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Influence of Packaging Materials on Storage Quality of Supplementary Food Mix

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Pearl millet based supplementary food mix was prepared with 5.0 per cent incorporation of carrot and araikeerai (*Amaranthus dubius*) powder. The food mix was packed in polyethylene bags (P_1), Metallized Polyethylene Pouches (P_2) and Polyethylene terephthalate jars (P_3) and stored at room temperature. The initial free fatty acid content of supplementary food mix was 0.231 per cent of oleic acid which had changed to 0.274, 0.257 and 0.248 per cent of oleic acid in P_1, P_2 and P_3, respectively after 180 days of storage. The freshly prepared supplementary food mix contained 1.2 mEq / kg of peroxide value. The corresponding values at the end of the storage were 3.9 (P_1), 2.8 (P_2) and 2.4 (P_3) mEq / kg of peroxide value. Initially the supplementary food mix had 8,048 μg of β-carotene per 100 g and after 180 days of storage period, the β-carotene reduced to 6,586 in P_1, 7,236 in P_2 and 7,215 μg / 100 g in P_3. The freshly prepared supplementary food mix contained 2.85 mg of ascorbic acid, which had reduced to 2.17 (P_1), 2.36 (P_2) and 2.51 mg / 100 g (P_3) at the end of storage period. The study revealed that the supplementary food mix packed in Polyethylene terephthalate jars had undergone minimum changes in physico-chemical characteristics. Hence, it is concluded that the storage of supplementary mix in Polyethylene terephthalate jars extent the shelf life of the product and reduce the nutrient losses during storage.

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1. INTRODUCTION

India is one of the biggest producer and consumer of millets in the world. The pearl millet (*Pennisetum glaucum*) is one of the most widely grown millet in India. It is grown in about 7.6 million hectares and yielding 9.1 million tons of grains per year [1]. Pearl millet grain contains starch (61.78%), crude protein (10.96%), fat (5.43%), ash (1.37%) and dietary fiber (11.49%). The calcium, magnesium, phosphorus and iron content of pear millet are 27.35, 124.00 and 289.00, 6.42 mg, respectively [2]. Hence, the pearl millet is dense in essential nutrients and can be utilized along with pulses and oil seeds for the preparation of supplementary foods. But the major constraints of utilization of pearl millet is poor shelf life of the flour. Pearl millet grain can be stored for longer periods without substantial quality alteration if the kernels remain intact. However, once the grain is decorticated and ground, the quality of flour deteriorates rapidly [3]. Storability of the pearl millet based supplementary food is poor owing to its high oil content. Rapid development of rancidity and bitterness in the flour has been a major problem in the acceptability and utilization of pearl millet flour based supplementary foods. Both hydrolytic and oxidative changes are reported in the lipids of the meal resulting in release of free fatty acid and formation of peroxides [4]. The degree of unsaturation in pearl millet lipids is one of the main factors responsible for development of rancidity in pearl millet flour [5]. However, the development of rancidity and other quality deteriorations can be reduced by using appropriate packaging materials. Hence an attempt was undertaken to find out the suitable packaging materials for the storage of pearl millet based supplementary food mix.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

Pearl millet, araikeerai (*Amaranthus dubius*), carrot, roasted Bengal gram dhal, roasted groundnut and Jaggery were purchased in bulk from the local market of Madurai, Tamil Nadu.

2.2 Packaging Materials

Polyethylene bags (15 x 20 cm) of 400 gauge thickness, Metallized Polypropylene Pouches (MPP) (11 x 15 cm) and Polyethylene terephthalate (PET) jars were used for packing the samples.

2.3 Chemicals

The chemicals used in the study were either Analytical Reagent (AR) or Laboratory Reagent (LR) or Guaranteed Reagent (GR) grade.

2.4 Preparation of Supplementary Food Mix

The supplementary food mix was prepared on the basis of a standardized supplementary food, 'Kuzhandai Amudhu' composition [6]. The pearl millet, Bengal gram, ground nut and jiggery are taken in the proportion of 30:20:15:25 and 5.0 per cent of carrot and araikeerai *(Amaranthus dubius)* powder were also incorporated. The flow chart for the preparation of pearl millet based supplementary food mix is given in Fig. 1.

2.5 Storage Studies

The prepared pearl millet based supplementary food mix was packed in 400 gauge polyethylene bag, Metallized Polyethylene Pouches (MPP) and Polyethylene terephthalate (PET) jars and stored at room temperature. The changes in the chemical composition and the organoleptic characteristics were analyzed once in 30 days for the period of 180 days, whereas the microbial load was analyzed before and after storage.

2.6 Physico-Chemical Analysis

Moisture, acidity, pH, free fatty acid, peroxide value, total sugar, reducing sugar, β-carotene, ascorbic acid, crude fibre, total ash, calcium and iron were determined by AOAC method [7].

2.7 Organoleptic Evaluation

The supplementary food mix were developed and evaluated organoleptically by using 9-1 hedonic rating scale with the help of 20 semi-trained judges [8].

