Quality Characteristics of Processed Wild Rice[1]

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ABSTRACT

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Growing wild rice in paddies using modern farming techniques has increased production of the grain manyfold over the historical recovery of the rice from natural stands in northern lakes and sluggish streams. This has placed some pressure on the wild rice processor to provide processing capacity for handling the increased volumes without impairing quality characteristics of the grain. These characteristics have been evaluated on commercially processed wild rice. Also, engineering research on several aspects of the wild rice process has suggested some alternative procedures for increasing the efficiency of the process. These procedures involve a direct steaming treatment and a microwave treatment, both in conjunction with hot air drying, and steaming and drying the grain in a continuous interrupted flight conveyor. Chemical, physical, and cooking properties and flavor evaluations indicated that wild rice processed by the new methodology was similar to the commercially processed grain.

Wild rice (*Zizania aquatica* L.) has become more available since farmers have been growing this grain in paddies using modern farming techniques. Four to five times more wild rice is produced annually from 12,000–15,000 acres of paddies than from the total harvest of natural stands growing in shallow lakes and sluggish streams. This has placed some pressure on the wild rice processor to provide processing capacity for handling the increased volumes without impairing quality characteristics of the grain.

Wild rice quality is closely related to the several processing steps involved in treating the rice after harvest. These steps include "curing," where the freshly picked rice is placed in windrows on the ground for a period varying from 7 to 14 days. The grain is turned daily and watered to keep it from heating. During the cure, the grain darkens and some desirable flavor characteristics appear to develop. After the grain is cured, it is placed in parching drums where a combination of steaming, drying, and roasting takes place under controlled conditions. This operation, in addition to drying the grain, also helps develop kernel flavor, color, and texture. The dried grain is dehulled, slightly polished or scarified to scratch seed coat, sized, and packaged.

Workers at the University of Wisconsin have studied the drying and dehulling of wild rice and have related the effects of these processing steps to product quality (Lund et al 1975). They have also studied the effect of extended storage on quality factors of wild rice (Lund et al 1977). Engineering studies at the Northern Regional Research Center (NRRC) on aspects of the wild rice process have suggested some alternative procedures for increasing the efficiency of the process, particularly in the parching step. Studies on the use of a direct steam treatment and a microwave oven treatment, both in conjunction with hot air drying, and of a continuous steam-jacketed interrupted flight-conveyor have provided the industry with several options for performing the parching process (Anderson et al 1979). Quality factors such as chemical and physical properties, color, cooking properties, and sensory evaluations on finished rice from the new procedures and on finished rice from commercial sources and processing are described in this report.

MATERIALS AND METHODS

Commercially processed wild rice samples were obtained from Kosbau Bros., Deerwood, MN; United Wild Rice, Inc., Outing, MN; Gibbs Bros. Wild Rice, Deer River, MN; MacGregor Wild Rice Co., Aitkin, MN; and Daigle Wild Rice Co., Ball Club, MN.

Freshly harvested wild rice used in laboratory and pilot-plant experiments was from the 1976 crop year and was purchased commercially. Experimental studies have been extensively described in a previous publication (Anderson et al 1979) and conditions of the various treatments used are given in Table VI.

Ash, fat, fiber, and protein (N×6.25) were determined according to Approved Methods of the AACC. Moisture was determined in the Brabender moisture tester. Cooking test directions were provided by Uncle Ben's Foods, Houston, TX, and consisted of adding 20.0 g of wild rice to 2 qt of boiling water and maintaining a gentle boil for 25 min. The contents were transferred to a tared strainer, allowed to drain for 30 sec, and weighed. Optimum values for weight of cooked rice were 44 to 57 g. This test is part of the specification used by this company in their purchasing of wild rice.

