CHAPTER 6

Objective 5: Determination of the keeping quality of mixes and biscuits

Introduction

During storage, flours of cereals and legumes tend to develop musty, rancid and bitter flavours because of their lipid contents. It has been reported that the flour lipids are susceptible to storage deterioration and their degradation has been related to the development of off flavours. The spoilage of flours has also been associated with both oxidative and hydrolytic degradation of lipids and both these changes are related to the moisture content of the flours (Arya 1981).

Biscuits are prepared from dough containing wheat flour, fat, sugar, water, flavouring and colouring agents. The dough is rolled, cut into desired shapes, baked and packed. Biscuits baked to a low moisture content of about 2 to 5% usually remain unaffected by staling and moulding but lose both texture and taste if their moisture contents rise above a relatively low critical value. However, biscuits can be maintained in the acceptable condition by packaging in efficient moisture proof barrier material. Such barriers may also need to be oxygen proof to minimize oxidative rancidity occurring in long term storage when fat contents of biscuits are relatively high (Paine 1985). However, in packaged biscuits, the loss of crispness due to moisture ingress is considered to be a more serious problem than the rancidity development. Thus shelf life of biscuits depends on the environmental factors like humidity, temperature, light and the packaging material used (Balasubrahmanyam et al 1981).

Keeping quality of flours and products

In 1977, Mahadeviah et al had demonstrated that the moisture contents of about 15% for pulse and 14% for cereal flours were the critical moisture levels with respect to various physiochemical and microbiological spoilages. The authors considered that above these levels of moisture, the products developed musty odour and became susceptible to mould growth. The authors determined the keeping quality of wheat and bengal gram flours stored in flexible films under normal (27°C and 65±2% RH) and accelerated (38°C and 92±2% RH) environmental conditions. Wheat flour was stored in low density polyethylene (LDPE), high density polyethylene (HDPE) and polycell bags for a period of 190 days (6 months) under both normal and accelerated conditions. The moisture content of wheat flour remained markedly below the critical moisture level when it was stored at 27°C and 65% RH for a period of 190 days in 350 gauge LDPE, 200 gauge HDPE and polycell bags But it increased from 8.8% to a maximum of 12.9% in samples stored in LDPE or HDPE bags at 38°C and 92% RH for a period of 190 days and to 14.3% in those stored in polycell film. Therefore, the authors stated that wheat flour can be stored for at least 6 months even at accelerated conditions provided it is not stored in polycell. Refined wheat flour having the initial moisture content of 13.0% stored in 350 gauge LDPE, 200 gauge HDPE and polycell bags at 38°C and 92% RH had attained the critical moisture content of 14% after 120 days. The results indicated that the initial moisture content of the flours influenced the keeping quality of the flours as wheat flour having a moisture content of 8.8% had a shelf life of over 6 months while refined wheat flour with initial moisture content of 13.0% had a shelf life of only 4 months. Moreover, the packaging material had a bearing on the shelf life of the flours as the moisture gain of sample flour stored in polycell film was higher than that of those stored in HDPE and LDPE bags. The moisture content of bengal gram flour packed in 400 gauge polythene bags and stored at 38°C and 92% RH for a period of 7 months did not increase markedly (from 10.2 to 10.6%) and remained below the critical level of 15%. Therefore, the authors suggested that pulse flours can be kept for at least 7 months even at accelerated conditions from the point of moisture ingress.

Gandhi et al (1985) determined the keeping quality of full fat soya flour stored for a period of 10 months. The flour was stored in metallic tins, polythene bags (700 gauge), cloth bags and jute bags under room conditions from April '81 to January '82. The samples were drawn at monthly intervals and analysed for moisture content and free fatty acid levels. The results showed that the moisture content of flour stored in metallic tins and polythene bags (700 gauge) remained static at the initial moisture content of 8.0% throughout the experimental period irrespective of the summer, rainy and winter seasons. But the moisture content of the flour stored in cloth bag remained static in summer months of April to June then increased from 8.0% of the initial value to 15.0% in the rainy months of July and August and thereafter, decreased gradually so that the moisture content was 8.1% in the month of January. Likewise, the moisture content of the flour stored in the jute bag did not change till June but then increased to 11.6% in July and later decreased gradually so that it was 8.5% in January. The authors attributed the increase in moisture content of the flour in cloth and jute bags to their semipervious structures and found them unsuitable for storage.

The free fatty acid content of flours stored in metallic tins and polythene bags (700 gauge) did not vary from their respective initial values of 1.9 and 2.4% oleic acid, throughout the storage period of 10 months from April to January. While the free fatty acid content of the flour stored in cloth bags remained unchanged in the months of April, May and June but increased from 1.7 to 17.0% during the rainy season (June to September) and thereafter remained constant till January. The free fatty acid content of flour stored in jute bags also increased from 2.2 to 17.0% by September and then remained constant. The increase in free fatty acid levels according to the authors, was due to the high moisture gained by the flour which might have resulted in non-enzymatic rancidity and peroxide formation. The flours with 17.0% free fatty acid content were considered to be unfit for human consumption. Thus, it was concluded that full fat soya flour can be kept in metallic tins and polythene bags (700 gauge) even beyond 6 months without affecting its quality but cloth and jute bags were unsuitable for long term storage (Gandhi et al 1985).

The effect of water activity on lipids of bengal gram flour stored for 24 weeks was determined by Arya (1981). One hundred and fifty grams of flour was stored in petridishes in desiccators having anhydrous potassium pentaoxide, saturated solution of magnesium chloride, potassium bromide and sodium nitrate to obtain water activities of 0.00, 0.33, 0.57 and 0.73, respectively. All the desiccators were kept at room temperature (20 to 35°C). Initially and after 12 and 24 weeks of storage the flours were analysed for moisture and fat acidity. The bengal gram flour stored at 0.00, 0.33, 0.57 and 0.73 water activities had equilibrium moisture contents of 2.0, 8.0, 10.8 and 13.9%, respectively. The initial fat acidity expressed as mg KOH/100 g was 20.8. After 12 and 24 weeks of storage, the fat acidity was respectively 19.9 and 23.8 mg KOH/100 g at 0.00 water activity, 32.1 and 37.0 mg KOH/100 g at 0.33 water activity and 61.1 and 76.5 mg KOH/100 g at 0.57 water activity. The increase in fat acidity on storage was attributed to the hydrolysis of bengal gram lipids. But in sample stored at 0.73 water activity, the fat acidity was 184.9 mg KOH/100 g after 12 weeks of storage which decreased to 25.9 mg KOH/100 g after 24 weeks of storage. This decrease in fat acidity was attributed to mould growth. The results therefore indicated that the fat acidity increased with increase in water activity of the flour provided there was no mould growth.

Prasad and Mandokhot (1982) determined the changes in fat acidity of 4 varieties of sorghum flour over a period of 6 months. The authors observed that in 3 varieties of sorghum flours there were increases in fat acidity ranging from 52 to 238% while in the fourth variety there was a decrease of 21% after 6 months of storage. In one variety, the fat acidity increased from 112 to 300 mg KOH/100 g flour, in the second variety it had increased from 74 to 250 mg KOH/100 g flour and in the third variety, it had increased from 124 to 188 mg KOH/100 g flour while in the fourth variety, the fat acidity had decreased from 136 to 108 mg KOH/100 g flour. These data suggested that varietal differences in a grain determined the changes in fat acidity during storage.