2.8 Microbial Examination

Approximately one gram of the sample was taken in a 9.0 ml sterile water blank and thoroughly mixed in a rotary shaker for 10 minutes. From the solution, a series of 10^6 to 10^3 dilutions were obtained by using serial dilution

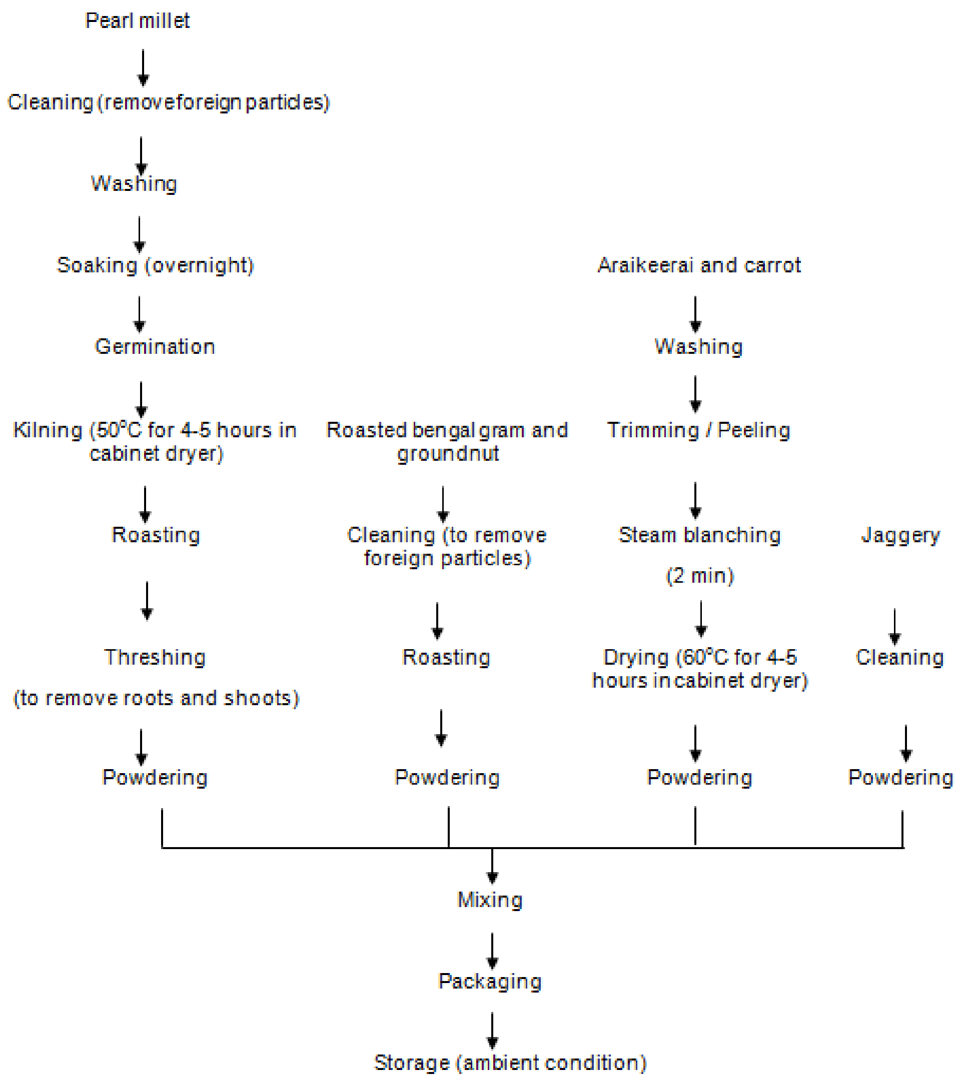

Fig. 1. Flow chart for the preparation of pearl millet based supplementary food mix

techniques. The dilutions10^6, 10^4 and 10^3 were used for bacteria, fungi and yeast, respectively. From the respective dilutions, 1.0 ml of sample was poured in a petri dish. Appropriate medium was prepared, sterilized and cooled (40°C). The medium was poured into petri dishes and rotated clockwise and anticlockwise for uniform spreading of the medium, then allowed to solidify. After solidification, the plates were incubated at room temperature (28 ± 2°C) for 24 to 48 hours for bacteria, 2 to 3 days for fungi and 5 days for yeast [9].

2.9 Statistical Analysis

The data obtained were subjected to statistical analysis to find out the impact of storage periods and packaging materials on the quality of the products during storage. Factorial completely randomized block design was applied for analyzing data at 0.05 level of significance with triplicate number of samples [10].

3. RESULTS AND DISCUSSION

3.1 Changes in Physico-chemical Characteristics of Supplementary Food Mix during Storage

The changes in moisture, acidity, pH, total sugar, reducing sugar, crude fibre, total ash and minerals during storage of supplementary food mix were analyzed and given in Table 1. The free fatty acid, peroxide value, β-carotene and ascorbic acid content were also analyzed.

3.1.1 Moisture

An increasing trend in the moisture content was noted in all the samples packed in different packaging materials during storage. The moisture permeable nature of the polyethylene bag and the presence of jaggery, which is highly hygroscopic could have attributed to the higher moisture content. The initial moisture content of the supplementary food mix was 5.96 per cent and it recorded a final moisture content of 6.35 per cent in P_3 which was observed to have minimum moisture permeability than P_1 (6.64%) and P_2 (6.47%). This result agreed with [11] who reported the increasing trend in the moisture content from 11.0 to 11.34 g per cent on storage (3 months) in the composite flour mix containing cereals and pulse flours. Another author [12] reported that composite flour mix packed in Metallized Polyethylene Pouches (MPP) indicated less moisture absorption followed by polyethylene bags. Similar results were observed in the present study.

