Effect of Storage on Fatty Acid Profiles of Basmati Rice (*Oryza sativa* L.) Genotypes

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Eleven basmati and one non-basmati rice genotypes were evaluated for fatty acid profiles of fresh, 4, 8 and 12 months old rice, at different storage periods. Results indicated that the total saturated fatty acids increased steadily, while the total unsaturated fatty acids showed a reverse trend. The saturated fatty acids comprised myristic, palmitic and stearic acids, while unsaturated fatty acids constituted oleic, linoleic and linolenic acids. After 12 months of storage myristic, stearic and linolenic became invisible. Palmitic acid content was high as compared to myristic and stearic acids. Except in fresh rice, 'HKR 92-445' recorded maximum content of palmitic acid. Among unsaturated, oleic acid followed by linolenic acid were the major fatty acids and concentrated maximum in 'Haryana Basmati I' and 'PR 106'.

Keywords : Rice, Storage, Fatty acids, Saturated fatty acids, Unsaturated fatty acids, Saturated : Unsaturated ratio.

Majority of Indians are traditionally vegetarians by their dietary habits and derive most of their nutrient requirement from plant foods. There is an ever growing need of cereal grains to meet the energy and protein requirements. Rice (*Oryza sativa* L.) is the staple food of the Indian population and mainly consumed in the form of whole grains. Basmati rice and its various strains are part of India's traditional cultivation practices and it grows only under specific set of prevailing soil and environmental conditions. Basmati rice is valued highly in many parts of the world and is preferred over non-basmati, because after cooking, they are soft, non-sticky, possess pleasant aroma and show linear kernel elongation without significant increase in breadth (Rao et al. 1996).

The overall assessment of a foodgrain is determined by its physical, physico-chemical, nutritional, milling, cooking, processing, eating and storage qualities besides economic values (Goyal and Sharma 1998). It is a common practice to store the freshly harvested rice for sometime before consumption. Besides, chemical and biochemical changes occur in the rice grain during aging. Changes in fat and fatty acid composition also occur. The rice lipids are liable to oxidation and/or hydrolysis during storage and thereby contribute to the flavour characteristics of the aged rice. (Ramarathnam and Kulkarni 1983; Dhaliwal et al. 1990). Changes taking place during storage, influence the chemical, physical and functional qualities of rice and it may produce desirable and undesirable effects on the end product, depending upon storage conditions and rice variety. In the present study, an attempt was made to investigate the changes in fatty acid profiles of 11 varieties of basmati and one non-basmati rice grown extensively, mostly in Haryana and adjoining areas.

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Materials and Methods

Paddy seeds of 'Pusa Basmati 1', 'Haryana Basmati 1', 'Basmati 370', 'Tarori Basmati', 'HKR 91-406', 'HKR 92-401', 'HKR 93-401', 'HKR 93-402', 'HKR 91-455', 'HKR 92-445', 'HKR 92-447', representing basmati and 'PR 106', a non-basmati type were procured from CCS Haryana Agricultural University, Rice Station, Kaul, Karnal during December 1996. Paddy samples were dehusked and polished uniformly utilising the locally existing facilities available. One kg sample of each genotype was fumigated in an air tight circular steel container of 20 kg capacity with one tablet of aluminium phosphide for 3 days as per the instructions outlined in package of practices (HAU 1981). The rice grains were cleaned for dust, stones, broken seeds and other foreign material. Rice grains (250 g) of all the genotypes were stored in the dark, for one year at room temperature. During one year of aging, rice samples were removed after 4, 8 and 12 months. Fresh and aged samples were ground to pass 80 mesh sieve, having 0.2 mm particle size using Udytec Cyclone sample mill.

Total lipids in rice samples were extracted three times with a cold, chloroform/methanol mixture (2:1v/v) by the method of Folch et al (1957) and methyl esters were prepared by the method of Luddy et al (1968) by taking a suitable lipid sample in a test tube with 0.4 ml of 0.4N sodium methylate and incubated at 65°C for 3 min. The methyl esters were extracted with carbon disulfide. Methyl esters of fatty acids were separated, employing NUCON 5765 gas chromatograph equipped with flame ionization detector, using stainless steel column (10" x 1/8") packed with 20% diethylene glycol succinate (DEGS) in 60–80 mesh chromosorb–w. The column temperature was 190°C and the flow of the nitrogen carrier gas was 35 ml min^{-1}. The peaks were identified by comparison of their retention times with those of standard fatty acid esters. The area under each peak was calculated by triangulation: half the base x height and converted directly into relative percentage. The data were statistically analyzed for SD, SE and CV(%) as per the method of Raghuramulu et al (1983).