The effects of storage conditions on free fatty acids, fat acidity and peroxide value of 3 varieties of pearl millet flours were evaluated by Chaudhary and Kapoor (1984). The flours were stored in gunny sacks, earthen pots, tin cans and polythene bags at room temperature (20±5°C) with relative humidity between 60 and 65%. The flours were tested for rancidity by flavour and taste determinations. The day on which flour first developed an off flavour and bitter taste was recorded. It was found that the flour stored in gunny sacks, earthen pots, tin cans and polythene bags became rancid on days 6, 7, 8 and 10 (Phase 1) and inedible on days 11, 12, 13 and 14 (Phase 2). The flours were analysed for free fatty acids, fat acidity and peroxide value initially and in Phase 1 and Phase 2. The concentration of free fatty acid and fat acidity initially ranged from 24.6 to 27.5 mg/100 g lipids and 18.3 to 19.4 mg KOH/100 g flour, respectively. The increases in free fatty acids and fat acidity varied respectively from 6 to 13% and 39 to 52% in Phase 1, and from 6 to 17% and 74 to 92% in Phase 2. The initial peroxide values of fresh samples of 3 varieties of flours ranged from 10.1 to 13.1 meq/kg flour which increased by 68 to 108% in Phase 1 and by 96 to 177% in Phase 2. The data indicated that although the flours of different varieties of pearl millet were found to be rancid and inedible at similar time periods, the increases observed in free fatty acids, fat acidity and peroxide values were not consistent so that if flour of one variety was considered rancid at a particular concentration of free fatty acids, the flour of another variety was not considered rancid at the same concentration of free fatty acids in terms of flavour and taste.

The changes in free fatty acids in two lots of bajra flour stored for 8 weeks were monitored by Pruthi (1981). One lot of bajra flour was stored as such while the other lot of bajra flour was heated in an oven at 100°C for 2 h prior to storing. The free fatty acid changes were determined weekly and were expressed as percent of oleic acid. The initial moisture content of unheated flour was 12.0% and that of heated flour, 1.5%. The results showed that the development of free fatty acids was slower in the heated bajra flour than in the unheated flour after 8 weeks of storage. The free fatty acids increased from their initial values by 271% (from 6.8 to 25.2%) in heated flour and by 332% (from 13.7 to 59.2%) in the unheated flour. The authors were of the opinion that bajra contained an active lipase which caused hydrolysis of glycerides and the resultant free fatty acids deteriorated the quality of the stored flour. According to the authors, bajra flour should be heated before storage to inhibit the lipase activity.

The keeping quality of a flour blend based on maize and pulses was studied by Kumar and Anandswamy (1979). Before storing, the blend was exposed to carbon dioxide for 7 days to ensure freedom from inset infestation. The blends were stored in pouches of size 20 x 23 cm made of HDPE woven sack material (150 gauge) at 2 conditions (a) 27°C with 65% RH (normal) for 151 days and (b) 38°C with 90% RH (accelerated) for 50 days. The stored product was analysed for moisture pick up, free fatty acids and peroxides. Under the normal environmental conditions of storage, the moisture content steadily increased from the initial value of 10.8 to 12.4% till 151 days of storage. The free fatty acids as percent of oleic acid, also increased gradually from 12.7 to 22.0% till 105 days of storage and then increased rapidly to 41.0 and 51.0% after 131 and 151 days of storage, respectively. The initial peroxide value of 35.3 meq/kg ~~of~~ fat increased rapidly after 105 days of storage reaching a maximum of 744.8 meq/kg fat by the end of 131 days andlater decreased to 269.7 meq/kg fat by the end of 151 days of storage. Due to the rapid increases in free fatty acids and peroxide valuesafter 105 days, the authors suggested that the shelf life of the product at 27°C and 65% RH was about 105 days. The storage studies conducted under the accelerated conditions of 38°C and 90% RH showed that the product had attained a moisture content of 13.1% from the initial value of 10.8% by the end of 30 days. After 50 days of storage the moisture content had increased to 13.9% and the product had turned soggy and unacceptable. The free fatty acid content had increased from 12.7 (initial value) to 30.1 and 41.7% after 30 and 50 days of storage, respectively. Likewise, the peroxide values were 35.3 meq/kg fat initially, 85.5 meq/kg fat after 30 days and 125.1 meq/kg fat after 50 days of storage. Hence at 38°C and 90% RH the product had a shelf life of only 30 days.

Inamdar (1980) had determined the keeping quality of a ready to eat mix prepared from malted wheat and bengal gram mixed in the ratio of 4:1. The ready to eat mix was packed in polythene packets (200 gauge), heat sealed and stored at room temperature for a period of 28 days. The samples were drawn at weekly intervals and analysed for moisture content, alcoholic acidity, peroxide value and bacteriological count. The mix had an initial moisture content of 9.2% which increased to 14.9% after 28 days of storage. Similarly the alcoholic acidity increased from 0.071 to 0.110%, peroxide value from 2.3 to 12.8 milimoles/kg fat and bacteriological count from 56,00 to 3,42,000/g mix after 28 days of storage. The moisture content of the malted mix after storage for 14 days was above the IS specifications of 14% suggested as the maximum moisture limit for such products. The alcoholic acidity till 28 days of storage was below the IS specifications of 0.12% but the peroxide value and the bacteriological count of the malted mix after 14 days of storage, were higher than the

IS specifications of 10 millimole/kg fat and 50,000/g mix. Hence, it was concluded by the author that the shelf life of the malted mix was 14 days.

Later in 1982, Pandya determined the keeping quality of a similar malted mix prepared from wheat and bengal gram (4:1) packed in 200 gauge polythene bags, heat sealed and kept for 42 days. The samples were analysed for moisture content, alcoholic acidity, peroxide value and bacteriological count. At the end of the storage period the moisture content of the mix had increased from 5.2 to 5.4%, the alcoholic acidity from 0.040 to 0.085%, peroxide value from 0.5 to 5.0 meq/kg fat and bacterial count from 1,025 to 19,279/g mix. All these values were below the IS specifications and therefore the author had suggested that the mix could be stored for at least 42 days.

The shelf life of a mix prepared from malted wheat and roasted bengal gram in the ratio of 4:1 was determined by Nayak (1983). The parameters used by her were moisture content, alcoholic acidity and peroxide value. She observed that following one month of storage the moisture content had increased from 5.9 to 7.3%, the alcoholic acidity as percent sulphuric acid, from 0.082 to 0.109% and the peroxide value from zero to 3.12 meq/kg fat. As all these values were below the IS specifications, she recommended that the mix could be kept for a period of 28 days. Based on the moisture content, alcoholic acidity and peroxide values, Gandhi (1985) had demonstrated that bajra malt can be kept for a period of 28 days.

The effect of heat treatment and addition of jaggery to extend the shelf life of 'Balahar' (a mixture of precooked and dried maize semolina, edible groundnut cake flour and defatted soya flour in the ratio of 70:15:15) was investigated by Venkatesh et al (1984). Balahar was toasted at 100°C for 10 min in an electric roaster. It was observed that heat treatment protected the material against free fatty acid development during storage although a marginal increase in peroxide value was observed. Addition of jaggery (at 2% level) retarded peroxide value but had no effect on free fatty acid development. Acceptability scores on off flavour, bitterness and rancidity were found to be correlated with free fatty acid content.

Chandrasekhara and Balasubrahmanyam (1982) packed 100 g of weaning food with and without added fat and antioxidant in 300 gauge LDPE unit pouches, the packets were heat sealed and kept in tin containers at 27, 37 and 45°C. The samples were withdrawn at regular intervals of 30, 60, 90, 120 and 150 days to determine free fatty acid and peroxide values. The weaning food had an initial free fatty acid value of 0.5% expressed as percent of oleic acid. It increased to 1.4 and 1.6% when stored respectively at 27°C and 37°C for the storage period of 30 to 150 days. However, at these storage temperatures the product was free from off flavours, and its acceptability was good. But when the storage temperature was increased to 45°C the free fatty acid value increased to 2.0%, off flavour was noticed and the product was found unacceptable.

The initial peroxide value of the product was 3.1 millimoles/kg fat which increased to 25.4 and 28.4 millimoles/kg fat when it was stored for 150 days at 27°C or 37°C respectively but the product was found to be free from off flavours and was good and acceptable. However, the product stored for 150 days at 45°C had high peroxide value of 45.1 millimoles/kg fat and it had developed rancid odour and was unacceptable. Under all conditions of storage, the sample with added fat and antioxidant had lower free fatty acid and peroxide values as compared to the weaning food without fat and antioxidant except that it developed rancid odour and was unacceptable at the end of 150 days of storage at 45°C. From the results it was concluded that the product will keep well in tin containers for a period of 150 days at 27°C and 37°C and that the addition of fat and antioxidant had made no difference in the storage behaviour of the weaning food. The authors further suggested that since the polythene pouch of 300 gauge are highly moisture proof, it could offer desired moisture protection during storage under normal conditions even if it was not placed in a tin container (Chandrasekhara and Balasubrahmanyam 1982).

