Pak. j. sci. ind. res., vol.38, no.2, February 1995

BIOCHEMICAL CHANGES IN RICE DURING STORAGE AT THREE DIFFERENT TEMPERATURES

ZIA-UR-REHMAN, M.YASIN, W.H. SHAH AND A.F.M. EHTESHAMUDDIN

Biotechnology and Food Research Centre, PCSIR Laboratories Complex, Lahore-54600, Pakistan

(Received May 18, 1994 ; revised December 19, 1994)

Biochemical changes in rice stored at 10°, 25° and 45°C for 6 months were studied. The changes in pH, titratable acidity and loss in solids of the rice stored at 25° and 45°C were significant. Amylase activity of the samples showed a decrease during storage. A significant decrease in water soluble amylose alongwith an increase in insoluble amylose contents was observed during storage of rice at 25° and 45°C. However, total amylose contents of rice remained unchanged during 6 months storage.

Key words: Rice, Biochemical changes, Storage.

Introduction

Storage of rice in jute bags, plastic bags and pots is a common practice in Pakistan. It is a well known fact that rice undergoes pronounced changes in its cooking and eating qualities during storage [1-7]. Freshly harvested rice when cooked becomes sticky or pasty mass, swells only slightly and leaves a thick gruel. These properties change dramatically upon storage for a few months. The rice then swells more easily, and on cooking (cooked rice) becomes more flaky and the gruel becomes thin. Although this phenomenon has attracted considerable attention, the reasons for the changes are far from clear. The aim of the present study was to investigate the biochemical changes in rice during storage at various temperatures.

Materials and Methods

The samples of rice (Basmati 385) supplied by Rice Research Institute, Kala Shah Kaku, were stored at 10°, 25° and 45°C for a period of 180 days. About 100g of each sample with 11% moisture was placed in screw cap bottles of uniform size. Three bottles of each sample were randomly taken after 15 days and its contents pooled and thoroughly mixed.

The samples were analyzed for pH, titratable acidity, loss in solids, moisture, amylase and amylose contents after grinding to 40 mesh size. The pH was determined on a filtrate of 2 g ground samples in 20 ml distilled water using a glass electrode pH meter (PYE Unicam, England). The titratable acidity was expressed as sodium hydroxide required to neutralize the acids in 100 g samples using phenolphthalein as indicator [8]. Moisture was determined by the standard method of AOAC [8]. 100 g of rice was boiled in 250 ml water for 10 min to estimate loss in solids as described by Bhattacharya and Sowbhagya [9]. Total amylose and water soluble amylose contents in stored rice samples were determined by Sowbhagya and Bhattacharya methods [10] while the insoluble amylose contents were calculated by difference method. Amylase activity in rice was measured by the method of Bernfeld [11] after extraction of the enzyme with sodium acetate buffer.

Results and Discussion

A number of biochemical changes occurred during storage of rice at various temperatures. The range of storage temperature included in this study cover the atmospheric temperatures that the rice generally encounters in Pakistan i.e. 10°-45°C.

The results (Table 1) showed that there was no change at all in pH and titratable acidity of rice samples kept at 10°C for 6 months. However, significant changes in pH and titratable acidity were observed when rice grains were stored at 25°C for different time periods. A decrease in pH and a progressive increase in titratable acidity started appearing just after one month of storage at 25° and 45°C. The mean titratable acidity of the stored rice was 4.4 mg NaOH/100 g at 25°C and 4.7 mg NaOH/100 g at 45°C after 5 months, while it was 3.2 mg NaOH/100 g for freshly harvested rice. However, pH of the freshly harvested rice was 6.4 whereas the pH values of the rice at 25° and 45°C were 5.5 and 5.0 respectively after 5 months storage. No further change in pH and acidity was observed after 5 months. These results are in agreement with the findings of ByeongSam *et al.* [12] who reported an increase in acidity during storage of rice. The increase in the acidity of the samples, as shown by the values of pH and titratable acidity, could be attributed to the increasing concentration of the acids such as fatty acids, phosphates and hydrogen ions resulting from increased grain deterioration [13,14]. The binding of amino group of amino acids, short chain peptides and

TABLE 1. EFFECT OF STORAGE TIME AND TEMPERATURE ON CHEMICAL COMPOSITION OF RICE[a].

