of three species of wild rice (Zizania; Gramineae). Bot. Gaz. 136:312.

WIRAKARTAKUSUMAH, M. A., and LUND, D. B. 1978. Kernel hardness of wild rice as affected by drying air temperature and moisture gradient. J. Food. Sci. 43:394.

[Received January 27, 1978. Accepted October 16, 1978]