Sensory evaluation was conducted by NRRC's 15-member panel, who are experienced in testing various cereal products for odor and flavor. This panel was trained to recognize the predominant flavor components of wild rice. Wild rice was prepared in a 13:1 ratio of water to rice and cooked at a boil for 40 min. One-ounce portions were served in coded 50-ml glass beakers covered with watch glasses. A standard scalar scoring test was used to evaluate the experimental wild rice samples for flavor in comparison with a coded commercial wild rice sample (Kosbau). Only two samples of rice were tested at each panel sitting. Panel members were instructed to rate the intensity of each flavor they perceived in the rice samples on a 1 to 10 scale, where 10 is bland and 1 is very strong. The panelists also gave an overall intensity score for each sample, using the same scale. Mean scores for each predominant description and for overall sample intensity were computed. A one-way analysis of variance test was used to determine whether differences between the commercial and experimental samples were significant. Comparisons also were made between the various experimental samples.

Quality Evaluation of Commercially Processed Wild Rice

Physical Examination of Commercially Processed Wild Rice. As the production and use of wild rice increase, the quality of the final product becomes increasingly important. In addition, uniform quality of product must be maintained since quality uniformity is vital to the industry in developing expanding markets for wild rice. Some quality comparisons were made on six samples of commercial paddy wild rice obtained from different processors. In screening these samples, we were primarily interested in the amount of whole and broken kernels and the number of white centers present in the samples. White centers are considered objectionable. A commercial cooking test also was conducted on the six samples. Results of the evaluation are found in Table I.

Kernel breakage is an important quality parameter in wild rice. Broken kernels have less value in the marketplace, where emphasis

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

is placed on aesthetic quality as well as on flavor. The ratio of whole to broken kernels was somewhat variable from plant to plant, and even within the same plant (B1 and B2). This is probably due to the differences in the processing equipment and flow in the various plants or to the wild rice itself. White centers varied from 0 to 11%, again quite variable throughout the different plants. White centers may be indicative of incomplete parching, ie, incomplete gelatinization of starch. Wisconsin workers (Lund et al 1977) have evidence that while kernels with completely gelatinized starch do not exhibit white centers, kernels with translucent centers are not necessarily composed of completely gelatinized starch. The results of the cooking tests also were variable from plant to plant, ranging from 38 to 52 g. These are generally in the acceptable range, although one purchaser lists a range of 44 to 57 g as his requirement.

To measure the cooking properties of wild rice by a procedure other than the cooking test, we tested the wild rice samples in the Brabender amylograph (Sandstedt and Abbott 1964). Inasmuch as starch gelatinization is an integral part of the wild rice process, occurring primarily in the parching process, it was felt that this instrument might be of value in establishing some quality parameters. Critical points taken from the amylograph curves of the commercial wild rice samples, which were ground through 20 mesh and tested at 9% solids in water, are given in Table II.

There was variability in the samples from plant to plant at all the critical points. The temperature of initial gelatinization ranged from 89 to 95°C. Peak viscosity was somewhat variable but not as much as might be expected. The final viscosity varied considerably, from 170 up to 700. Some gelatinization apparently occurred in all samples during processing, but at different rates and levels. In an untreated white rice starch, peak viscosities would be in the range of 650 Brabender Units and a viscosity at 50°C (cold paste viscosity) would be about 900; therefore, the character of the curves indicates that some gelatinization is definitely occurring in the processing of wild rice, but it is incomplete.

Data presented in these tables point out variability between plants and between the final products emanating from these plants. As the wild rice industry grows, the maintenance of product quality and uniformity will be demanded by manufacturers and consumers.

Analysis of Wild Rice Collected at Different Stages of the Process. Samples of wild rice were collected at various stages of the process, beginning with the harvest and ending with the finished product, to determine where breakage occurred. Seven samples were selected for this evaluation: 1) hand-picked sample from the field before combining; 2) sample from the combine; 3) hand-picked sample from the fermented pile; 4) sample from a rotating drum parcher; 5) sample from double roller dehuller; 6) sample from scarifier; and 7) sample of finished rice.

Preparation of the samples for analysis included air drying and then hand separating the broken kernels from the other components. Table III lists the data compiled from the separation.