For commercial packaging of biscuits, Kumar and Balasubrahmanyam (1978) had suggested that aluminium foil combinations such as vinyl coated foil and laminated material such as cellophane/foil/polyethylene or paper/foil/polyethylene can be used where longer shelf life is required. In their study, biscuits with an initial moisture content of 2.0 % and critical level of 4.5% were kept in 2 types of packaging materials, namely double waxed paper and vinyl coated aluminium foil at 27°C and 65% RH to determine the shelf life in terms of softening of biscuits. It was observed that wax paper gave short shelf life of 8 days whereas vinyl coated aluminium foil package gave a shelf life of about 40 days indicating that for long term storage, aluminium foil would be more suitable than wax paper.

Later in 1981, Balasubrahmanyam et al had evaluated the shelf life of packaged salty biscuits (crackers). About 60 to 65 g of crackers were packed in (a) paper coated cellophane laminate factory pack, (b) 200 gauge LDPE and (c) 300 gauge HDPE pouches. Unit pack of crackers were individually weighed and exposed to storage conditions of (a) 38°C and 92% RH and (b) 27°C and 65% RH. The pouches were periodically weighed and the moisture gain during storage was recorded. The crackers had an initial moisture content of 3.1% and were considered to be unacceptable at critical moisture level of 7.0%. The results showed that the shelf life of the biscuits at 38°C and 92% RH was 4, 12 and 56 days in factory pack, 200 gauge LDPE and 300 gauge HDPE pouches, respectively. Similarly, the shelf life of biscuits at 27°C and 65% RH was found to be respectively 40, 38 and 196 days in the 3 types of pouches used. Therefore it was inferred that the factory pack was not as good as the 300 gauge HDPE pouch and that 300 gauge HDPE pouches were found to be the best as far as the shelf life of the crackers was concerned.

The studies reviewed herein indicate that packaging material and storage conditions determine the shelf life of a product.

The present experiment was planned to determine the keeping quality of mixes prepared from malted and raw wheat and bengal gram, and biscuits prepared from these mixes with or without colocasia leaf powder stored under 2 storage conditions at (a) 38°C and 90% RH (accelerated conditions) and (b) 28°C ranging from 25 to 34°C and 78% RH ranging from 46 to 99% RH (room conditions). The parameters used for the determination of keeping quality were (a) moisture gain, (b) alcoholic acidity, (c) fat acidity and (d) peroxide value.

The experiment was conducted for a period of one month keeping in mind the preparation and distribution of biscuits from local bakeries where the flour and the biscuits are generally not stored for more than one month. For packaging, 200 gauge low density polyethylene (LDPE) bags were used as they offer adequate protection in short term storage and are relatively cheaper in comparison to other packaging materials.

Materials and methods

As described in Chapter 3, cleaned wheat and bengal gram in the ratio of 4:1 by weight were soaked for 12 h and germinated for 48 h at 27°C (24 to 33°C). The germinated grains with rootlets were dried in an oven at 70±5°C for 9 to 11 h and milled. Mixes made from malted and raw wheat and bengal gram were used in the preparation of biscuits. Biscuits were prepared from 40 g mix, 40 g of jaggery and 20 g of vanaspati with or without 7.5 g of colocasia leaf powder.

Storage of mixes and biscuits

About 50 g of the mixes and 35 g of the biscuits were packed in 200 gauge LDPE packets of size 4 x 5 inches. The packets were heat sealed. For a period of one month, 8 packets of each sample were placed at 38°C and 90% RH in the relative humidity controlled oven to facilitate pullouts in duplicates, at weekly intervals. Two packets of each sample were placed in a cardboard box at room conditions for withdrawal after a period of one month. The temperature and relative humidity readings were obtained from the recordings of the meteriological observatory, M.S. University of Baroda, Baroda. Zero day estimations were carried out on fresh samples.

Analytical procedure

Moisture content : The moisture contents of mixes and biscuits were estimated by the method described in Chapter 5.

Alcoholic acidity : The method of IS:1155-1968 (1983) was followed for the determination of alcoholic acidity. Approximately 5 g of the sample was weighed into a conical flask and 50 ml of 90% ethyl alcohol was added. The flasks were covered, shaken and allowed to stand for 24 h with occasional shaking. The alcoholic extract was filtered through a dry filter paper. Ten millilitres of the combined alcoholic extract was titrated against 0.005 N sodium hydroxide solution using phenolphthalein as an indicator.

Calculation:

$$\text{Alcoholic acidity (as } H_2SO_4) \text{ with 90\% alcohol (\%)} = SR - SR_1 x N x \frac{V}{V_1} x \frac{100}{S} \frac{g}{} x 49.04 x \frac{1}{1000}$$

where: SR = sample litre (ml)

SR_1 = blank titre (ml)

N = normality of standard hydroxide solution

V = total volume (ml)

V_1 = aliquot taken for titration (ml)

S = weight of the material taken for analysis (g)

49.04 = equivalent weight of sulphuric acid

Acidity of extracted fat : Acidity of extracted fat was measured by the method of IS:1011-1981 (1983). The acid value is the measure of the extent to which the glycerides in the oil have been decomposed by lipase action. The decomposition is accelerated by heat and light. As rancidity is usually accompanied by free fatty acid formation the determination is often used as a general indication of the condition and edibility of oil.

Fat from about 10 g of the biscuit powder was extracted in 100 ml of petroleum ether by keeping the flask on a mechanical shaker for 24 h. The contents were filtered through Whatman No. 1 filter paper in a preweighed conical flask. The petroleum ether was evaporated on a water bath. The traces of the residual solvent were removed by keeping the flask in the hot air oven for about half an hour, they were cooled and weighed. Fifty millilitres of the mixed benzene-alcohol-phenolphthalein reagent (one litre benzene + one litre alcohol + 0.4 g of phenolphthalein) was added and the contents were boiled for 5 min on a boiling water bath and titrated to a distinct pink colour with 0.01 N potassium hydroxide solution. A blank titration of the 50 ml reagent was carried out. The blank titre value was substracted from the titre value of the fat.

Calculation:

$$\text{Acidity of extracted fat \% (as oleic acid)} = \frac{0.2825 \times N \times R \times 100}{W}$$

where: R = volume of 0.01 N potassium hydroxide solution used in titration after subtracting the blank (ml)

N = normality of potassium hydroxide solution

W = weight of the fat sample taken for analysis (g)

1 ml of 0.01 N ~~sodium~~ potassium hydroxide solution = 0.2825 g of oleic acid

Peroxide value : Peroxide value was estimated by the method of Jacobs (1951). The peroxide value is a measure of the peroxide contained in a sample of fat, expressed as milliequivalents of peroxide per 1000 g of fat. Unsaturated fatty acids appear to be able to add oxygen at the double bonds and form peroxides. These peroxides are highly reactive and are estimated iodometrically. The fat in an acetic acid chloroform medium is treated with an aqueous solution of potassium iodide. The liberated iodine is titrated with standard sodium thiosulphate solution.

Fat from 35 g of the mixes and 15 g of biscuit powder was extracted with petroleum ether into preweighed iodine flasks. The extracted fat was weighed. Thirty millilitres of acetic acid chloroform (60:40) solution was added to the iodine flasks. The contents were swirled until the fat dissolved. Then 0.5 ml of saturated potassium iodide solution was added. The solution was allowed to stand exactly for one minute with occasional shaking and then 30 ml of distilled water was added. The contents were titrated with 0.001 N sodium thiosulphate solution with constant and vigorous shaking. The titration was continued until the yellow colour almost disappeared. Then 0.5 ml of starch solution was added and the titration continued until the blue colour just disappeared.

Calculation:

$$\text{Peroxide value (meq/1000 g fat)} = \frac{SR \times N \times 1000}{S}$$

where: SR = sample titre (ml)
N = normality of the sodium thiosulphate solution
S = weight of the extracted fat (g)

Statistical analysis

The means, standard errors and percent changes were calculated (Snedecor and Cochran 1968).

