Laboratory Parboiling Apparatus and Methods of Evaluating Parboil-Canning Stability of Rice[1]

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ABSTRACT

A laboratory parboiling apparatus and methods used in evaluating parboil-canning stability of new rice varieties and early generation breeding material are described. The system permits the conduct of all operations involved in the rice parboil-canning process. This includes presteep vacuum treatment, steeping, steaming, drying, milling, and pressure canning of the parboiled milled rice in excess water. Canned kernel stability is subjectively evaluated according to clarity of broth, kernel splitting, and fraying of edges and ends. Objective methods are based on the amount of soluble and insoluble solids lost during canning of the parboiled rice. Solids loss for selected commercial and experimental rice varieties ranged from 9% (excellent parboil-canning stability) to 44%.

The development of new and improved long-grain rice (*Oryza sativa* L.) varieties, having the parboil-canning stability required for use in heat-processed formulations such as canned soups, is an important part of our rice breeding programs. Varieties with kernels suitable for parboiling and canning have the dry fluffy texture desired in home-cooked rice and are utilized widely in the manufacture of quick-cook and other rice products. Thus, determining the parboil-canning stability of new rice varieties provides an essential means of evaluating their potential for many uses.

To aid in evaluating new rice varieties and hybrid selections, a laboratory-scale parboiling apparatus was designed and constructed[3], under our supervision, for use at the Regional Rice Quality Laboratory[4]. The apparatus, parboiling and canning procedures, and subjective and objective methods of routinely evaluating kernel stability of canned parboiled rice are described. Parboil-canning, as used in this report, refers to rough rice that is parboiled, dried, milled, and pressure-canned in excess water.

The apparatus was designed to produce parboiled rice comparable to that

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[3]The rice parboiling apparatus was constructed by the United States Testing Company at Hoboken, New Jersey, under contract with the U.S. Department of Agriculture (Contract No. 12-14-100-4508(34)).

[4]The Regional Rice Quality Laboratory located at Beaumont, Texas, is operated by the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, in co-operation with the Texas Agricultural Experiment Station and the Texas Rice Improvement Association, and serves the co-operative rice breeding programs conducted in Texas, Louisiana, Arkansas, and California. The program is also supported in part by grants-in-aid from Campbell Soup Company, New Jersey, and General Foods Corporation, New York.

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manufactured commercially in the United States. General phases (1,2,3,4) involved in the production of parboiled rice are: steeping rough rice to moisture contents of 30 to 35%; steaming to gelatinize the starch in the steeped kernels; drying the parboiled rice to 12 to 13% moisture; and milling. In commercial plants (5,6,7,8), various presteeping, steeping, and steaming conditions are employed. These variations in parboiling treatment include: the use of reduced pressure prior to steeping; steeping at atmospheric or under hydraulic pressure in cold, warm, or hot water; and steaming over rather wide ranges of temperature and pressure. The apparatus was developed to permit these flexible variations in parboiling techniques, as well as close control and reproducibility of experimental conditions[5].

The component parts of the laboratory-scale parboiling apparatus are shown in Fig. 1. These are: a retort chamber, a vacuum pump system, an air compressor, a

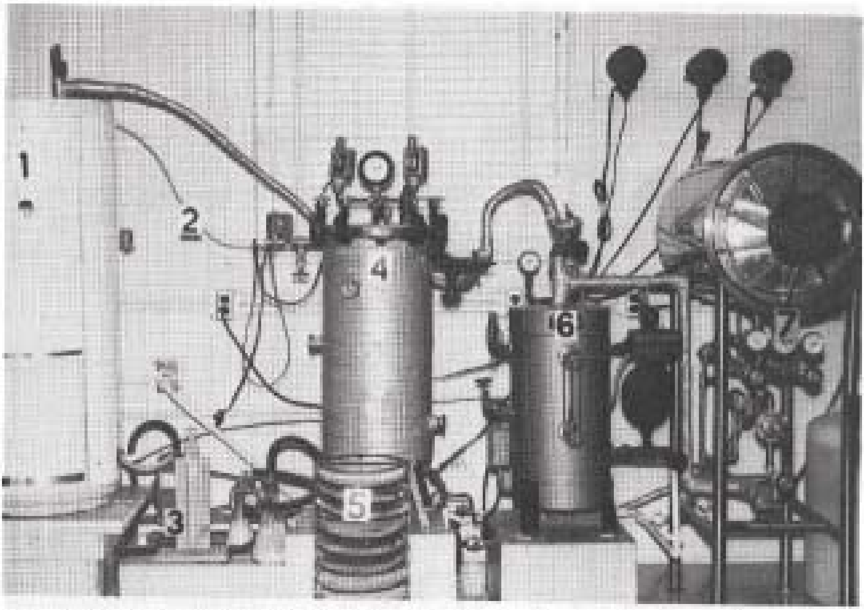

Fig. 1. Laboratory rice parboil-canning apparatus: 1, water heater; 2, air line to portable compressor; 3, vacuum system; 4, retort chamber; 5, sample rack and baskets; 6, steam generator. The horizontal autoclave, 7, facilitates canning of parboiled rice.