The hand-picked sample collected from the field contained essentially whole kernels, with only a small amount of broken material. Relatively small amounts of broken kernels were also found in the combine sample and in the sample from the fermented pile. As the rice enters the mechanical handling process, the amount of broken kernels increases dramatically, as evidenced by the data for rice from different processing steps. Most breakage of kernels appears to occur in the dehulling step. This would be expected since this operation contributes the most severe mechanical treatment to rice. Chemical analyses of wild rice kernels taken from several of the samples are given in Table IV.

There was essentially no difference in the chemical composition of the field samples or the finished rice. Protein content of the wild rice kernel is comparable to that of wheat. Moreover, it has been shown to have a very favorable amino acid balance when compared to the FAO Provisional Pattern (Anderson 1976, Lindsay et al 1975, Oelke 1976, Terrell and Wiser 1975). The hulls from the hand-picked rice samples were also analyzed and were found to contain almost 35% fiber and about 5.6% protein. Considering the relatively large quantity of crude fiber in the hulls together with a rather favorable protein content, this fraction might be used as a potential source of dietary fiber.

We ran amylograph curves on the hand-picked and combine-picked samples as well as on the sample from the fermented pile and compared them to a curve from a finished rice. Critical points are given in Table V.

There was little difference in the values for the critical points for the first two samples. However, there was a slight lowering of temperature of initial gelatinization and a moderate increase in peak and cold paste viscosity in the sample from the fermented pile. The values for the finished rice are substantially lower than those from the green rice. Values for kernels from fermenting piles were more like the raw grains. This is, of course, indicative of the gelatinization of starch occurring during the parching process. Usefulness of these viscosity measurements, both in following processing and in quality control, deserves more detailed investigation.

TABLE I
Quality Comparisons of Commercial Wild Rice from Different Processors

Plants	Whole Kernels (%)	Broken Kernels (%)	White Centers (%)	Cooking Test[a] (g)
A	84	16	4	43
B1[b]	74	26	11	42
B2[b]	84	16	7	38
C	75	25	0	39
D	72	28	3	52
E	89	11	6	46

[a] Weight of wet grain after a standard cook.
[b] Two different samples from the same plant.

Quality Evaluation of Wild Rice from NRRC Developed Processes

Engineering studies have been done in which several approaches to the parching step of the wild rice process were investigated. This work resulted in three possible procedures for parching wild rice and pointed out the importance of a "steaming" step in the process (Lund et al 1975, 1977). The procedures are: (a) autoclaving the green wild rice, followed by hot air drying; (b) microwave treatment of green wild rice, followed by hot air drying; and (c) passing the

TABLE II
Critical Points from Amylograph Curves of Wild Rice from Different Processors

Plant	Viscosity at 29°C (BU)[a]	Temperature of Initial Gelatinization (°C)	Peak Viscosity (BU)	Viscosity at 95°C (BU)	Viscosity at 95°C + 16 min (BU)	Viscosity at 50°C (BU)
A	55	89	90	90	225	480
B1	60	95	103	68	110	200
B2	60	93.5	75	62	98	170
C	62	89	130	130	360	700
D	55	92	98	80	130	215
E	35	89	...	45	160	370

[a] Brabender Units.

green rice through a steam-jacketed interrupted flight mixer-conveyor to steam the rice, followed by a second pass to dry the rice. The wild rice from the treatments was dehulled by passing the grain twice through a Satake laboratory rice huller. Hulls were recovered by aspiration, and the remaining wild rice was hand separated into whole grain, broken kernels, and undehulled fractions, which were then evaluated for the quality factors. In Table VI, the effects of these procedures on breakage of wild rice kernels are compared to direct hot air drying of the green rice and commercial practice. Kernel fragility is used as an indicator of breakage and is defined as the weight of whole rice divided by the weight of whole and broken kernels. This is equivalent to the kernel hardness index reported by Wirakartakusumah and Lund (1978).