Results and discussion

The keeping quality of mixes and biscuits stored under accelerated and room conditions was determined on the basis of moisture content, alcoholic acidity, acidity of extracted fat and peroxide value.

Keeping quality of mixes

Moisture content : The mean moisture content of malted mix increased from its initial value of 7.95 to 10.26 g/100 g over 28 days of storage under accelerated conditions (Table 47).

Table 47. Moisture content (g/100 g) of malted and raw mixes stored under accelerated conditions for 28 days

Mix	Days of storage				
	0	7	14	21	28
Malted mix (Mean ± SE)	7.95 ±0.030	8.58 ±0.130	9.08 ±0.040	9.60 ±0.110	10.26 ±0.085
Percent increase from initial value (%)		7.9	14.2	20.8	29.0
Raw mix (Mean ± SE)	9.80 ±0.045	10.49 ±0.110	10.61 ±0.100	11.08 ±0.025	11.78 ±0.155
Percent increase from initial value (%)		7.0	8.3	13.1	20.2

This increase estimated to 29%. At each successive weekly interval from 7 until 28 days of the storage period a steady increase of 6 to 8% was observed in the moisture content of malted mix.

The pattern in moisture gain by the raw mix stored at accelerated conditions did not vary from that of the malted mix

(Table 47). A steady increase in the moisture content was observed over the entire period of storage. Table 47 shows that the total moisture gain in raw mix tended to be of a smaller magnitude than that of the malted mix (20 Vs 29%). Also at each time interval until 28 days the moisture gain of raw mix was lower than the corresponding values of the malted mix. This perhaps was due to the fact that the initial moisture content of the raw mix was 23% higher than that of the malted mix (9.80 Vs 7.95 g/100 g). Similar effects of initial moisture content on moisture gain of stored flours has been reported by Mahadeviah et al (1977).

When the mixes were stored for 28 days under room conditions the mean moisture content of malted mix increased from 7.95 g/100 g of its initial value to 8.65 g/100 g exhibiting an increase of 9% and that of raw mix increased from 9.80 to 10.22 g/100 g exhibiting an increase of 4% (Table 48).

Table 48. Moisture content (g/100 g) of the malted and raw mixes stored under room conditions for 28 days

Mix	Initial	Final	Percent increase (%)
		Mean ± SE	
Malted mix	7.95±0.030	8.65±0.000	8.8
Raw mix	9.80±0.045	10.22±0.010	4.3

Comparing the moisture gain by malted and raw mixes stored for 28 days under accelerated and room conditions it appeared that irrespective of the storage conditions the malted mix gained more moisture than the raw mix (Table 49). The differences in moisture gain between malted and raw mixes were attributed to the differences in the initial moisture contents.

Table 49. Comparison of the moisture content and alcoholic acidity of the malted and raw mixes stored under accelerated and room conditions for 28 days with the PFA 1955 (1985) standards

Mix		Accelerated condition 38°C & 90% RH		Room condition 25-34°C & 46-99% RH		PFA 1955 (1985) standards
	Initial	Final	Percent increase (%)	Final	Percent increase (%)	
			Mean ± SE			
Moisture content (g/100 g)						
Malted mix	7.95 ±0.030	10.26 ±0.085	29.0	8.65 ±0.000	8.8	14.0[a]
Raw mix	9.80 ±0.045	11.78 ±0.155	20.2	10.22 ±0.010	4.3	
Alcoholic acidity (%)						
Malted mix	0.10 ±0.004	0.14 ±0.004	40.0	0.13 ±0.001	30.0	0.15[a]
Raw mix	0.04 ±0.002	0.10 ±0.001	150.0	0.08 ±0.001	100.0	

[a]For whole wheat flour

Table 49 highlights that the mean values for moisture contents of the malted and raw mixes stored under accelerated and room conditions for 28 days (Table 47, 48) were lower than the PFA 1955 (1985) and IS specifications. A maximum moisture content of 14.0% has been permitted for whole wheat flour by PFA 1955 (1985). Both the IS specifications, IS:1155-1968 (1983) and IS:7463-1974 (1975) for wheat flour, and ~~wheat and~~ wheat flour for use by biscuit industry respectively, permit a maximum moisture contents of 13.0%. Also the moisture contents of the stored mixes were well below the critical moisture levels of about 15% for pulse flours and of about 14% for cereal flours suggested by Mahadeviah et al (1977). Therefore, it follows that both the malted and the raw mixes can be stored for a period of 28 days or may be more with regards to moisture contents.

In 1980, Inamdar had determined the keeping quality of a mix prepared from malted wheat and bengal gram packed in 4 x 3 inches 200 gauge LDPE bags and stored for 28 days under room conditions in the months of January to September, when the temperature ranged from 22 to 25.5°C and the RH from 17 to 67%. The moisture content increased from the initial value of 9.18 to 14.02% by 14 days of storage. Considering the IS specification of 14% moisture for weaning foods the author concluded that the mix can be kept only for a period of 14 days.

Later Pandya (1982) had conducted a similar study for a period of 42 days. She had reported that the malted wheat and bengal gram mix stored in 200 gauge polythene bags gained only 4% moisture from the initial value of 5.16%. This increase in moisture content was lower than that observed in the present study (9%) and that reported by Inamdar (62%) in a similar mix stored for 28 days. The variations in findings might be due to the initial moisture content of the mix and the storage conditions (see below).

Reference	Initial moisture	Temperature and relative humidity during storage	Days of storage	Final moisture
Inamdar (1980)	9.18%	22 to 25.5°C 17 to 67% RH January to February	28	14.92%
Pandya (1982)	5.16%	28 to 30°C November to January	42	5.39%
Present study	7.95 g/100 g	25 to 34°C 46 to 99% RH August	28	8.65 g/100 g

In these 3 studies cited herein the initial moisture content varied between 5.16 and 9.18%. Considering the storage temperature comparable between Pandya's(1982) and the present study it appeared that lower initial moisture content led to a small increase in moisture gain. Comparing the results of Inamdar (1980) and that of the present study again it emerges that it is the initial moisture content which determines the moisture gain during storage.

Mahadeviah et al (1977) had reported that wheat flour had gained 10% moisture from the initial value of 8.8% when stored in 200 gauge LDPE pouches for 30 days at 38°C and 92% RH. This value was lower than that observed in the present study for raw mix stored under similar conditions (10 Vs 20%).

Earlier, Kumar and Anandswamy (1979) had determined the moisture pick up by a flour blend prepared from maize and pulses. The flour blend was stored in 150 gauge HDPE pouches under both normal (27°C and 65% RH) and accelerated (38°C and 90% RH) conditions for 30 days. Under normal conditions the moisture content had increased by 4% from the initial value of 10.8% and under accelerated conditions it increased by 21%. In the present study when the raw mix was stored in 200 gauge LDPE bags for 28 days under room conditions, the moisture content increased by 4% and under accelerated conditions, it increased by 20%. These values were comparable with those observed by Kumar and Anandswamy (1979) irrespective of the differences in grain type and packaging material. Kumar and Anandswamy (1979) had stored a blend of maize and pulses in 150 gauge HDPE pouches while in the present study a mix of wheat and bengal gram was stored in 200 gauge LDPE bags.

However, when bags of higher gauge were used it did prevent moisture gain by the stored flour. Gandhi et al (1985) had observed that the moisture content of full fat soya flour stored in sealed 700 gauge polythene bags under room conditions for a period of 10 months from April to January had remained static at 8.0%. While in the present study, the raw mix kept for 28 days under room conditions in 200 gauge LDPE bags had gained 4% moisture.

Alcoholic acidity : The initial mean alcoholic acidity of the malted mix was 0.10% (Table 50) which increased steadily to 0.14% exhibiting a 40% increase during 21 days of storage under accelerated conditions. At each successive weekly interval until 21 days of storage, the alcoholic acidity increased by 8 to 18%. After 21 days of the storage period however no further increase in alcoholic acidity was recorded.