steam generator, and a water heater[5]. The vacuum pump, air compressor, steam generator, and water heater are standard electrically operated systems and are connected directly to the retort chamber in which the rice is parboiled. The retort chamber is constructed of 600-lb. test stainless-steel tubing and is 27 in. high and 13 in. in diameter. It is equipped with three thermometers located at the top,

[5]Detailed specifications for the design and operation of the apparatus are available from the authors.

middle, and bottom of the chamber to measure water temperature during steeping. Three flexible heating tapes connected to powerstats are wound around the chamber to maintain constant steeping temperature. Automatic air and steam pressure controls on the chamber maintain constant conditions during parboiling. Asbestos sheeting is taped around the chamber for insulation purposes.

Rough rice to be parboiled is inserted in the retort chamber by means of a stainless-steel sample rack and wire-mesh sample baskets (10 in. in diameter and 1 in. deep) equipped with inside fitting lids. These baskets permit holding the rice in even layers throughout the parboiling procedure.

MATERIALS AND METHODS

Parboiling, Drying, and Milling Procedures

Clean, dry rough rice samples (130 g. each) are spread evenly in each of ten sample baskets and inserted in the retort chamber by means of the sample rack. After sealing the chamber lid, the samples are subjected to reduced pressures (25 to 50 mm. Hg) for 30 min. Immediately following the vacuum treatment, steep water, preheated to 70°C., is introduced to fill the chamber to within 4 in. of the top. Air pressure (80 p.s.i.) is applied and the rice steeped for 2 hr. at 60°C. After steeping, the water is drained and the rice steamed for 10 min. at 15 p.s.i. to gelatinize the starch. The chamber is vented slightly during steaming to evacuate any accumulated moisture. After steaming, the parboiled rice is allowed to dry to approximately 12% moisture content in a storage room maintained at 25°C. and 55 to 60% r.h. The dry parboiled rice is milled by using the modified McGill No. 1 milling method (9).

Pressure Canning Procedure

Samples (15 g.) of parboiled milled rice prepared by the above procedure are transferred to 250-ml. Erlenmeyer flasks and 150 ml. of distilled water is added. The flasks are placed in a constant-temperature water bath maintained at 95°C. and precooked for 20 min. After cooling to room temperature in running tap water, the contents of the flasks are transferred to No. 1 tin cans and additional distilled water is added to within 0.5 in. of the top. The cans are sealed, placed in the autoclave, and retorted for 1 hr. at 15 p.s.i. After processing, the cans are cooled in running water and stored at room temperature until evaluated.

Evaluation of Canned Kernel Stability

The canned parboiled rice samples are both subjectively and objectively evaluated for parboil-canning processing. Kernel stability of each sample is rated subjectively, according to broth turbidity, kernel splitting, and fraying of edges and ends. An over-all numerical value (1–5, minimum to maximum) for these characters is assigned to each sample. The five subjective rating classes for canned kernel stability are illustrated in Fig. 2. Rice varieties or selections receiving a value of 2 or lower are considered to be potentially suitable for parboil-canning uses. Samples receiving a rating of 3 show a tendency toward kernel instability. Those samples receiving higher values would be unsuitable for these processes.

Canned samples of each variety are evaluated objectively by determining the amount of solids (dry matter) lost in canning the parboiled rice. Relatively low loss