Storage time (days)	Storage temperature											
	10°C				25°C				45°C			
	Moisture (%)	Loss in solids*(%)	pH	Acidity**	Moisture (%)	Loss in solids*(%)	pH	Acidity**	Moisture (%)	Loss in solids*(%)	pH	Acidity**
0	11.06	5.5	6.4	3.2	11.06	5.5	6.4	3.2	11.06	5.5	6.4	3.2
30	11.06	5.5	6.4	3.2	11.04	5.4	6.1	3.4	10.09	4.4	6.0	3.6
60	11.05	5.4	6.4	3.2	10.25	5.1	6.0	3.6	9.79	3.7	5.8	3.9
90	11.03	5.4	6.4	3.2	10.00	4.9	5.7	4.0	9.55	3.3	5.5	4.4
120	11.03	5.2	6.4	3.2	9.16	4.4	5.6	4.2	8.81	3.2	5.2	4.5
150	11.02	5.2	6.4	3.2	8.93	4.2	5.5	4.4	8.30	2.7	5.0	4.7
180	11.01	5.0	6.4	3.2	8.77	4.0	5.2	4.5	7.95	2.6	4.8	4.8

* Loss of solids on boiling rice in the course of cooking. ** mg NaOH/100g. a = Average of three determinations.

proteins, leaving the carboxylic ends free and the presence of acids by-products of advanced Maillard reactions are other possible causes of the increased acidity in the samples stored at elevated temperatures [15,16]. It is known that free amino groups of protein and carbonyl groups of reducing sugars interact with each other during storage of food materials (Maillard reaction). Although, it is a very complicated reaction, yet the chemistry of Maillard reaction is known to some extent. As a result of Maillard reaction different types of simple or complex aldehydes, ketones, carboxylic acids and many other intermediate complex compounds are formed with the passage of time during storage at elevated temperatures.

The samples stored at 45°C showed remarkable losses both in moisture and in solids (loss of solids on boiling rice in the course of cooking) after 6 months storage (Table 1).

The loss in moisture became significant in the rice samples after 2-3 months while that in solids became significant after on month storage. However, losses in moisture as well as solids at 25° were comparatively less than at 45°C, whereas no distinct difference in moisture and loss in solids was observed on storage at 10°C for 6 months.

Results of amylase activity in the stored rice samples at different temperatures during storage are given in Table 2. It is obvious from these results that there was a gradual decrease in amylase activity at all temperatures but it was very slow at 10°C and significantly higher at elevated temperatures (25° and 45°C) upto a storage period of 6 months. The amylase activity of the freshly harvested rice was 24.0 units/g which was reduced to 16.0 and 12.8 units/g at 25° and 45°C respectively after 6 months. The total amylose contents remained unchanged in the rice samples during storage (Table 3) as already reported by Swamy *et al.* [17]. In contrast, there was a slow but steady decrease in water soluble amylose content as the storage progressed. The trend was about the same for all conditions. In freshly harvested rice, the concentration of

TABLE 2. EFFECT OF STORAGE TIME AND TEMPERATURE ON RICE AMYLASE ACTIVITY (UNITS/g)[a].

Storage time (days)	Storage temperature		
	10°C	25°C	45°C
0	24.0*	24.0*	24.0*
15	24.0	23.0	22.0
30	24.0	22.6	20.0
45	23.2	21.8	19.6
60	22.5	21.6	18.8
75	22.4	21.5	18.0
90	22.2	20.0	17.0
105	22.0	19.6	16.6
120	21.0	19.0	15.0
135	20.6	17.0	14.8
150	20.3	16.6	13.4
165	20.0	16.0	12.8
180	20.0	16.0	12.8

*Units of amylase/g rice. a = Average of three determinations.

soluble and insoluble amylose contents were 26.5 and 1.7% respectively whereas these values were found to be 21.8 and 5.2% at 10°C, 11.2 and 15.8% at 25°C, and 8.8 and 18.2% at 45°C after 6 months. It is apparent from these results that the decrease in soluble amylose was accompanied with an increase in the insoluble amylose contents. The process of formation of insoluble amylose contents was significantly slow in case of rice stored at 10°C. This may be due to the presence of higher amount of amylases in the sample stored at this temperature. It was higher at 25° and 45°C upto a storage period of 4 months after that the conversion process was slowed down. A significant increase in insoluble amylose may probably be due to polymerization of straight chain compounds of glucose (water soluble amylose) into branched chain compounds containing hundreds of glucose

TABLE 3. EFFECT OF STORAGE TIME AND TEMPERATURE ON THE AMYLOSE CONTENTS OF RICE[a].