Results and Discussion

From the data given in Table 1, it is quite evident that palmitic acid was considerably higher as compared to myristic and stearic acids among saturated fatty acids. 'Taroari Basmati' exhibited maximum palmitic acid (21.10%) and 'Haryana Basmati 1' showed the minimum (12.37%). Stearic acid varied from 1.06 to 1.74% and averaged to 1.74%. Among genotypes, 'Pusa Basmati–1', 'HKR 91–406', 'HKR 92–401', 'HKR 91–455', 'HKR 92–445' and 'HKR 92–447' were found to contain appreciable amounts. Among unsaturated fatty acids, the maximum content was oleic acid, followed by linoleic and linolenic acids. Oleic acid was the highest in 'Haryana Basmati1' and lowest in 'PR 106' whereas, this genotype recorded the highest content of linoleic acid. In all the rices, linolenic acid content was very low, varying from 0.12 to 0.17% with an average value of 0.15%. Palmitic acid values in all genotypes were low as compared to oleic and linoleic acids that are akin to the findings of earlier researchers (Lugay and Juliano 1964; Lee et al. 1965; Ramarathnam and Kulkarni 1983). The most desirable feature of this oil is its low linolenic acid content which, in turn improves the keeping quality of oil. In general, high (18:3) is unsuitable for food products due to its instability and reversion of flavour associated with autooxidation (Smouse 1978; Green 1986). In the food industry, a maximum of 3% linolenic acid is desirable for edible oils (Thomas and Von Bruck 1985), while level below 1% is more beneficial for improving the stability of good flavour (Cowen et al. 1970). The U/S ratio in rice genotypes varied from 3.38 to 6.27.

Fatty acid values in basmati rice samples after 4, 8 and 12 months of aging are presented in Tables 2, 3 and 4. During the entire aging period, total saturated fatty acids increased continuously, but gradually and unsaturated fatty acids decreased.' Haryana Basmati–1' contained the highest amounts of unsaturated fatty acids after 4, 8 and 12 months of storage and 'HKR 92–445', possessed maximum amounts of saturated fatty acids. The U/S ratio, was also observed to be maximum in 'Haryana Basmati 1' and it decreased continuously in 'PR 106' during the entire storage period and exhibited

TABLE 1. GC PROFILES OF FATTY ACIDS (%) OF FRESH BASMATI RICE GENOTYPES

Genotype	Total lipids, %	Myristic (14:0)	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)	Total saturates	Total unsatu-rates	U/S ratio
'Pusa Basmati1'	1.20	0.11	14.29	1.74	48.97	34.72	0.17	16.14	83.86	5.20
'Haryana Basmati1'	1.21	0.12	12.37	1.27	49.19	36.89	0.16	13.76	80.24	6.27
'Basmati 370'	1.17	0.12	12.81	1.13	49.07	36.72	0.15	14.06	85.94	6.11
'PR 106'	1.15	0.10	19.14	1.10	40.66	38.84	0.16	20.34	79.66	3.92
'Taraori Basmati'	1.17	0.12	21.10	1.19	43.66	33.77	0.16	22.41	77.59	3.46
'HKR 91–406'	1.19	0.12	21.01	1.67	42.67	34.37	0.16	22.80	77.20	3.39
'HKR 92–401'	1.19	0.11	18.10	1.44	45.02	35.16	0.17	19.65	80.35	4.09
'HKR 93–401'	1.21	0.10	18.85	1.09	44.29	35.55	0.12	20.04	79.96	3.99
'HRK 93–402'	1.15	0.10	18.30	1.06	43.22	37.20	0.12	19.96	80.54	1.14
'HKR 91–455'	1.19	0.10	20.72	1.52	43.67	33.87	0.12	22.34	77.66	3.48
'HKR 92–445'	1.17	0.11	20.97	1.48	43.68	33.62	0.14	22.56	77.44	3.43
'HKR 92–447'	1.15	0.11	21.07	1.71	44.62	32.37	0.12	22.84	77.11	3.38
Mean	1.18	0.11	18.23	1.37	44.80	35.26	0.15	19.70	80.30	4.24
Range	1.15–1.21	0.10–0.12	12.37–21.10	1.06–1.74	40.66–59.19	32.37–38.84	0.12–0.17	13.76–22.34	77.11–86.24	3.38–6.27
SD	0.02	0.009	3.28	0.26	2.75	1.85	0.021	3.34	3.34	1.05
SE	0.006	0.003	0.95	0.07	0.79	0.53	0.006	0.96	0.96	0.30
CV, %	0.51	8.18	17.98	18.76	6.12	5.25	14.00	16.93	4.16	24.68