3.1.2 Sugar content

As the storage period increased the reduction in the total sugar content was noted. The retention of total sugar in the supplementary food mix packed in P_3 was found to be higher than the P_2 and P_1 during the storage period. Initially supplementary food mix had 14.10 g / 100 g of the total sugar. At the end of 180 days the values of the total sugar was decreased to 12.43, 12.68 and 12.81 g / 100 g in P_1, P_2 and P_3, respectively. The findings of the present study are in line with that of [13] who noted that the initial sugar content was between ranges of 11.87 to 12.70 per cent. During storage, the supplementary food also exhibited a loss in the total sugar content of samples after 180 days of storage. Similar picture was noted in the present investigation too. The freshly prepared supplementary food mix contained 8.65 g / 100 g of reducing sugar, whereas at the end of storage period, the supplementary food mix had increased to 10.81, 10.21 and 10.04 g / 100 g in P_1, P_2 and P_3, respectively. Similarly, there was an increasing trend in reducing sugar content of malted wheat flour and skim milk powder based weaning mix during storage [14]. Similar situation was observed in the present investigation too.

3.1.3 Acidity and pH

During the storage of supplementary food mix exhibited a reduction in the acid content, whereas an increasing trend in the pH was noted. The acid content of the freshly prepared supplementary food mix had 0.507 per cent. The corresponding values at the end of 180 days in P_1, P_2 and P_3 were 0.481, 0.495 and 0.498 per cent respectively. Initially the pH of the supplementary food mix was 6.2 which had increased to 6.6 after 180 days of storage. This result agreed with [14] who reported similar observation in weaning mix that initial pH of the weaning mix was 5.50 and it was reduced after 180 days and their final values ranged between 5.42 and 5.49. The similar trend of decrease in pH was also observed in the present study.

3.1.4 Crude fiber and total ash

A negligible reduction in the crude fibre content and total ash was seen among the sample during storage irrespective of packaging materials. The crude fibre content of supplementary food mix ranged from 3.23 to 3.26 g / 100 g whereas the total ash content ranged between 2.01 and 2.04 g/ 100 g g. / 100 g before and after storage, respectively. Anand et al. [15] reported that the crude fibre and total ash content of weaning mixes ranged from 2.03 to 2.51 and 2.97 to 5.12 g / 100g respectively. More or less similar value of total ash was observed in the present study. Another author [16] reported that the total ash content of the millet based gruel was 3.24 g / 100 g. Similar picture was noted in the present study too. In the present study the crude fibre content of the supplementary food mix recorded lesser than the values (2.3 to 4.9 g / 100 g) quoted by Nwanekezi and Okorie [17].

3.1.5 Minerals

Similar to total ash and crude fibre a negligible changes in the mineral content of the supplementary food mix was also observed. The initial calcium content of the supplementary food mix was 490.2 mg / 100 g which was changed to 489.6 and 490.1 mg / 100 g after 180 days of storage. The initial and final iron content of the supplementary food mix was 9.13 and 9.10 mg / 100 g respectively. The supplementary food mix used for the study had recorded higher percentage of calcium than the values reported by other researchers [18,19].

Table 1. Changes in Physico-chemical characteristics of supplementary food mix during storage

Particulars	Packaging materials		
	P_1	P_2	P_3
Moisture (%)			
Initial	5.96	5.96	5.96
Final	6.64	6.47	6.35
Total sugar (%)			
Initial	14.10	14.10	14.10
Final	12.43	12.68	12.81
Reducing sugar (%)			
Initial	8.65	8.65	8.65
Final	10.81	10.21	10.04
pH			
Initial	6.2	6.2	6.2
Final	6.6	6.4	6.3
Acidity (%)			
Initial	0.507	0.507	0.507
Final	0.481	0.495	0.498
Crude fibre (%)			
Initial	3.26	3.26	3.26
Final	3.23	3.25	3.25
Total ash (%)			
Initial	2.04	2.04	2.04
Final	2.01	2.02	2.03
Minerals - Calcium (mg / 100 g)			
Initial	490.2	490.2	490.2
Final	489.6	490.1	490.1
Iron (mg / 100 g)			
Initial	9.13	9.13	9.13
Final	9.10	9.10	9.11

P_1- Polyethylene bags, P_2- Metallized polyethylene pouches and P_3- PET jar

3.2 Free Fatty Acid and Peroxide Value

An increasing trend in the free fatty acid content of the supplementary food mix was noted as the storage period increased (Fig. 2). The initial free fatty acid content of supplementary food mix was 0.231 per cent of oleic acid which had changed to 0.274, 0.257 and 0.248 per cent of oleic acid in P_1, P_2 and P_3, respectively after 180 days of storage. The findings of the present study are in line with that of [20] who reported the storage stability of vegetable protein based baby foods. Initially the free fatty acid content of the baby food was 1.02 per cent and increased to 2.26 per cent at the end of storage period.

A gradual increase in peroxide value was observed in the supplementary food mix at the end of the storage period. The freshly prepared supplementary food mix contained 1.2 mEq / kg of peroxide value (Fig. 3). The corresponding values at the end of the storage were 3.9 (P_1), 2.8 (P_2) and 2.4 (P_3) mEq / kg of peroxide value. A slight variation in the peroxide value was noted in supplementary food mix packed in PET jars. A significant difference in the free fatty acid content and peroxide value was observed between packaging materials and storage period. The peroxide value was 0.75 mEq/kg at initially and increased to 2.90 mEq/kg after 180 days of storage. The researcher [21] reported that increased trend in peroxide value during the storage of complementary food produced from flour blends of orange flesh, sweetpotato, sorghum, and soybean. Similarly, the peroxide value of weaning foods developed from locally available food stuffs was between the ranges of 2.13 and 5.34 [22]. However, the peroxide value of the supplementary food mix recorded lesser than the values (42.0 to 560.22 mEq/kg) quoted by Kumar [23].