Direct hot air drying of the green rice resulted in considerable kernel breakage and a low kernel fragility, 0.35–0.5. The three alternative procedures for parching wild rice gave similar results as far as kernel breakage was concerned, kernel fragility values varying from 0.84 to 0.89. Commercial control samples had an average kernel fragility of 0.80, ranging from 0.72 to 0.89.

The amount of kernels with white centers varied slightly between the alternative treatments. The values were considerably lower in all treatments when compared to the average value for the six commercial samples.

Cooking properties of wild rice processed by the several different procedures are given in Table VII. Results of the standardized cooking test showed little variation between the samples from the different treatments or procedures. The values might be a little low, however, since these rice samples were not scarified, as is done in commercial processing. Nevertheless, the cooking values fell within the range usually obtained from the testing of commercial samples (Table I), regardless of the parching procedure used.

Brabender amylograph curves on the wild rice samples from different treatments showed some variability between treatments. However, Brabender values for the critical points were generally within the range found for samples of wild rice obtained from commercial sources. Gelatinization apparently occurs during all treatments but, as was noted with the commercial samples parched under different conditions, at different rates and levels. This would

TABLE III
Processing Effects on Breakage of Wild Rice Kernels (Samples Collected at Different Stages of Process)

Sample	Broken Kernels (%)
Hand-picked from field	0.8
From combine	1.9
From fermenting pile	1.9
From parcher	7.5
From dehuller	21.5
From scarifier	21.7
Finished rice	20.6

TABLE IV
Chemical Analyses of Wild Rice Samples Collected from Different Stages of Process[a]

Sample	Fat (%)	Fiber (%)	Ash (%)	Protein (%)
Kernels hand-picked from field	1.1	1.4	1.6	14.3
Kernels from combine	1.3	1.4	1.7	16.3
Kernels from fermented pile	1.1	1.6	1.9	17.1
Final rice	1.1	1.7	1.7	14.7

[a] Moisture-free basis.

TABLE V
Critical Points from Amylograph Curves of Wild Rice Samples Collected from Different Stages of Process

Sample	Viscosity at 29°C (BU)[a]	Temperature of Initial Gelatinization (°C)	Peak Viscosity (BU)	Viscosity at 95°C (BU)	Viscosity at 95°C + 16 min (BU)	Viscosity at 50°C (BU)
Kernels hand-picked from field	45	83	275	275	330	590
Kernels from combine	45	83	260	260	320	590
Kernels from fermented pile	42	77	458	458	410	745
Final rice	57	93	65	65	108	198

[a] Brabender Units.

TABLE VI
Effect of Parching Treatment on Wild Rice Kernel Breakage and White Center Count

Treatment	Treatment Conditions	Kernel Fragility[a]	White Centers (%)
Direct hot air drying (C)[b]	85°C—120 min	0.35	...
Direct hot air drying (NC)[c]	85°C—120 min	0.49	1
Autoclave followed by hot air drying (NC)	100–104°C—20 min 94°C—75 min	0.87	0.5
Microwave followed by hot air drying (C)	0.5 mA—6 min 121°C—8 min	0.84	0
Microwave followed by hot air drying (NC)	0.3 mA—8 min 121°C—8 min	0.89	2
Interrupted flight mixer-conveyor; 2 passes (C)	154°C—15 min 154°C—14 min	0.84	0.5
Interrupted flight mixer-conveyor; 2 passes (NC)	154°C—14 min 154°C—12 min	0.85	0
Microwave followed by interrupted flight mixer-conveyor; 1 pass (NC)	0.3 mA—8 min 154°C—14 min	0.88	3
Control: 6 commercial samples from 5 plants (range of values)		0.72–0.89 (0.80 av)	0–11 (5 av)

[a] Kernel fragility = (wt of whole rice)/(wt of whole + broken rice). Test carried out on a fully processed rice after passage through the Satake laboratory huller (two passes).
[b] C = Cured.
[c] NC = Not cured.