TABLE 2. GC PROFILE OF FATTY ACID (%) OF BASMATI RICE GENOTYPES AFTER FOUR MONTHS OF STORAGE

Genotype	Myristic (14:0)	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolrnic (18:3)	Total saturates	Total unsatu rates	U/S ratio
'Pusa Basmati 1'	0.88	17.43	1.05	48.30	32.18	0.16	19.36	80.64	4.17
'Haryana Basmati 1'	1.13	15.41	1.60	49.78	31.93	0.15	18.14	81.85	4.51
'Basmati 370'	0.83	16.41	1.62	48.89	41.61	0.14	18.86	81.14	4.30
'PR 106'	0.82	19.45	1.60	42.19	35.79	0.15	21.87	78.13	3.57
'Taraori Basmati'	0.91	20.77	1.18	43.82	33.17	0.15	22.86	77.14	3.37
'HKR 91-406'	1.21	20.45	1.16	43.40	33.63	0.15	22.82	77.18	3.38
'HKR 92-401'	0.80	17.89	1.10	45.10	34.95	0.16	19.79	80.21	4.05
'HKR 93-402'	0.86	21.75	1.61	44.34	31.33	0.11	24.22	75.78	3.13
'HKR 93-401'	0.88	18.83	1.08	47.60	33.49	0.11	20.79	79.21	3.81
'HKR 91-455'	0.47	20.29	1.60	44.89	32.64	0.11	22.36	77.64	3.47
'HKR 92-445'	1.39	22.78	0.81	38.42	34.67	1.93	24.98	75.02	3.00
'HKR 92-447'	1.84	19.89	1.64	42.73	32.28	1.52	23.47	76.53	3.26
Mean	1.01	19.28	1.34	44.96	33.14	0.40	21.63	78.37	3.67
Range	0.47–1.94	15.41–22.78	0.81–1.64	38.42–42.49	33.35–35.79	0.11–1.93	18.14–24.98	77.14–81.85	3.00–4.51
SD	0.37	2.18	0.30	3.26	1.42	0.63	2.21	2.21	0.49
SE	0.11	0.63	0.09	0.94	0.41	0.18	0.64	0.64	0.14
CV. %	36.93	11.28	22.39	7.23	4.27	1.56	10.24	2.82	13.37

TABLE 3. GC PROFILE OF FATTY ACID COMPOSITION (%) OF BASMATI RICE GENOTYPES AFTER EIGHT MONTHS OF STORAGE

Genotype	Myristic (14:0)	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolrnic (18:3)	Total saturates	Total unsatu rates	U/S ratio
'Pusa Basmati 1'	0.90	19.01	0.72	47.23	31.99	0.15	20.63	79.37	3.85
'Haryana Basmati'	1.17	17.07	1.69	48.98	30.95	0.14	19.93	80.07	4.02
'Basmati 370'	1.15	18.43	1.71	47.88	30.69	0.14	21.29	78.71	3.70
'PR 106'	1.45	21.65	1.44	41.00	34.34	0.12	24.54	75.46	3.07
'Taraori Basmati'	1.92	21.24	1.94	42.15	32.61	0.14	25.10	74.90	2.98
'HKR 91-406'	1.75	21.18	1.36	43.23	32.35	0.13	24.29	75.71	3.12
'HKR 92-401'	0.88	20.12	1.01	43.98	33.87	0.14	22.01	77.99	3.54
'HKR 93-401'	1.38	20.57	1.51	43.81	32.62	0.11	23.46	75.64	3.22
'HKR 93-402'	1.40	23.47	1.49	43.22	30.31	0.11	26.36	73.64	2.79
'HKR 91-455'	0.88	22.72	1.09	43.33	31.95	0.11	24.61	75.39	3.06
'HKR 92-445'	1.50	24.56	1.62	38.40	33.27	0.65	27.68	72.32	2.61
'HKR 92-447'	1.09	23.42	1.29	41.97	31.62	0.61	25.80	74.19	2.88
Mean	1.29	21.12	1.40	43.77	32.21	0.21	23.81	76.12	3.23
Range	0.88–1.92	17.02–24.56	0.72–1.94	38.40–48.98	31.34–34.34	0.11–0.65	19.93–27.68	72.32–80.07	2.61–4.02
SD	0.34	2.23	0.35	3.00	1.23	0.20	2.40	2.40	0.44
SE	0.10	0.04	0.10	0.87	0.36	0.06	0.60	0.64	0.13
CV. %	26.28	10.58	24.79	6.85	3.83	93.33	10.08	3.16	13.70