3.3 β-carotene

Fig. 4 shows changes in β-carotene content of supplementary food mix during the storage period. Initially the supplementary food mix had 8,048 µg of β-carotene per 100 g and after 180 days of storage period, the β-carotene reduced to 6,586 in P_1, 7,236 in P_2 and 7,215 µg / 100 g in P_3. The loss of β-carotene was lower in P_3, than P_2 and P_1, which was due to the difference in permeability of packaging materials for oxygen and light. The statistical analysis of the data revealed a significant difference in the β-carotene content of supplementary food mix between packaging materials and period of storage. Aruna et al. [24] reported that loss of β-carotene was observed in cereal based papaya powder after the storage period. Similar trend of reduction in β-carotene was observed in the present study too. The instant convenience mix prepared by Shilpi and Shashi [25] contained 54.30 mg of β-carotene. In the present study the β-carotene content was higher than the value stated by the researchers. It might be due to the incorporation of greens and carrot powder in supplementary food mix.

3.4 Ascorbic Acid

The value pertaining to the changes in ascorbic acid content of the supplementary food mix is given in Fig. 5. The freshly prepared supplementary food mix contained 2.85 mg of ascorbic acid, which had reduced to 2.17 (P_1), 2.36 (P_2) and 2.51 mg / 100 g (P_3) respectively at the end of storage period. The fall in ascorbic acid content might have been attributed to its oxidation. A significant difference in ascorbic acid was existed between the packaging materials and storage period. Similarly the ascorbic acid content of the apple powder showed a gradual decrease during storage of six months [26]. It was observed that there is reduction in vitamin C content during the study period in the present investigation also.

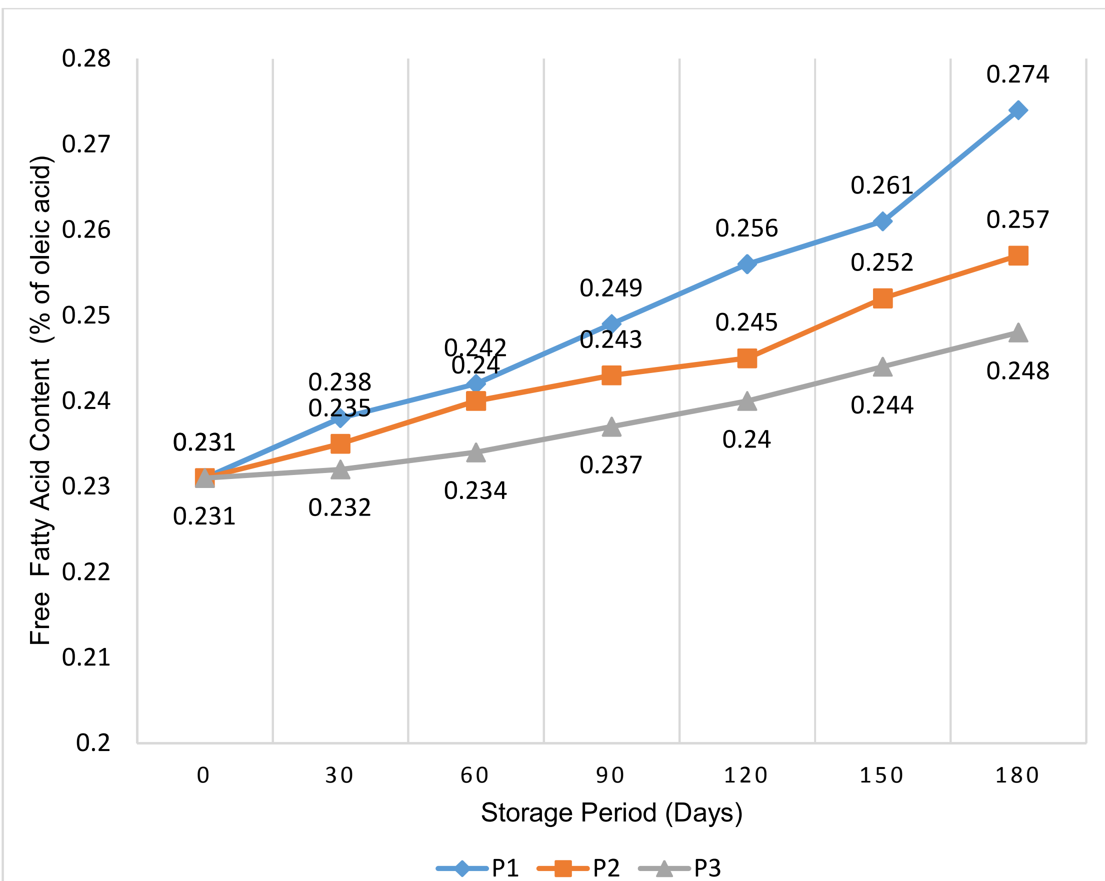

Fig. 2. Changes in free fatty acid content (% oleic acid) during storage
P_1- Polyethylene bags, P_2- Metallized polyethylene pouches and P_3- PET jars