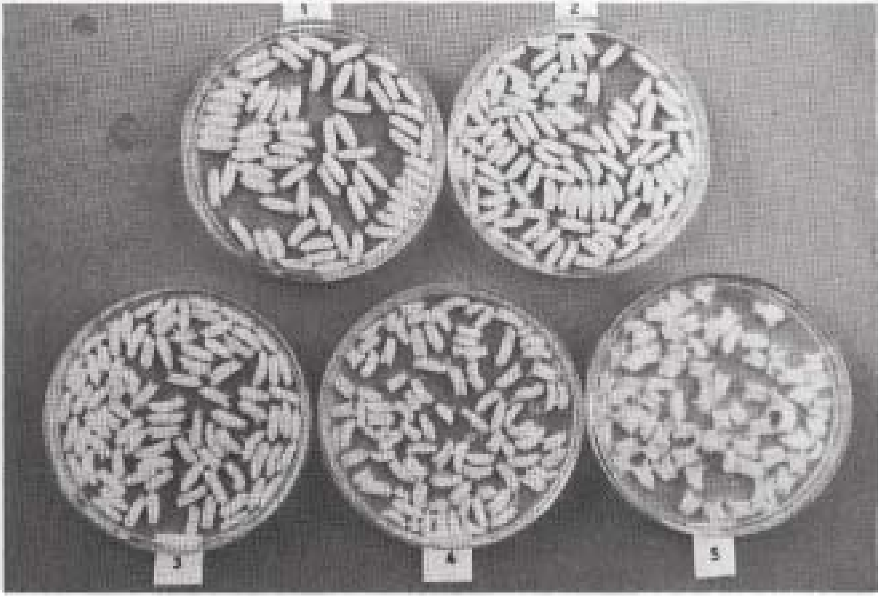

Fig. 2. Samples of parboiled-canned long-grain rice illustrating numerical ratings for kernel stability.

of solids indicates satisfactory stability. Solids loss is determined by washing the contents of the canned sample over a 1.6-mm. (1/16 in.) wire-mesh screen. That portion of the sample retained by the screen, which includes whole kernels and the larger grain fragments, is spread on filter paper and dried overnight at 70°C. in a forced air oven. Solids loss is obtained by calculating the difference in weight between the dry matter content of the original parboiled sample and the dry matter content of the sample retained by the screen. This loss is expressed in percent and includes soluble and insoluble solids of the canned product which pass through the 1.6-mm. screen. Statistically, the standard error of the mean for percent solids loss was 0.22 and standard deviation 0.81 for 60 replicated daily check samples parboiled and canned over a period of several months.

Alternate Procedure

In rice breeding programs it is necessary each year to evaluate parboil-canning stability of several thousand early generation rice breeding samples. To accomplish this screening program, the procedures described in previous sections of this report were modified for use with 10-g. rough rice samples. In the modified procedure, a 10-g. sample is placed in a 2 × 5-in. single-layer cheesecloth bag. The samples are arranged on racks as illustrated in Fig. 3 and inserted in the retort chamber. Up to 100 samples are parboiled at one time by this technique. Procedures for parboiling and drying of the samples are conducted the same as before. Micro-milling methods (10) are used to mill the parboiled samples.

Canning of the small samples is simulated by transferring a 5-g. sample of the parboiled milled rice to a 250-ml. Erlenmeyer flask containing 100 ml. of distilled

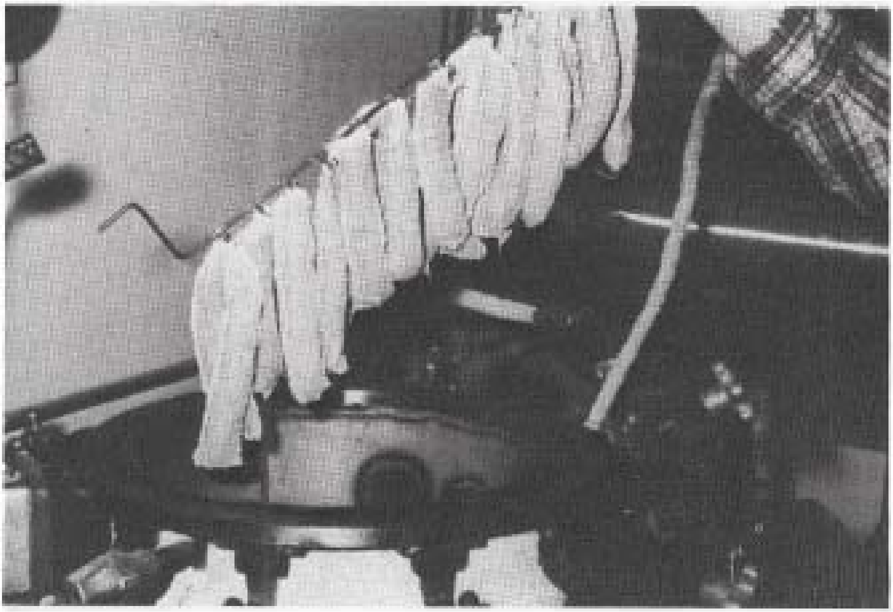

Fig. 3. Arrangement for parboiling small samples of rice breeding material.

water. The contents of the flasks are precooked at 95°C. for 20 min., and cooled to room temperature in running tap water. After cooling, the flasks and contents are autoclaved for 1 hr. at 15 p.s.i. Objective evaluation, based on solids loss, of the heat-processed samples is carried out as before. Thousands of early generation breeding selections have been evaluated by this procedure. It is sufficiently accurate for effective selection of varieties possessing satisfactory parboil-canning stability (11).