maximum coefficient of variation (24.68%). On perusal of the data (Tables 1 – 4) it was revealed that the major fatty acids of rice lipids were oleic, linoleic and palmitic acids, coinciding with the findings of Hemavathy and Prabhakar (1987) and Taira et al (1988) in rice. The absolute essential fatty acids namely, linoleic and linolenic in rice oil in the present study varied from 31.41 to 35.26% and 0.15 to 0.40% during storage, which were falling very well within the values earlier reported (Jaiswal 1983). Grundy (1997) has viewed that the most desirable ratio of oleic to linoleic acid lies between 1:1 to 3:1. In the present study, the storage of rice upto 12 months resulted in gradual decreases in oleic and linoleic acids and finally, complete lack of linoleic acid with concomitant apparent increase in palmitic acid was observed. These findings are in confirmity was with the

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Received 1 January 1999; revised 26 October 1999; accepted 13 May 2000

TABLE 4. PERCENT FATTY ACID DISTRIBUTION OF BASMATI RICE GENOTYPES AFTER TWELVE MONTHS OF STORAGE

Genotype	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Saturates	Unsaturates	U/S ratio
'Pusa Basmati 1'	21.91	–	47.15	30.94	21.91	78.01	3.56
'Haryana Basmati 1'	21.69	–	48.12	30.19	21.69	76.31	3.61
'Basmati 370'	21.08	1.00	47.77	30.15	22.08	77.92	3.53
'PR 106'	26.42	–	40.16	33.42	26.42	73.58	2.79
'Taraori Basmati'	26.30	–	41.87	31.83	26.30	73.70	2.80
'HKR 91-406'	26.16	–	42.56	31.28	26.16	72.84	2.82
'HKR 92-401'	23.99	–	43.18	32.83	23.99	76.01	3.17
'HKR 93-401'	24.12	–	43.16	31.92	24.92	75.08	3.01
'HKR 93-402'	27.21	–	42.92	29.87	27.21	72.79	2.68
'HKR 91-455'	26.35	–	42.58	31.12	26.35	73.65	2.80
'HKR 91-445'	29.88	–	37.63	32.49	29.88	70.22	2.35
'HKR 92-447'	27.98	–	41.19	30.83	27.98	72.02	2.57
Mean	25.32	–	43.19	31.41	25.41	74.59	2.97
Range	21.08– 27.98	–	37.63– 48.12	29.87– 33.41	21.69– 29.88	70.12– 78.31	2.35– 3.61
SD	2.70		3.13	1.12	2.57	2.57	0.41
SE	0.78		0.90	0.32	0.74	0.74	0.12
CV, %	10.66		7.25	3.56	10.10	3.44	4.15

reports of Shin and Godfer (1996) in brown rice during storage upto 52 weeks. Linoleic and linolenic acid decreased in wheat on storage upto 185 days (Tripples and Noris 1965) whereas, palmitic acid increased but oleic and linoleic acids decreased with advancement of storage period upto 12 months in rice (Dhaliwal et al. 1999) that supported the present findings.

However, conflicting reports were also earlier recorded by Tsuzuki et al (1981) and Ramarathnam and Kulkarni (1983), concerning rice fatty acid composition during storage. The present results are in agreement with those of Tsuzuki et al (1981) for linoleic acid, but are at variance for oleic acid. Studies on changes in fatty acid profiles of ten Indian brown rices revealed slight increases in linoleic acid, while palmitic and oleic acid levels decreased slightly during 120 days of aging (Ramarathnam and Kulkarni 1983), comparing well with to the present results. However, a slight variation was found with linoleic and palmitic acids that could be due to differences in the storage conditions. It is quite evident from the present study that the fatty acid profiles of rice lipids changed during aging of basmati rice and the differential behaviour of different genotypes presently investigated may also be due to differences in endogenous levels of lipases, desaturation and elongation enzymes implicated in lipid metabolism and also due to varied interactions between rice lipids and other rice constituents.

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