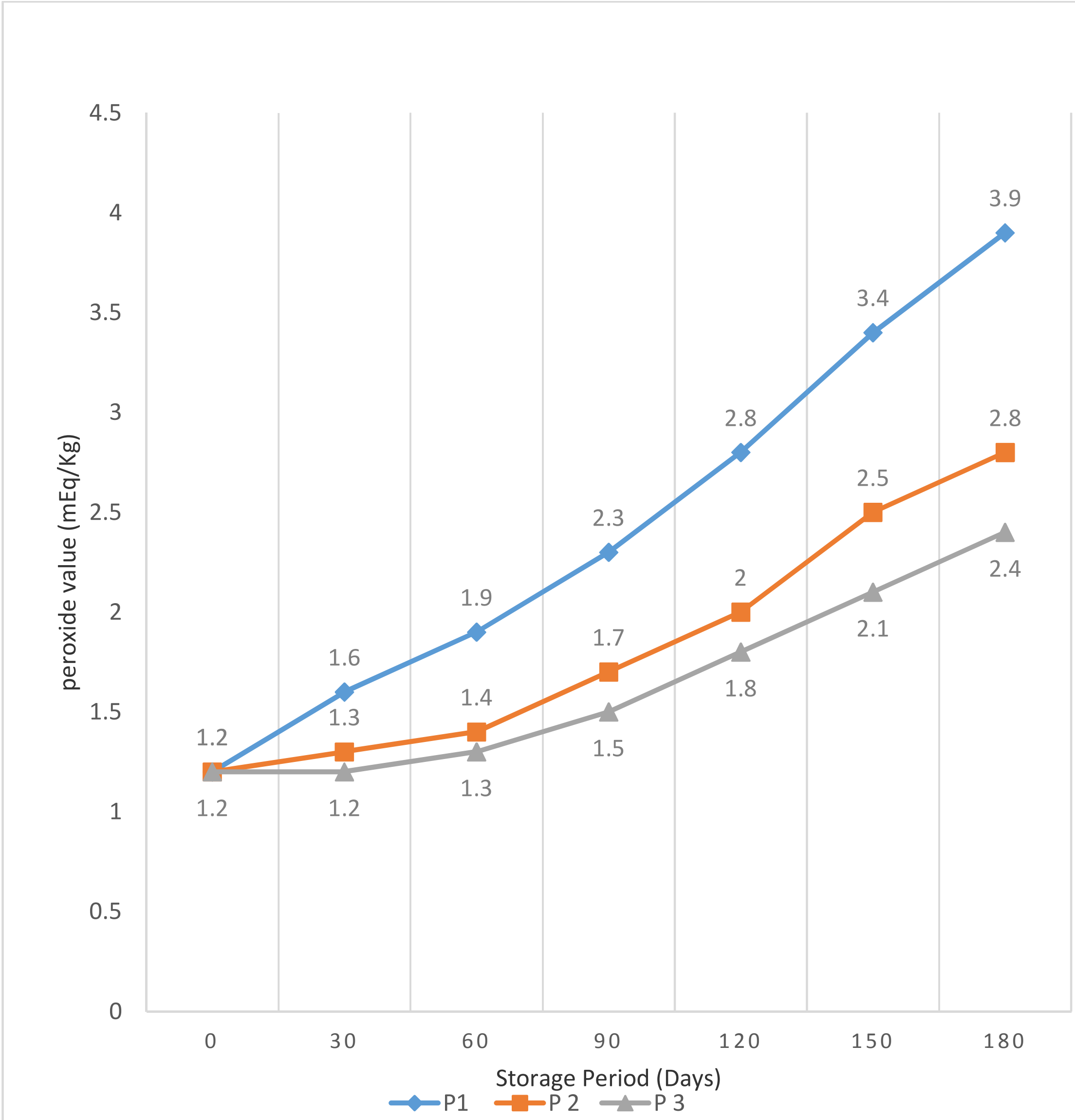

Fig. 3. Changes in peroxide value (mEq/kg) during storage
P_1- Polyethylene bags, P_2- Metallized polyethylene pouches and P_3- PET jars

3.5 Organoleptic Evaluation of Supplementary Food Mix during Storage

The organoleptic characteristics viz., appearance, colour, flavour, texture, taste and overall acceptability of the supplementary food mix were recorded every month during the period of storage by a panel of 15 semi trained judges with 9-1 hedonic scale. The mean organoleptic scores of the supplementary food mix are given in Table 2. Neither the storage period nor the packaging materials influenced the organoleptic characteristics. The colour, flavour, texture, tastes and overall acceptability of supplementary food mix was highly acceptable during the storage period. The mean overall acceptability of supplementary food mix packed in P_3 was slightly higher than P_2 and P_1. The results obtained in present study are comparable to the findings of earlier workers [27]. The researchers reported that the overall acceptability score of the cereal based complementary food was slightly decreased from 8.40 to 8.28 within 60 days of storage periods. Another authors also reported that the sensory score for colour, appearance, aroma, texture and taste were slightly reduced from 7.4 to 7.2, 7.3 to 7.1, 7.0 to 6.8, 7.0 to 6.9 and 7.2 to 7.1, respectively [28].