Table 50. Alcoholic acidity (%) of malted and raw mixes stored under accelerated conditions for 28 days

Mix	Accelerated Days of storage				Room
	0	7	14	21	28
Malted mix (Mean ± SE)	0.10 ±0.004	0.11 ±0.000	0.13 ±0.004	0.14 ±0.002	0.14 ±0.004
Percent increase from initial value (%)		10.0	30.0	40.0	40.0
Raw mix (Mean ± SE)	0.04 ±0.002	0.07 ±0.002	0.08 ±0.005	0.08 ±0.001	0.10 ±0.001
Percent increase from initial value (%)		75.0	100.0	100.0	150.0

The mean alcoholic acidity of the raw mix increased drastically during first week of storage from 0.04 to 0.07% and later exhibited a steady increase until end of the 28 day experimental period (Table 50). During the entire period of 28 days the alcoholic acidity of the raw mix increased from 0.04 to 0.10% illustrating an increase of 150%.

The mean alcoholic acidity of the malted mix stored under room conditions for 28 days increased by 30% from 0.10% and that of the raw mix by 100% from 0.04% (Table 51). Although the increase in the alcoholic acidity of the raw mix was 3 fold than that of the malted mix, the actual value of the former mix remained lower than that of the latter mix (0.08 Vs 0.13%).

Table 51. Alcoholic acidity (%) of malted and raw mix stored under room conditions for 28 days

Mix	Initial	Final	Percent increase (%)
	Mean ± SE		
Malted mix	0.10±0.004	0.13±0.001	30.0
Raw mix	0.04±0.002	0.08±0.001	100.0

The higher alcoholic acidity of malted mix as compared to that of the raw mix was probably due to the greater breakdown of fats in the malted mix because of the increases that occur in lipase activity during malting (Mayer and Poljakoff-Mayber 1982).

Scrutiny of the increases in moisture contents under both accelerated and room conditions it was observed that the malted mix had gained 20% (29.0 Vs 8.8%) and raw mix 16% (20.2 Vs 4.3%) more moisture under accelerated than under room conditions (Fig 8). Likewise, comparing the increases in alcoholic acidity observed under both accelerated and room conditions it appeared that the increase in alcoholic acidity was 10% higher (40 Vs 30%) in malted mix and 50% higher (150 Vs 100%) in raw mix when the mixes were stored under accelerated than when stored under room conditions (Fig 8).

Comparisons between the increases in moisture content and alcoholic acidity of mixes stored under accelerated and room conditions revealed that the increase in alcoholic acidity was higher than the increase in moisture content (Fig 8). The diagram also shows that there was no relationship between the magnitude of increase between the 2 parameters, for example, under accelerated conditions the increase in moisture content of malted mix was 29% and that of alcoholic acidity, 40% and under room conditions the increase in moisture content was 8% and that of alcoholic acidity, 30%. Such differences were more wider in raw mix,as,when stored under accelerated conditions the moisture content increased by 20% and alcoholic acidity by 150% and under room conditions, the moisture content increased by 4% and alcoholic acidity by 100%. Figure 9 shows that the elevations in alcoholic acidity versus moisture content in samples stored at accelerated

Fig 8. Percent increases in moisture content and alcoholic acidity of the malted and raw mixes stored under accelerated and room conditions for 28 days

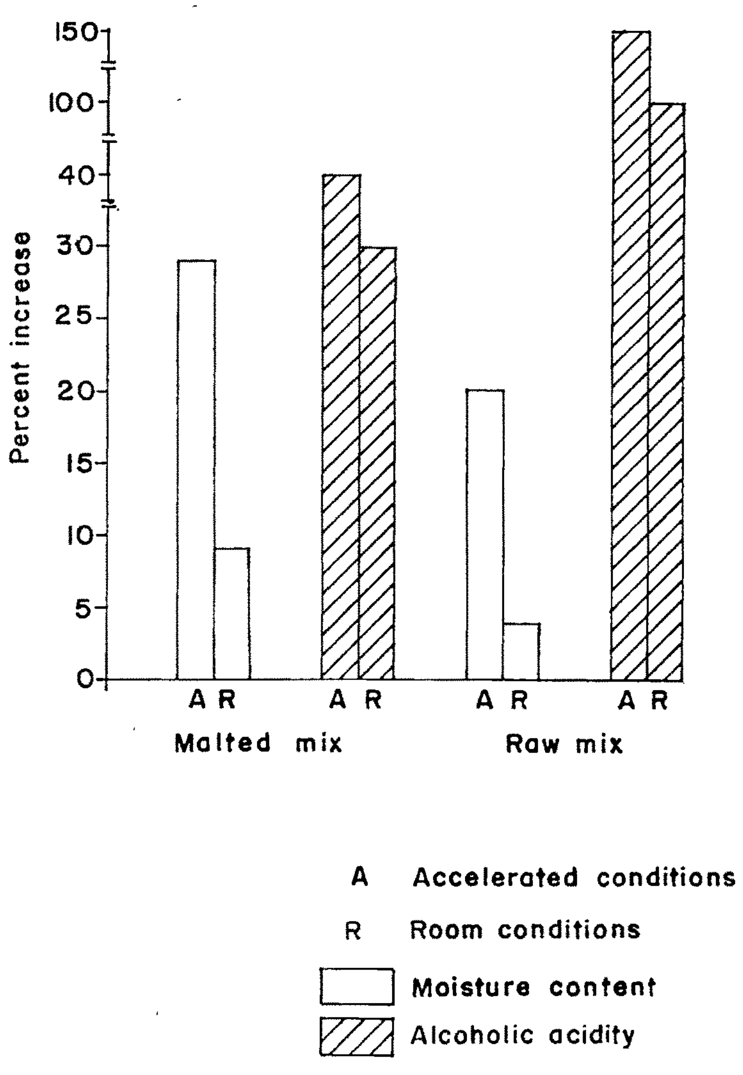
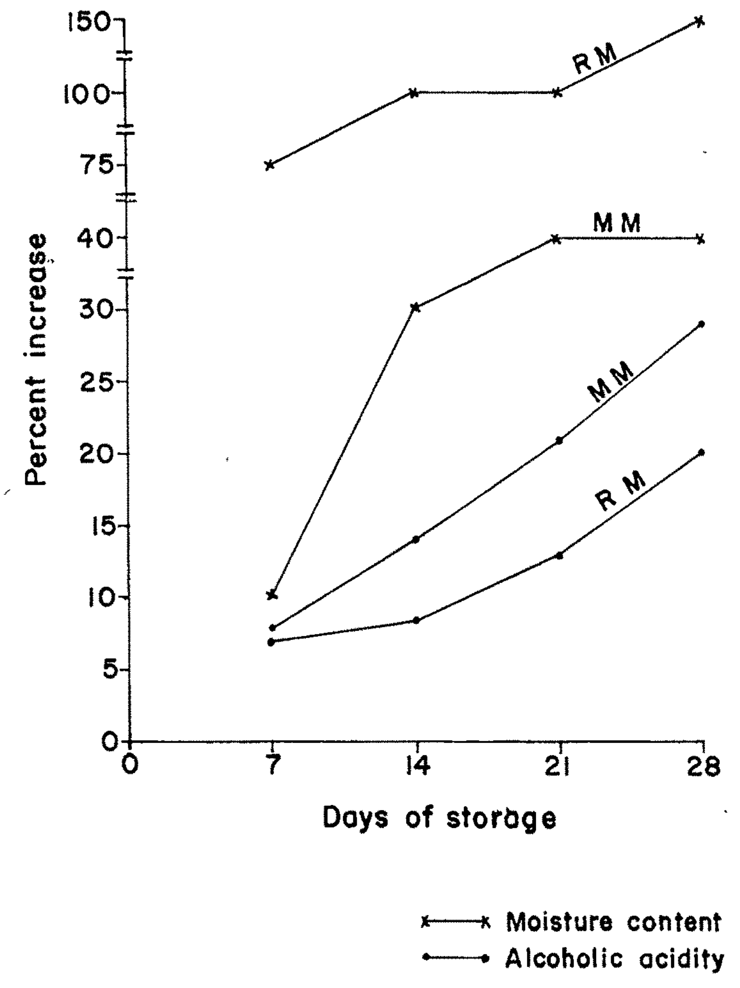


Fig 9. Percent increases at weekly intervals in moisture content and alcoholic acidity of mixes stored under accelerated conditions



conditions began to be higher from day 7 of the storage period and continued to be higher until end of the 28 day period although the sharp increase was between 7 to 14 days, particularly in the malted mix.