RESULTS AND DISCUSSION

Typical results showing varietal differences in kernel stability, as indicated by percent solids lost during canning, of selected commercial and experimental rice varieties are given in Table I. Values listed for each variety represent the average of three seasons and four locations of growth. Varieties showing relatively low solids loss (20% or less) usually have the clearest broth and show a minimum amount of kernel splitting and fraying of edges and ends. Canned samples of varieties showing solids losses of 25% or more are characterized by high broth turbidity and extensive disintegration of the canned kernels. Of the varieties shown in Table I, Jojutla, a Mexican variety not adapted in the U.S., has the lowest percentage solids loss and is considered to have excellent kernel stability for parboil-canning processes (12). Solids loss for U.S. commercial long-grain varieties ranged from 15% for Rexoro to 36% for Century Patna 231. Of these, the varieties Century Patna 231 and Toro, both long-grain types, are completely undesirable for this type processing (9,12). In

TABLE I. VARIETAL DIFFERENCES IN PARBOIL-CANNING STABILITY (SOLIDS LOSS) OF SELECTED COMMERCIAL AND EXPERIMENTAL RICE VARIETIES

Grain Type and Variety	Parboil-Canning Stability (solids loss) Av. %[a]
Long-grain	
Jojutla	9
Rexoro	15
Belle Patna	18
Bluebelle	17
Dawn	19
Bluebonnet 50	21
Century Patna 231	36
Toro	33
Medium-grain	
Nato	33
Saturn	34
Nova 66	33
Calrose	30
Short-grain	
Caloro	30
Colusa	28
Mochi Gomi (waxy endosperm)	44

[a]Values listed for each variety represent the average of three seasons and four locations of growth.

some instances, short- and medium-grain varieties are parboiled in the U.S. but they are not used for the canned products described.

The results obtained by the parboil-canning techniques discussed have aided rice breeders in recent years to develop and release new high-quality long-grain varieties (13), adaptable for use in heat processed semi-liquid formulations such as canned soups.

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Literature Cited

1. ROBERTS, R. L., POTTER, A. L., KESTER, E. B., and KENEASTER, K. K. Effect of processing conditions on the expanded volume, color, and soluble starch of parboiled rice. Cereal Chem. 31: 121 (1954).
2. ROBERTS, R. L., HOUSTON, D. F., and KESTER, E. B. Expanded rice product. A new use for parboiled rice. Food Technol. 5: 361 (1951).
3. KIK, M. C., and WILLIAMS, R. R. The nutritional improvement of white rice. Bull. Natl. Research Council, No. 112, 76 pp. (1945).
4. JONES, J. W., ZELENY, L., and TAYLOR, J. W. Effect of parboiling and related

treatments on the milling, nutritional and cooking quality of rice. U.S. Dept. Agr., Cir. No. 752, 15 pp. (1946).

5. HUZENLAUB, E. G. Apparatus for the treatment of cereals, starch or the like with fluids or by heating. U.S. Patent 2,239,608 (1941).

6. HUZENLAUB, E. G. Treatment of wheat and kindred cereals. U.S. Patent 2,287,737 (1942).

7. YONAN-MALEK, M. Method and control system for treating and canning rice. U.S. Patent 2,334,665–666 (1943).

8. OZAI-DURRANI, A. Method of treating rice. U.S. Patent 2,498,573 (1950).

9. ADAIR, C. R., BEACHELL, H. M., JODON, N. E., JOHNSTON, T. H., THYSELL, J. R., GREEN, V. E., Jr., WEBB, B. D., and ATKINS, J. G. Rice breeding and testing methods in the United States. In: Rice in the United States: Varieties and production, p. 19. U.S. Dept. Agr. Handbook No. 289 (1964).

10. SCOTT, J. E., WEBB, B. D., and BEACHELL, H. M. A small-sample rice test-tube miller. Crop Sci. 4: 231 (1964).

11. WEBB, B. D., BOLLICH, C. N., ADAIR, C. R., and JOHNSTON, T. H. Characteristics of rice varieties in the U.S. Department of Agriculture collection. Crop Sci. 8: 361 (1968).

12. HAGBERG, E. C. Canned rice products. Proc. Natl. Rice Utilization Conference, New Orleans, La., April 1966. p. 58, ARS 72-53 (1967).

13. BOLLICH, C. N., SCOTT, J. E., WEBB, B. D., and ATKINS, J. G. Bluebelle – A lodging resistant, very early maturing, long grain rice variety released in Texas. Rice J. 69(1): 13 (1966).

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