3.6 Microbial Changes in the Supplementary Food Mix

The changes in the microbial population were observed before and after storage of supplementary food mix. The microbial load of the supplementary food mix packed in P_1 was found to be higher after storage than P_2 and P_3. The packaging material exhibited its influence on the microbial population of the supplementary food mix during the study period with a few exceptions. Initially the bacterial population of the supplementary food mix was 3.0 x 10^5 cfu / g which had changed to 6.0, 5.0 and 4.0 x 10^5 cfu / g in P_1, P_2 and P_3, respectively (Fig. 6). The freshly prepared supplementary food mix contained 2 x 10^3 cfu / g of fungi population. At the end of storage period, the fungal population was 3.0 (P_1), 3.0 (P_2) and 2.0 (P_3) x 10^3 cfu / g, respectively (Fig. 7). The yeast population of 4.0 x 10^4 cfu / g was noted in the supplementary food mix initially which had increased to 5.0 to 6.0 x 10^4 cfu / g at the end of storage period in P_2 and P_1, respectively(Fig. 8). No change in P_3 was observed. The bacterial population was appeared to be in close agreement with [29] those developed weaning food from sorghum supplemented with legumes and oil seeds and reported that at initially the bacterial count was between the ranges of 4.3 x 10^2 and 1.1 x 10^3 cfu/g and increased into the ranges of 2.3 x 10^3 and 7.6 x 10^4 cfu/g. Similarly, initial microbial load in the cereal based soyabean fortified instant weaning food was 4.38 cfu/ml and increased into 4.66 cfu/ml after the 60 days of storage [30].

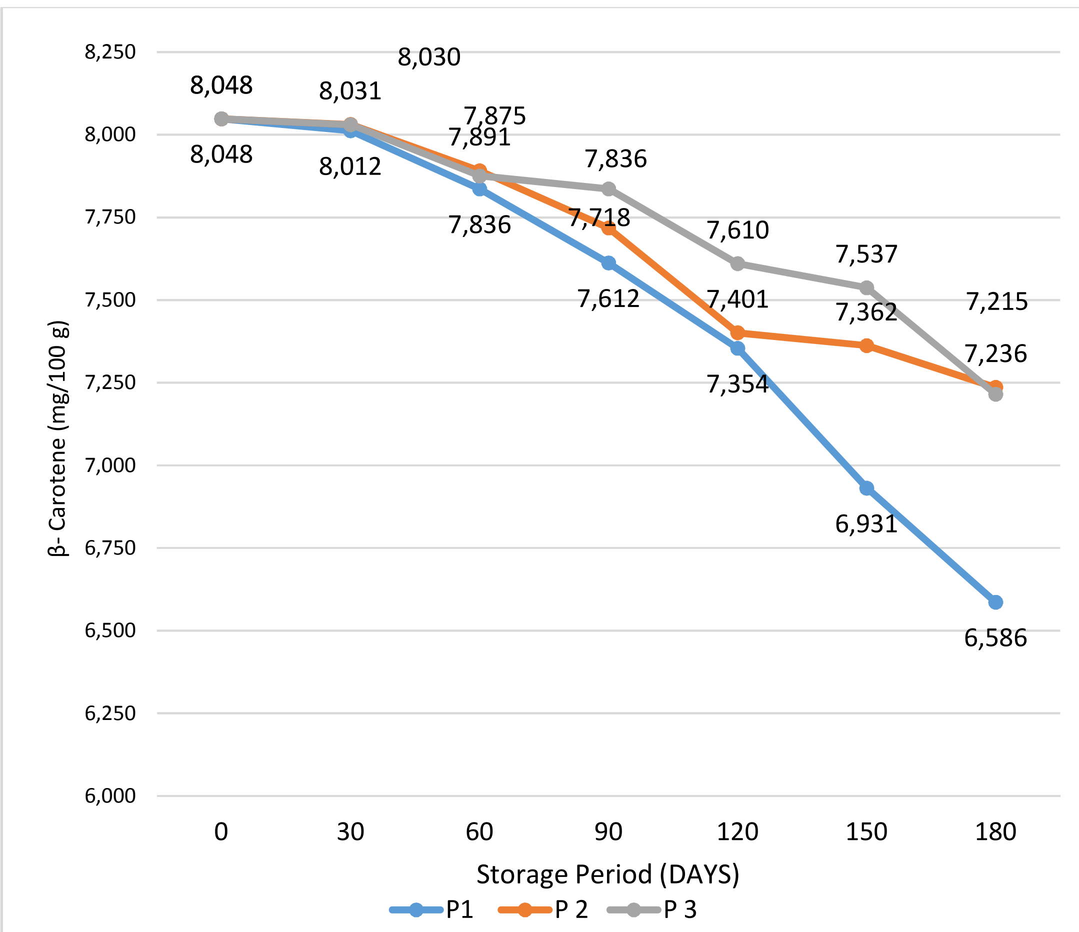

Fig. 4. Changes in β- carotene (mg/100 g) during storage
P_1- Polyethylene bags, P_2- Metallized polyethylene pouches and P_3- PET jars