The mean values for alcoholic acidity of the malted and raw mixes stored under both accelerated and room conditions were lower than that of the PFA 1955 (1985) standard of 0.15% for wheat flour (Table 51). Considering alcoholic acidity as the criterion it seemed that the keeping quality of the malted and raw mixes under accelerated conditions and under room conditions was 28 days. However, the mean values for alcoholic acidity of the malted and raw mixes after 28 days of storage were higher than the IS specification, IS:1155-1968 (1983), of 0.1% for wheat flour. Earlier, based on alcoholic acidity of the stored mix Pandya (1982) concluded that the mix could be safely stored for 42 days as in her study the alcoholic acidity had increased from 0.04 (initial value) to 0.08% which was below the IS specification of 0.12% for weaning foods.

Inamdar (1980) had also determined the alcoholic acidity of mix prepared from malted wheat and bengal gram stored under room conditions for 28 days. She reported that the initial alcoholic acidity of the malted mix was 0.07% and it had increased to 0.11% by the end of the storage period. This value was lower than the IS specification of 0.12% for weaning foods. In the present study, the alcoholic acidity of the malted mix increased from 0.10 to 0.13%. Although the increase in alcoholic acidity observed in the present study was lower (30 Vs 57%) than that reported by Inamdar (1980) but because of its relatively higher initial alcoholic acidity (0.10 Vs 0.07%) the final value for alcoholic acidity was higher than that reported by Inamdar (1980).

Increases in free fatty acids and fat acidity on storage of flours and products have been reported by many investigators. Pruthi (1981) had reported that the free fatty acids of bajra flour had increased from 12.0 (value of the first week) to 41.8% after 4 weeks of storage at room temperature exhibiting an increase of 248% in 3 weeks. Likewise, Prasad and Mandokhot (1982) had observed increases of 21 to 238% over the initial values of 74, 112 and 136 mg KOH/100 g flour in 3 varieties of sorghum flour after a storage period of 6 months.

Kumar and Anandswamy (1979) had stored a flour blend based on maize and pulses at normal (27°C and 65% RH) conditions for 30 days and had observed that the free fatty acid value increased from 12.7 (initial value) to 13.9%. When the flour blend was stored at accelerated conditions (38°C and 90% RH), the alcoholic acidity had increased from 12.7 (initial value) to 30.1%. These data indicated that the increase in free fatty acids was rapid in samples stored at accelerated conditions. In the present study also higher increases in alcoholic acidity were observed when mixes were stored under accelerated than under room conditions (Fig 8). Chaudhary and Kapoor (1984) had also observed increases in free fatty acids and fat acidity in 3 varieties of pearl millet flours stored in polythene bags at room conditions for 14 days.

Chandrasekhara and Balasubrahmanyam (1982) reported that free fatty acid values of a weaning food after storage for 30 days increased from 0.5 (initial value) to 0.6% of oleic acid at 27°C, to 0.8% of oleic acid at 37°C, and to 1.2% of oleic acid at 45°C suggesting that the storage temperature determined the changes in free fatty acids in stored products.

Peroxide value : The initial mean peroxide value of the malted mix stored under accelerated conditions was zero. It increased to 3.1 meq/kg fat, after a storage period of 28 days (Table 52).

Table 52. Peroxide value (meq/kg fat) of the malted and raw mixes stored under accelerated and room conditions for 28 days

Mix	Accelerated Days of storage					Room
	0	7	14	21	28	28
	Mean ± SE					
Malted mix	0	0	0	0	3.1 ±0.186	0
Raw mix	0	0	0	0	0	0

This value was well below the 20 meq/kg fat and 75 meq/kg fat, as given by Jacobs (1951) for rancid lard and hydrogenated vegetable oil shortenings, respectively. The peroxide value of the raw mix remained zero throughout the storage period of 28 days both at accelerated and room conditions (Table 52).

Peroxide value is an indication of the rancidity of fat over a long period of storage. Therefore it was not surprising to note that the peroxide value did not appreciably change on storage for 28 days. The results suggested that the flours did not become rancid. This was supported by the observation that there was no off flavour development in the mixes stored for 28 days.

Inamdar (1980) had demonstrated that the peroxide value of a similar malted mix had increased from the initial value of 2.3 to 12.8 millimoles/kg fat, after 28 days of storage. The peroxide value of the malted mix had exceeded the IS specification of 10 meq/kg fat after 14 days of storage. Therefore, the author had suggested that the malted mix can be kept for a period of only 14 days. The data of the present study corroborate with those of Pandya (1982) who had found that the initial peroxide value of the malted mix was zero and of the 42 days stored mix was 5.0 meq/kg fat. The author had stated that the malted mix can be stored for 42 days.

Chandrasekhara and Balasubrahmanyam (1982) had related the increases in peroxide values to storage temperature. A weaning food was stored at 27°C or 37°C or 45°C and it was found that the peroxide value increased from the initial value of 3.1 to 8.21 millimoles/kg fat when stored at 27°C, to 18.4 millimoles/kg fat when stored at 37°C and to 24.2 millimoles/kg fat when stored at

45°C indicating that the peroxide value increased with the increase in storage temperature. Kumar and Anandswamy (1979) had demonstrated that from the initial value of 35.3 meq/kg fat, the peroxide value of a flour blend based on maize and pulses had increased to 50.2 meq/kg fat at 27°C and 65% RH, and to 85.5 meq/kg fat, at 38°C and 90% RH after 30 days of storage. Thereby suggesting that the increase in peroxide value of flour stored under accelerated conditions is higher in contrast to flour stored under room conditions.

In conclusion, the malted mix and raw mix with respect to moisture gain, alcoholic acidity and peroxide value can be kept for a period of 28 days under both accelerated and room conditions.

Keeping quality of biscuits

Moisture content : The initial mean moisture content of the MM biscuit was 4.52 g/100 g (Table 53). It increased by 20% (from 4.52 to 5.40 g/100 g) within one week in biscuits stored under accelerated conditions (38°C and 90% RH) but the crispness of the biscuits was not altered. Following 2 weeks of storage, the mean moisture content of the biscuits increased from 4.52 (initial value) to 6.82 g/100 g and at this moisture level the biscuits were found to be soggy. These data indicated that the critical moisture content of the MM biscuits was between 5.40 and 6.82 g/100 g. The biscuits at this level of moisture were considered to be unacceptable. The maximum moisture content of biscuits permissible by IS specification, IS:1011-1981 (1983), is 6.0%.

Table 53. Moisture contents (g/100 g) of biscuits stored under accelerated conditions for 21 days

