# IMPROVED SHELF-LIFE AT ROOM TEMPERATURE OF CANNED RICE MODIFIED BY CROSS-LINKING

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## ABSTRACT

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The investigation was designed to ascertain if canned rice continued to lose solids upon storage and what effect, if any, cross-linking had on the kernel stability during storage. The study revealed that rice continued to lose a substantial amount of solids on storage, which was accelerated by acidic pH levels. In the case of cross-linked rice, however, acidic pH conditions resulted in slightly less leaching than under neutral conditions. The cross-linked samples were considerably more stable to room-temperature (25° C) storage than their unmodified counterparts.

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 has been an important part of the rice breeding programs for a number of years (1). Belle Patna and Bluebelle are the U.S. varieties commonly used in parboil-canning processes. According to Webb and Adair (1) these varieties show a solids loss of 18 and 17%, respectively, after canning.

Recently, Rutledge *et al.* (2,3) and Rutledge and Islam (4) cross-linked the starch in rice, resulting in improved kernel stability as reflected in low solids loss after canning. This loss was in the range of 70% less than that obtained from commercial parboiled samples canned under the same conditions. However, a question has been raised concerning stability of the modified grain during subsequent storage. The literature has provided no information concerning the stability of the rice kernel after the initial canning treatment. Consequently, this investigation was designed to ascertain if canned rice continued to lose solids upon room-temperature storage, and what effect (if any) cross-linking had on the kernel stability during storage.

## MATERIALS AND METHODS

The white rice samples used in the investigation were Bluebelle samples obtained from Dore Rice Mill, Crowley, La. The parboiled rice (Bluebelle) was obtained from a leading parboiled rice supplier. The investigation was divided into three phases involving effect of storage on canned white rice treated with epichlorohydrin; parboiled rice treated with either epichlorohydrin, sodium trimetaphosphate, or phosphorous oxychloride; and parboiled rice treated with epichlorohydrin and canned under two different pH conditions (7 and 5). Appropriate control samples were employed for each phase. White rice can only be effectively cross-linked with epichlorohydrin (5) whereas parboiled rice can be cross-linked with all three of the above-listed cross-linking reagents. The rice samples were cross-linked as described by Rutledge *et al.* (2,3).

**Canning**

Twenty-gram samples of rice of known moisture content (11 to 12%) were placed in 211 × 400 C-enameled cans. Each can was filled to 0.5-in. headspace with boiling water adjusted to the appropriate pH with dilute acetic acid, after which the cans were sealed, retorted at 115° C for 60 min, and quickly cooled in running tap water.

Blanching is usually done commercially prior to canning rice in order to reduce the amount of solids leached into the canning liquor, thereby resulting in decreased turbidity. It also tends to cause the rice to more nearly approach the specific gravity of the canning medium and thus reduces its tendency to settle out and mat in the bottom of the cans. In the present investigation, the rice was not blanched in order to confine the solids loss entirely to the cans.

**Evaluation**

The solids loss during canning and subsequent storage was obtained by calculating the difference in weight between the dry-matter content of the original sample and that of the sample retained after washing over a 1.68-mm wire-mesh screen, as outlined by Webb and Adair (1). Five cans of rice were used for each treatment combination. Losses were determined initially after canning and after 6 months of storage at room temperature (25° C). Data collected were statistically analyzed using the analysis of variance technique employing factorial designs.

## RESULTS AND DISCUSSION

The mean percentages for solids loss of wetpack canned white rice are presented in Table I. Samples modified with epichlorohydrin show considerably less solids loss after canning than those of the control samples. Analysis of variance data are presented in Table II. The analysis revealed that the main

**TABLE I**
**Treatment Means for Percentage Solids Loss in Canned White Rice**

| Treatment | Storage Time months | % Solids Loss |
|---|---|---|
| Untreated | 0 | 25.79 |
| Untreated | 6 | 36.33 |
| Epichlorohydrin | 0 | 4.68 |
| Epichlorohydrin | 6 | 5.94 |

**TABLE II**
**Analysis of Variance for Percentage Solids Loss in Canned White Rice**

| Source | d.f. | MS |
|---|---|---|
| Treatment | 1 | 3314.54** |
| Time | 1 | 174.11** |
| Treatment × time | 1 | 107.32** |
| Residual | 16 | 0.69 |
| Corrected total | 19 | 189.84 |

effects, treatment and time, were highly significant ($P < 0.01$). A highly significant interaction between time and treatment was also found, which points to the fact that time was considerably more detrimental to the control samples than to the epichlorohydrin cross-linked samples. The treatment means (Table I) show a 10.54% increase in solids loss for control samples over a 6-month storage compared to a 1.26% increase for the cross-linked samples.

Table III shows the mean percentages for solids loss of canned parboiled rice cross-linked with either phosphorous oxychloride, epichlorohydrin, or sodium trimetaphosphate. All the treated samples showed considerably less leaching than the control parboiled samples. Analysis of variance data are presented in Table IV. Treatment and time, as well as the interaction between treatment and time, were both found to be highly significant ($P < 0.01$). Examination of treatment means indicates that the effect of storage was more detrimental to control or untreated samples than to cross-linked samples.