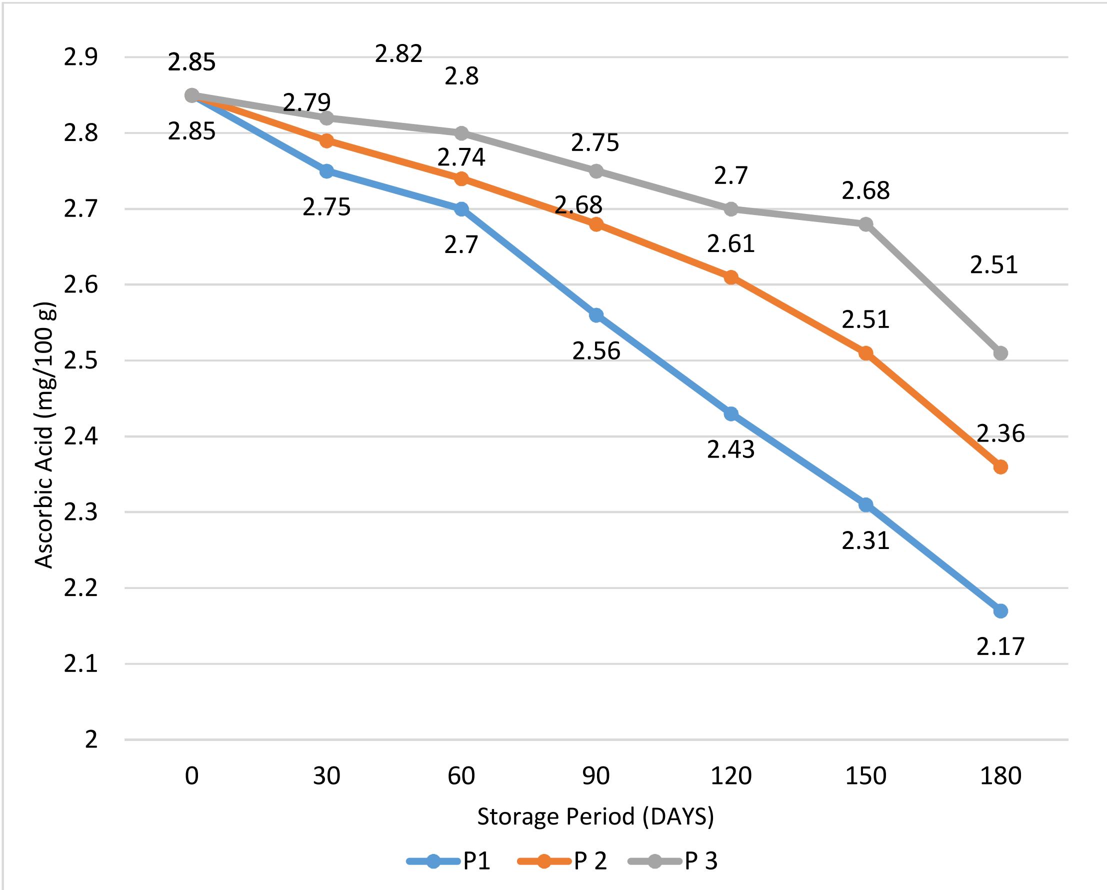

Fig. 5. Changes in ascorbic acid (mg/100 g) during storage

P_1- Polyethylene bags, P_2- Metallized polyethylene pouches and P_3- PET jars

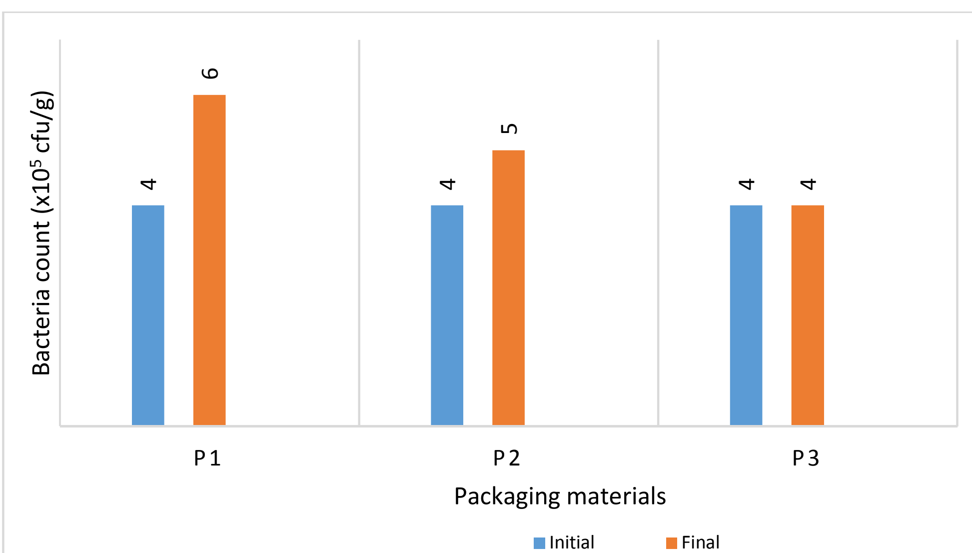

Fig. 6. Changes in bacteria population ($X10^5$ CFU/g) during storage

P_1 – Polyethylene bags, P_2 – Metallized Polyethylene Pouches and P_3 – PET jars