TABLE VII
Effect of Parching Treatment on Cooking Properties of Wild Rice

Treatment	Cooking Test (g)[a]	Brabender Amylograph-Critical Points: Viscosity at 29°C (BU)[b]	Temperature of Initial Gelatinization (°C)	Viscosity at 95°C (BU)	Viscosity at 95°C + 16 min (BU)	Viscosity at 50°C (BU)
Direct hot air drying (C)[c]	37	40	85	324	375	662
Direct hot air drying (NC)[d]	38	38	85	310	363	630
Autoclave followed by hot air drying (NC)	38	60	94	62	104	218
Microwave followed by hot air drying (C)	41	60	88	120	330	630
Microwave followed by hot air drying (NC)	38	62	90.5	128	390	690
Interrupted flight mixer-conveyor; 2 passes (C)	43	68	94	70	130	260
Interrupted flight mixer-conveyor; 2 passes (NC)	39	62	92	70	155	330
Microwave followed by 1 pass interrupted flight-mixer conveyor (NC)	40	63	95	63	142	308
Control samples from 5 plants (range of values)	38–52	35–62	89–95	45–130	98–360	170–700

[a] Weight after cooking 20 g wild rice in 2 qt of boiling water for 25 min.
[b] BU = Brabender Units.
[c] C = Cured.
[d] NC = Not cured.

TABLE VIII
Flavor Evaluation of Experimental Processed Wild Rice Samples[a]

Sample	Flavor Intensity Score	Cereal/ Grain	Toasted	Musty/ Stale	Sour/Fer- mented	Bitter	Nutty	Fishy	Meaty	Bran	Chocolate	Vegetable
Control (commercial wild rice)	6.5	7.1	8.2	9.4	9.3	9.0	9.4	9.9	9.7	9.0	9.8	9.3
Autoclave followed by hot air drying (NC)[b]	6.4	6.9	9.2	8.7	8.8	8.9	9.5	9.1	9.8	9.0	10.0	9.3
Microwave followed by hot air drying (C)[c]	6.2	6.8	8.6	8.6	8.9	9.0	9.3	9.1	9.8	9.0	9.5	9.4
Microwave followed by hot air drying (NC)	6.0	6.8	8.9	9.6	8.6	9.3	9.5	9.7	9.8	9.1	10.0	9.3
Interrupted flight mixer-conveyor; 2 passes (C)	6.3	7.6	9.1	9.2	8.4	9.5	9.7	9.8	9.8	8.8	9.7	9.2
Interrupted flight mixer-conveyor; 2 passes (NC)	5.7	7.0	8.6	9.8	9.5	8.4	9.3	10.0	9.6	9.0	10.0	8.2
Microwave followed by interrupted flight mixer-conveyor; 1 pass (NC)	5.8	6.4	8.8	9.3	8.7	8.7	9.5	9.6	9.8	9.3	9.7	9.2

[a] Data based on a 1–10 intensity scale with 10 as bland and 1 as very strong.
[b] NC = Not cured.
[c] C = Cured.

be expected since parching heat was applied in several different forms.

Flavor evaluations were conducted on wild rice prepared by the described procedures and exposed to different parching treatments. Results of the evaluation are given in Table VIII. Statistical analyses of the data show that there is neither a significant difference in flavor or overall intensity among experimental samples nor a significant difference between the commercial and the experimental samples. Several definite patterns were observed in the data. The descriptive intensity levels that the panel gave for cereal/grain, nutty, meaty, bitter, vegetable, chocolate, fishy, and bran were similar for all samples. Four of six experimental samples were rated as more musty/stale than the commercial rice. All but one experimental sample had stronger sour/fermented descriptions than the control. This is largely due to the toasting effect imparted by the commercial parchers and is shown by the rating of the commercial rice as having a more toasted flavor than the experimental samples. Where desired, the toasted flavor can be added to the experimental samples by a light roasting. The six experimental samples also were rated lower for overall intensity than the commercial rice. Statistical calculations on the overall mean differences between samples show the two scoring patterns of the commercial rice, which indicate more toasted flavor and less overall flavor than the experimental samples, as being statistically significant trends.

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