Orthogonal comparisons involving the various treatments were made on each time period. The F values are presented in Table V. The comparison between control and treated samples was found to be highly significant ($P < 0.01$) for both time periods. Highly significant differences were also found when comparing phosphorous oxychloride-treated samples to epichlorohydrin- and sodium trimetaphosphate-treated samples for both time periods. In the case of epichlorohydrin *vs.* sodium trimetaphosphate, differences were highly significant in the first time period, but were nonsignificant in the second time period. The control parboiled samples had a higher percentage solids loss than those reported by Webb and Adair (1). This could possibly be related to

**TABLE III**
**Treatment Means for Percentage Solids Loss in Canned Parboiled Rice**

| Treatment | Storage Time months | % Solids Loss |
|---|---|---|
| Control | 0 | 27.82 |
| Control | 6 | 35.84 |
| Phosphorous oxychloride | 0 | 8.24 |
| Phosphorous oxychloride | 6 | 11.72 |
| Epichlorohydrin | 0 | 6.10 |
| Epichlorohydrin | 6 | 8.02 |
| Sodium trimetaphosphate | 0 | 5.15 |
| Sodium trimetaphosphate | 6 | 7.51 |

**TABLE IV**
**Analysis of Variance for Percentage Solids Loss in Canned Parboiled Rice**

| Source | d.f. | MS |
|---|---|---|
| Treatment | 3 | 1469.30** |
| Time | 1 | 155.55** |
| Treatment × time | 3 | 19.52** |
| Residual | 32 | 0.52 |
| Corrected total | 39 | 118.94 |

differences in degree of parboiling. Webb and Adair parboiled their own samples whereas, in the present study, the samples were obtained commercially. Also, the canning procedures were different, especially in regard to the initial can temperature prior to retorting. Perhaps, in future studies, heat processing conditions could be expressed as $F_o$ values (sterilizing value), which would take into account differences in heat penetration, initial can temperature, come-up time, etc.

The mean percentages for solids loss of parboiled rice canned under two pH conditions are presented in Table VI. As shown by the mean square data in Table VII, treatment, time, pH, treatment × time, and treatment × pH were found highly significant ($P < 0.01$). However, time × pH was not significant ($P > 0.05$). One would thus assume, from the significance of the two interactions, and upon examination of the treatment means, that length of storage and pH were less detrimental in the case of cross-linked samples than in that of untreated parboiled rice.

It is evident from the above data that rice continues to leach solids into the surrounding liquor after initial canning. It is not known if the leaching process is completed after several days or months, or if it continues throughout the storage period. Regardless, cross-linked samples show less solids loss due to thermal processing than their control samples and the effects of storage are less

**TABLE V**
**F Values for the Orthogonal Comparisons**

| Source | F Value[a] | |
|---|---|---|
| | Time I | Time II |
| 1 *vs.* 2, 3, 4[b] | 3277.00** | 5161.00** |
| 2 *vs.* 3, 4 | 44.00** | 99.81** |
| 3 *vs.* 4 | 8.75** | 2.54[c] |

[a]F. 0.01 with 1 and 32 d.f.
[b]1 = Parboiled control, 2 = phosphorous oxychloride, 3 = epichlorohydrin, and 4 = sodium trimetaphosphate.
[c]Not significant.

**TABLE VI**
**Effects of Time and pH on Treatment Means for Percentage Solids Loss in Canned Parboiled Rice**

| Treatment | Storage Time months | pH | % Solids Loss |
|---|---|---|---|
| Control | 0 | 5 | 36.06 |
| Control | 0 | 7 | 23.14 |
| Control | 6 | 5 | 40.80 |
| Control | 6 | 7 | 26.96 |
| Treated | 0 | 5 | 6.62 |
| Treated | 0 | 7 | 7.32 |
| Treated | 6 | 5 | 8.19 |
| Treated | 6 | 7 | 8.24 |

**TABLE VII**
**Analysis of Variance for Time and pH Study of Canned Parboiled Rice**

| Source | d.f. | MS |
|---|---|---|
| Treatment | 1 | 5833.19** |
| Time | 1 | 76.34** |
| Treatment × time | 1 | 23.10** |
| pH | 1 | 422.63** |
| Treatment × pH | 1 | 473.07** |
| Time × pH | 1 | 1.53[a] |
| Treatment × time × pH | 1 | 0.05[a] |
| Residual | 32 | 1.54 |
| Corrected total | 39 | 176.39 |

[a]Not significant.

detrimental. Thus, cross-linked samples will result in a more stable canned product.

The effects of cross-linking on nutritional properties of rice have not yet been investigated. However, the reagents employed in this study are approved and have been used in the modification of starch with certain level restrictions for a number of years.

## Literature Cited

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