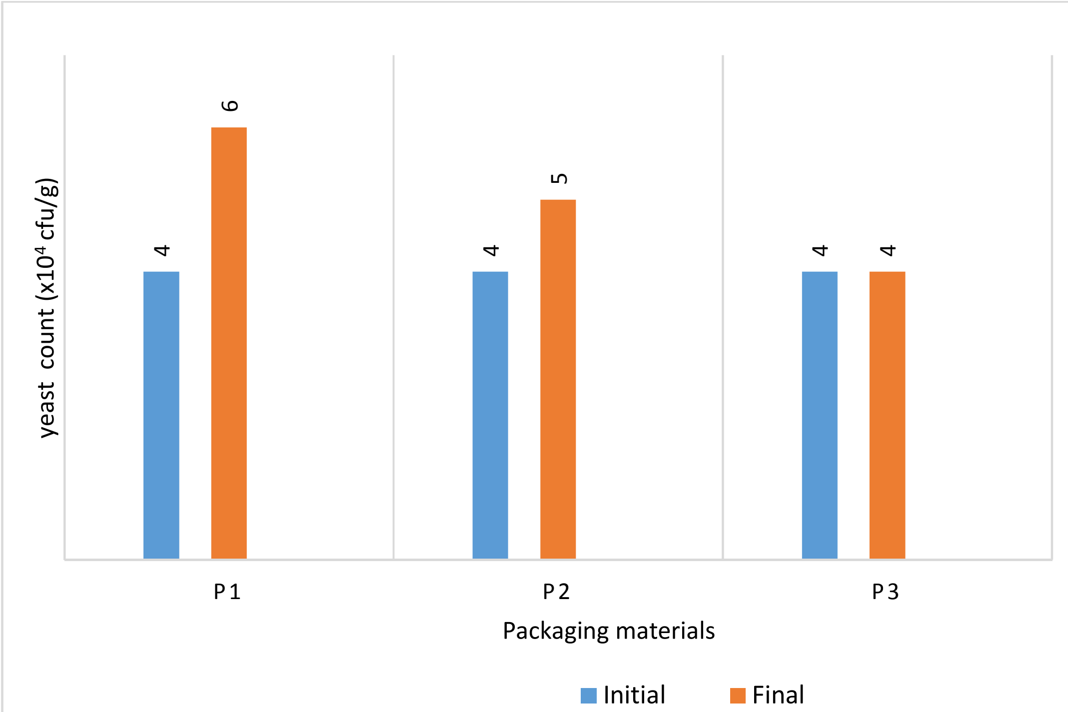

Fig. 7. Changes in yeast population ($X10^4$ CFU/g) during storage
P_1 – Polyethylene bags, P_2 – Metallized Polyethylene Pouches and P_3 – PET jars

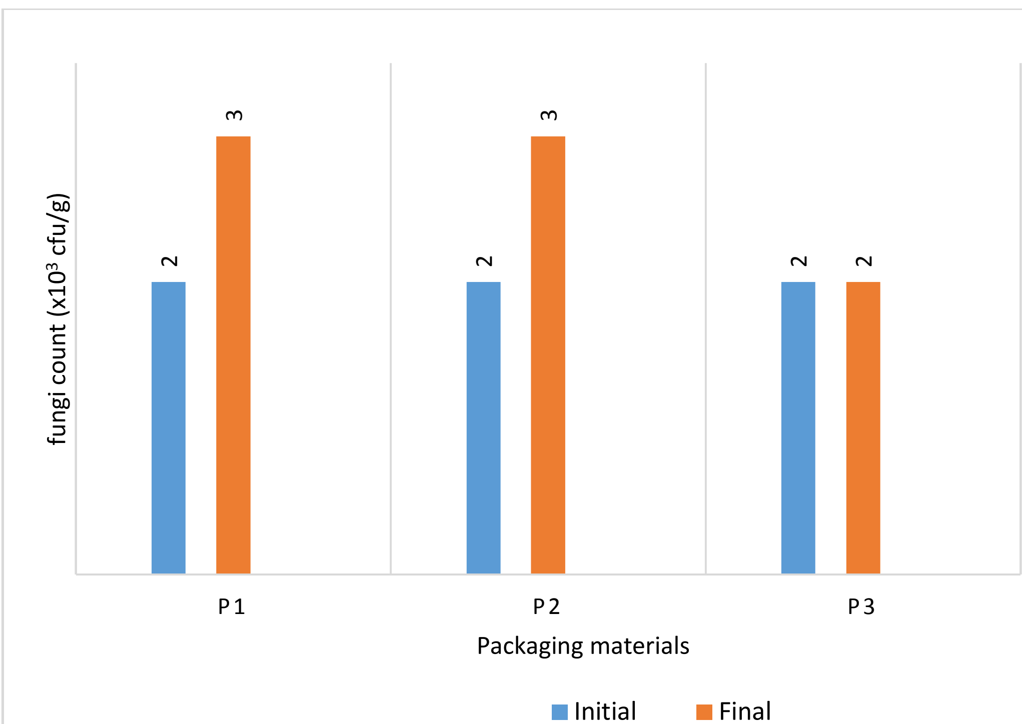

Fig. 8. Changes in fungi population ($X10^3$ CFU/g) during storage
P_1 – Polyethylene bags, P_2 – Metallized Polyethylene Pouches and P_3- PET jars

Table 2. Changes in organoleptic characteristics of supplementary food mix during storage

Storage period (days)	Packaging materials		
	P_1	P_2	P_3
0	9.0	9.0	9.0
30	9.0	9.0	9.0
60	8.8	8.8	9.0
90	8.5	8.8	9.0
120	8.1	8.7	8.9
150	7.8	8.3	8.7
180	7.5	8.1	8.5

P_1 –Polyethylene bags, P_2 – Metallized Polyethylene Pouches and P_3 – PET jars, CD ($P \leq 0.05$) between Packaging materials (P) = 0.087, Storage period (S) = 0.132, (P X S) = 0.229

4. CONCLUSION

The pearl millet based supplementary food mix which packed in Polyethylene terephthalate (PET) jars and metallized polyethylene pouches shows minimum changes in physico-chemical characteristics and organoleptic scores than the samples stored in the Polyethylene bags. The rate of increase in the free fatty acid content and peroxide value of the product is reduced when it is stored in PET jar. The losses in β-carotene and ascorbic acid content during storage also minimized when stored in PET jars. The samples stored in PET jars also shows minimum changes in the organoleptic characteristics of the products when compared to the metallized polyethylene pouches and Polyethylene bags. The bacteria, yeast and fungi population also lower in the samples stored in PET jars when compared to the other packaging materials used in this study. So it can be concluded that the PET jar is more suitable for the storage of pearl millet based supplementary food mix when compared to the metallized polyethylene pouches and Polyethylene bags.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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