Storage time (days)	Storage temperature								
	10°C			25°C			45°C		
	Total amylose (%)	Water soluble amylose (%)	Insoluble amylose (%)	Total amylose (%)	Water soluble amylose(%)	Insoluble amylose (%)	Total amylose (%)	Water soluble amylose(%)	Insoluble amylose (%)
0	27.2	26.5	1.7	27.2	26.5	1.7	27.2	26.5	1.7
15	27.2	25.0	2.2	27.2	24.0	3.2	27.2	22.0	5.2
30	27.0	24.6	2.4	27.0	22.4	4.6	27.0	20.3	6.9
45	27.0	24.3	2.7	27.0	21.9	5.1	27.0	19.3	7.7
60	27.0	24.2	2.8	27.0	20.1	6.9	27.0	18.2	8.8
75	27.0	23.5	3.5	27.0	18.5	8.5	27.0	17.0	10.0
90	27.0	23.0	4.0	27.0	16.3	10.7	27.0	14.8	12.2
105	27.3	22.7	4.6	27.3	15.4	11.9	27.3	12.5	14.8
120	27.3	22.5	4.8	27.3	14.2	13.1	27.3	12.0	15.3
135	27.1	22.0	5.1	27.1	12.2	14.9	27.1	9.7	17.4
150	27.1	21.1	5.0	27.1	12.1	15.0	27.1	9.3	17.8
165	27.0	21.8	5.2	27.0	11.4	15.6	27.0	8.7	18.3
180	27.0	21.8	5.2	27.0	11.2	15.8	27.0	8.8	18.2

a = Average of three determinations.

molecules [18]. It appears that storage of rice at elevated temperatures for 6 months significantly decreased the amylose activity alongwith an increase in insoluble amylose contents which might be responsible for improvement in the quality of stored rice.

References

1. Y. M. I. Swamy, C. M. Sowbhagya and K. R. Bhattacharya, J. Sci. Fd. Agric., **29,** 627 (1978).
2. H. S. R. Desikachar and S. R. Subrahmanyan, Cereal Chem., **36,** 385 (1959).
3. A. Sreenivasan, Indian J. Agric. Sci., **9,** 208 (1939).
4. N. Kongeree and B. O. Juliano, J. Agric. Fd. Chem., **20,** 714 (1972).
5. J. Chrastil, J. Cereal Sci., **11,** 71 (1990).
6. K. Kumar, Starch/Staevke, **43,** 165 (1991); (CA **115,** 48014 C).
7. K. R. Bhattacharya, C. M. Sowbhagya and Y. M. Indudhara Swamy, J. Fd. Sci., **47,** 564 (1982).
8. AOAC,*Official Methods of Analysis* (Association of Official Analytical Chemists, Washington DC, USA, 1984).
9. K. R. Bhattacharya and E. M. Sowbhagya, Cereal Sci. Today, **16,** 420 (1971).
10. C. M. Sowbhagya and K. R. Bhattacharya, Starke, **23,** 53 (1971).
11. P. Bernfeld, *Methods in Enzymology* (Academic Press, New York, 1955), Vol.I, pp.69.
12. K. Byeong Sam, P. Noh Hyum, S. Dong Hwa, Hanguk Yongyang Sikhyong Makhoech, **17,** 220 (1988).
13. O. A. Onigbinde and I. O. Akinyee, J. Fd. Sci., **53,** 117 (1988).
14. W. R. Morrison, J. Sci. Fd. Agric., **14,** 870 (1963).
15. H. W. Gardner, J. Agric. Fd. Chem., **27,** 220 (1979).
16. S. I. Fergerson, J. Agric. Fd. Chem., **17,** 747 (1969).
17. Y. W. I. Swamy, C.M. Sowbhagya and K. R. Bhattacharya, J. Sci. Fd. Agric., **29,** 627 (1978).
18. R. C. Hosenly, *Principles of Cereal Science and Technology* (American Association of Cereal Chemists Inc. St. Paul, Minnesota, USA, 1986), pp.38.