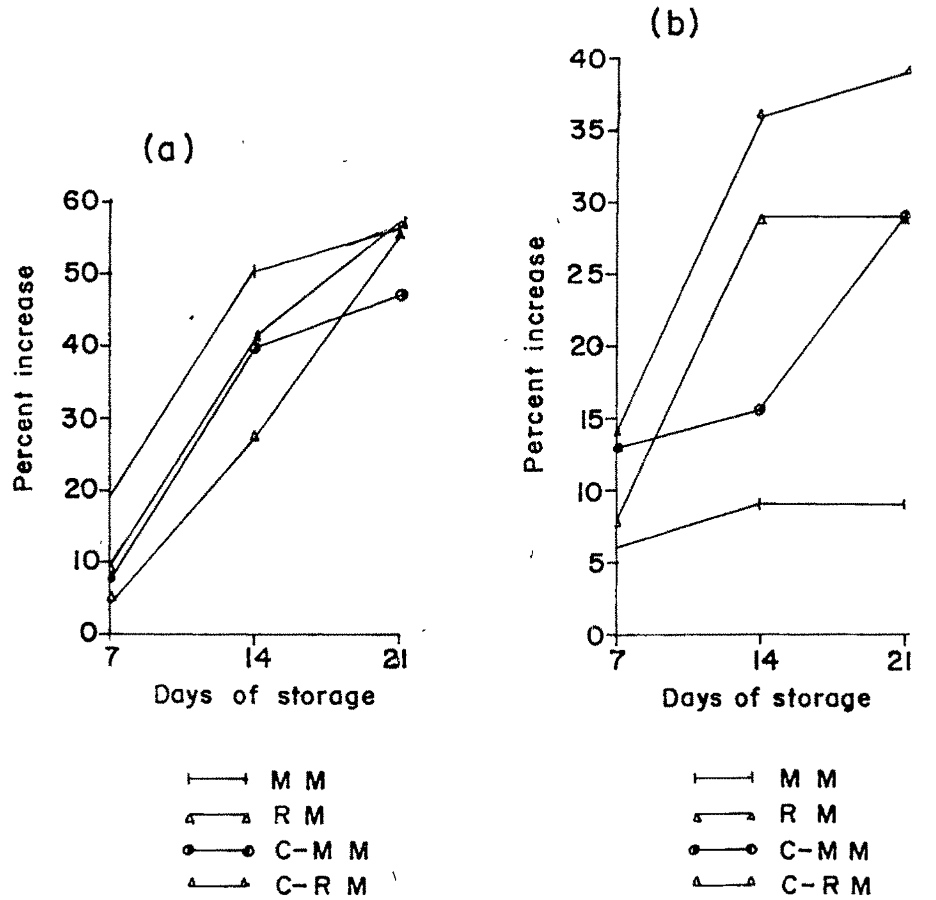
Mix	Days of storage 0	7	14	21
MM biscuits (Mean ± SE)	4.52 ±0.050	5.40 ±0.205	6.82 ±0.070	7.08 ±0.080
Percent increase from initial value (%)		19.5	50.9	56.6
RM biscuits (Mean ± SE)	4.22 ±0.030	4.62 ±0.065	5.94 ±0.295	6.62 ±0.495
Percent increase from initial value (%)		9.5	40.8	56.9
C-MM biscuits (Mean ± SE)	4.54 ±0.165	4.87 ±0.280	6.34 ±0.055	6.68 ±0.155
Percent increase from initial value (%)		7.3	39.6	47.1
C-RM biscuits (Mean ± SE)	4.49 ±0.250	4.68 ±0.125	5.71 ±0.020	6.96 ±0.200
Percent increase from initial value (%)		4.2	27.2	55.0

With prolongation of storage period, the mean moisture content of biscuits further increased and was 18% higher than the IS specification (7.1 Vs 6.0%). However, the rate of moisture ingress was markedly slower inththird week of storage as compared to that observed in the second week of storage (Fig 10a) perhaps the biscuits were approaching their maximum capacity to ingress moisture. These data suggest that under accelerated conditions the MM biscuits can be kept for less than 14 days.

The RM biscuit had an initial mean moisture content of 4.22 g/100 g (Table 53). It increased by 10% in the first week and by 29% in the second week of storage period. Although the rate of increase in moisture gain in RM as well as MM biscuits varied at different weekly intervals (Fig. 10a) but the total moisture gain was 57% over a period of 21 days in both the biscuits. As in the case of the MM biscuits, the RM biscuits remained crisp until 7 days of storage but by the fourteenth day they were found to be soggy. Hence, the critical moisture content of the RM biscuits was somewhere close to 5.94 g/100 g.

The C-MM biscuit stored at accelerated conditions, gained 7% moisture over the initial value of 4.54 g/100 g by the end of the 7 days of storage period (Table 53). In the second week, the moisture gain was 4 times than that observed in the first week. Thereafter, the rate of moisture gain declined as the experiment progressed to 21 days (Fig 10a). The total moisture gain by C-MM biscuits over 21 days was 47%.

Fig 10. Percent increases in (a) moisture content and (b) acidity of extracted fat of biscuits at weekly intervals, stored under accelerated conditions



The C-RM biscuit also showed steady moisture ingress when stored under accelerated conditions for a period of 28 days (Table 53). The moisture gain, however, was lower in the first week (4%) than that in the second (22%) and third week (22%) (Fig 10a). The total moisture gain was 55% over the initial value of 4.49 g/100 g which was higher than that observed in the C-MM biscuits. Like C-MM biscuits, the C-RM biscuits also appeared soggy after 14 days. It seemed that the critical level of moisture for C-MM biscuits was between 4.87 and 6.34 g/100 g and that for C-RM biscuit was between 4.68 and 5.71 g/100 g.

But when the biscuits were stored under room conditions for 28 days the MM biscuits had gained 12% moisture over the initial value of 4.52 g/100 g (Table 54) and were found to be crisp.

Table 54. Moisture contents (g/100 g) of biscuits stored under room conditions for 28 days

Biscuits	Initial	Final	Percent increase (%)
	Mean ± SE		
MM biscuit	4.52±0.050	5.08±0.070	12.4
RM biscuit	4.22±0.030	4.90±0.156	16.1
C-MM biscuit	4.54±0.165	4.99±0.255	9.9
C-RM biscuit	4.49±0.250	4.84±0.145	7.8

While the RM biscuits gained 16% moisture from the initial value of 4.22 g/100 g. The biscuits were found to be crisp. Similarly, the C-MM biscuit gained 10% moisture while C-RM biscuit gained 8% (Table 54). The moisture gain at room temperature by the colocasia containing biscuits (8 and 10%) was lower than those observed in non-colocasia biscuits (12 and 16%) thereby suggesting that colocasia leaf powder might have exerted a protective effect on the moisture gain.

Taking into consideration, the IS specification (IS:1011-1981, 1983) for moisture content of biscuit as 6.0%, the keeping quality of the biscuits with respect to moisture contents would be about 14 days under accelerated conditions and 28 days under room conditions.

Kumar and Balasubrahmanyam (1978) had reported that the shelf life of biscuits with an initial moisture content of 2.0% and critical level of 4.5% from the softening point of view was 8 and 6 days when stored at 27°C and 65% RM (normal conditions) in wax paper and cellophane, respectively. However, vinyl coated aluminium foil packages increased the shelf life to 40 days. But under 38°C and 90% RH (accelerated conditions), the shelf life of the biscuits in waxed paper was less than 4 days, in cellophane it was less than 2 days and in coated foil it was approximately 20 days.

Based on the moisture gain by the biscuits above the critical moisture content of 7.0% and loss of crispness, Balasubrahmanyam et al (1981) had concluded that the salty crisp biscuits with an initial moisture content of 3.1%, stored in 200 gauge LDPE bags, had a shelf life of 12 days under accelerated conditions (38°C and 92% RH) and of 38 days under normal condition (27°C and 65% RH). The results of Balasubrahmanyam (1981) support those of the present study. The shelf life of the biscuits was found to be below 14 days under accelerated conditions and above 28 days under room conditions.

Acidity of extracted fat : Since biscuits were found to be soggy even after 14 days of storage, the fat acidity and peroxide determinations were conducted on biscuits stored until 21 days, a week beyond the sogginess developed. Over the storage period of 21 days under accelerated conditions, the acidity of extracted fat of MM biscuit increased by 9% from its initial value of 0.33% and that of RM biscuit by 29% from its initial value of 0.24% (Table 55). But at each time interval within 14 days, the increase over the initial value in fat acidity was higher in RM versus MM biscuits (Fig 10b). But the actual values for fat acidity of RM biscuits remained lower that those of the MM biscuits. This was attributed to the initial lower value of RM biscuit as compared to that of the MM biscuit (0.24 Vs 0.33%). These results were not surprising since the initial alcoholic acidity (Table 49) of the malted mix was higher than that of the raw mix (0.10 Vs 0.04%).

Table 55. Acidity of extracted fat (% oleic acid) of the biscuits stored under accelerated storage conditions for 21 days

Mix	Days of storage 0	7	14	21
MM biscuits (Mean ± SE)	0.33 ±0.013	0.35 ±0.030	0.36 ±0.016	0.36 ±0.039
Percent increase from initial value (%)		6.1	9.1	9.1
RM biscuits (Mean ± SE	0.24 ±0.004	0.26 ±0.006	0.31 ±0.001	0.31 ±0.010
Percent increase from initial value (%)		8.3	29.2	29.2
C-MM biscuits (Mean ± SE)	0.45 ±0.008	0.51 ±0.012	0.52 ±0.012	0.58 ±0.008
Percent increase from initial value (%)		13.3	15.6	28.9
C-RM biscuits (Mean ± SE)	0.36 ±0.004	0.41 ±0.036	0.49 ±0.015	0.50 ±0.020
Percent increase from initial value (%)		13.9	36.1	38.9

Inclusion of colocasia leaf powder into biscuits led to higher elevations in alcoholic acidity of fat in biscuit samples stored under accelerated conditions. The increases were 29 and 39% in colocasia containing MM and RM biscuits, respectively as against 9 and 29% in corresponding non-colocasia biscuits. However the magnitude of the increases in response to colocasia leaf powder was higher in MM versus RM biscuit (Table 55).

In samples stored under room conditions, the increase in acidity of extracted fat over the initial values was 3% in MM, 21% in RM, 4% in C-MM and 8% in C-RM biscuits (Table 56).

Table 56. Acidity of extracted fat (% oleic acid) of biscuits stored at room condition for 28 days

Biscuit	Initial	Final	Percent increase (%)
	Mean ± SE		
MM biscuit	0.33 ±0.013	0.34 ±0.008	3.0
RM biscuit	0.24 ±0.004	0.29 ±0.009	20.8
C-MM biscuit	0.45 ±0.008	0.47 ±0.003	4.4
C-RM biscuit	0.36 ±0.004	0.39 ±0.020	8.3

Comparing the percent increases in moisture content and fat acidity of malted and raw mixes stored under accelerated (21 days) and room conditions (28 days), it was observed that the percent increases were higher in samples stored under former than under latter conditions (Fig 11). But unlike the findings on the mixes that the increases in alcoholic acidity were higher than those in moisture contents (Fig 8), in biscuits the increases in the latter far exceeded those in the former (Fig 11) perhaps indicating that enzymatic breakdown of flour lipids is adversely affected in presence of more moisture.

The maximum permissible acidity of extracted fat for biscuits by IS:1011-1981 (1983) is 1.0%. In the present study in all the biscuits the maximum limit reached was 0.6%. Hence it emerges from these data that the biscuits can be kept for at least 21 days under accelerated conditions and for 28 days under room conditions with respect to acidity of extracted fat.

Peroxide value : Peroxide value is a measure of rancidity of fat and in a short period of 21 days under accelerated conditions and of 28 days under room conditions it did not show any appreciable increase (Table 57). However, in the case of MM and RM biscuits, the mean peroxide value varied between zero to 0.76 meq peroxide/ kg fat when the biscuits were stored under accelerated conditions for 21 days. At room conditions the peroxide value remained zero (Table 57). The peroxide values of C-MM and C-RM biscuits stored under both accelerated and room conditions were below 0.70 meq peroxide/kg fat (Table 57).

Fig II. Percent increases in moisture content and acidity of extracted fat of biscuits stored under accelerated conditions for 21 days and room conditions for 28 days

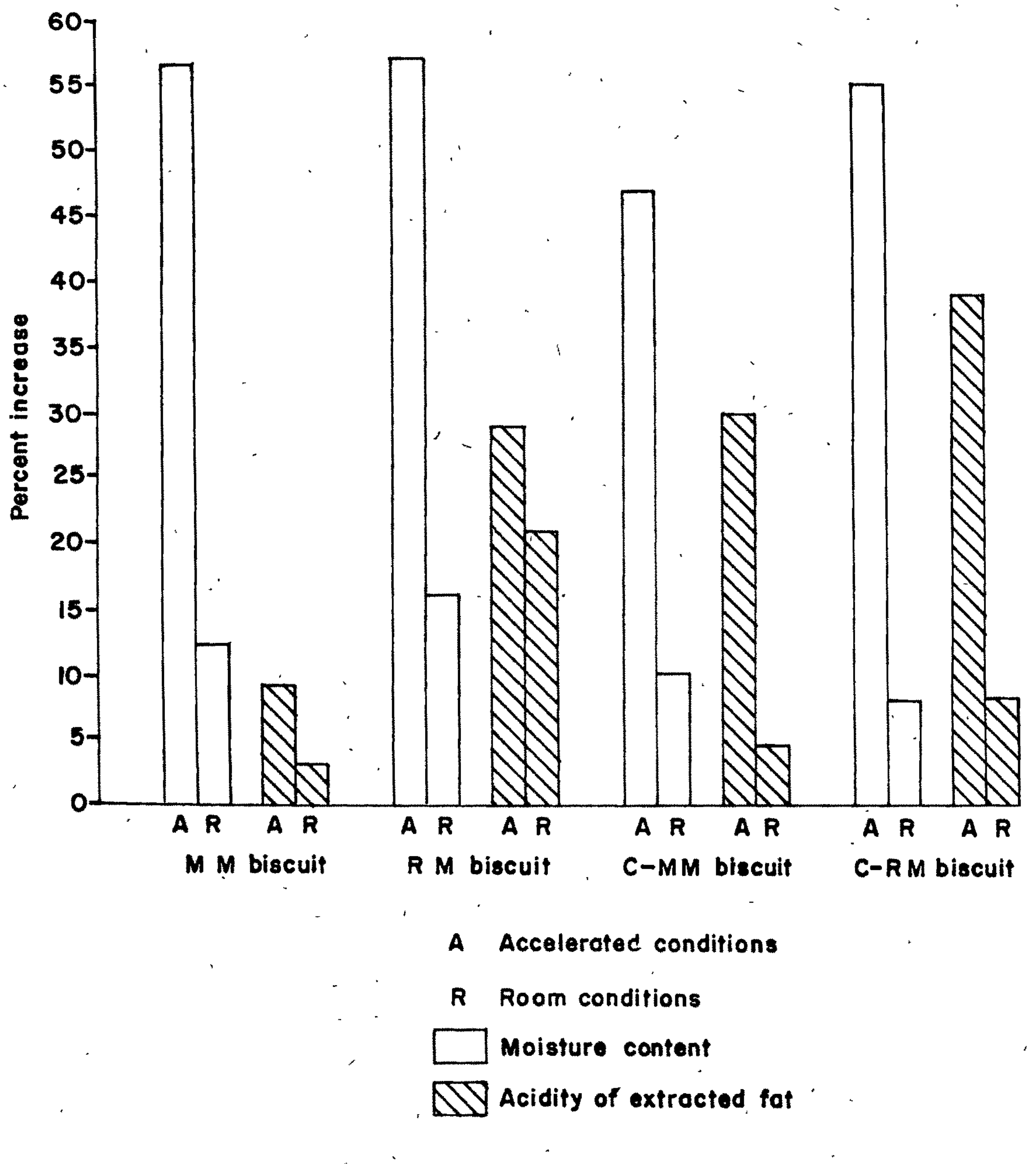


Table 57. Peroxide value (meq/kg fat) of biscuits stored under accelerated and room conditions for 21 and 28 days, respectively

Biscuit	Accelerated				Room
	Days of storage				
	0	7	14	21	28
	Mean ± SE				
MM biscuits	0	0	0.31 ±0.010	0.76 ±0.060	0
RM biscuits	0	0	0.16 ±0.005	0.50 ±0.095	0
C-MM biscuits	0	0.34 ±0.015	0,70 ±0.100	0.24 ±0.005	0
C-RM biscuits	0	0.35 ±0.010	0.44 ±0.095	0.20 ±0.035	0.22 ±0.015

The peroxide values of all the biscuits were below one milliequivalent peroxide/kg fat, therefore, biscuits were considered not rancid till the end of the storage period under both accelerated and room conditions.

Balasubrahmanyam et al (1981) have opined that the loss of crispness due to moisture ingress is a more serious problem than the rancidity development which is a problem in long term storage has been found true in the present study also. Based on the data on the acidity of extracted fat and peroxide value it seems that the biscuits can be kept for 21 days at accelerated conditions and 28 days at room conditions. But since in the present study MM and RM biscuits with and without colocasia leaf powder became soggy before 14 days of storage under accelerated conditions but had remained crisp until 28 days of storage under room conditions therefore it was concluded that these biscuits have a shelf life of about 14 days under accelerated conditions, and of 28 days and more under room conditions.