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***Research Paper*** ***Open Access***

# THE EFFECT OF EDIBLE COATINGS ON THE STORAGE LIFE OF FOXTAIL MILLET

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The shelf life of foxtail millet coated with gum acacia, fenugreek seed, curry leaf and aloe vera was studied. Samples were packed in High density polyethylene (HDPE) pouches and stored in ambient conditions at room temperature (25-30 ºC) and relative humidity (40-60%) for 3 months. Samples were drawn in triplicates for evaluation of moisture content, total antioxidant activity, peroxide value, TBARS assay and colour when fresh and after 30, 60 and 90 days of storage. Moisture content gradually increased in all the samples during the storage period. On storage the coated samples had lower increase in peroxide and TBARS values and a lower reduction in the antioxidant activity when compared to the uncoated millet. The highest antioxidant activity was found in curry leaf coated sample (71.10 mM vitamin C/g) followed by fenugreek seed coated sample (60.02 mM vitamin C/g). Gum acacia coated sample and aloe vera coated sample had similar antioxidant activity of 36.44 and 34.64 mM vitamin C/g. The uncoated sample had the lowest activity of 17.75 mM vitamin C/g. Change in colour was observed only in the curry leaf coated sample after the 60th day of storage.

***Keywords:*** Edible coatings, Foxtail millet, Storage life, Antioxidant activity

## INTRODUCTION

The polyunsaturated fatty acids content of the unpolished millet is high. Therefore after dehusking due to the exposure to ambient conditions, rancidity sets in rapidly reducing the shelf life drastically. Dehusking of foxtail millet is important to improve the sensory and edible quality of the grain (Liu *et al.*, 2012). This however leads to losses in its natural antioxidants because these are mostly present in the outer husk (Dykes and Rooney, 2006; Asharani *et al.*, 2010; Sridevi *et al.*, 2011; Chandrasekara *et al.*, 2012; and Suma and Urooj, 2012). A cheaper alternative is required for extending both postharvest life and keeping production costs low, hence the possibility of using edible coatings. The additional benefit conferred by natural edible coatings is that these are natural products and are not chemically synthesized (Ali *et al.*, 2010). Natural antioxidants are preferred to synthetic ones because they are safer and cause lesser adverse reactions but their antioxidant activities are lower than the synthetic antioxidants such as butylated hydroxyanisol (BHA) and butylated hydroxytoluene (BHT). Thus there is a need to find new and safe antioxidants from natural sources to replace these synthetic antioxidants (Miladi and Damak, 2008; and Sowndhararajan *et al.*, 2013).

Edible coatings create a passive modified atmosphere which can influence various changes in fresh and minimally processed foodstuff in some areas such as: antioxidant properties, colour, firmness, sensory quality, microbial growth inhibition, ethylene production and volatile compounds as a result of anaerobic processes (Del-Valle

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*et al.*, 2005; and Falguera *et al.*, 2011). Edible coatings can be used as a method of preservation of food products and improve the stability of lipids and lipid containing foods, thus preventing the loss of sensory and nutritional quality (Haq *et al.*, 2013).

Gum acacia, fenugreek (*Trigonella foenum-graecum* L) seeds, curry leaf (*Murraya koenigii*) and aloe vera gel are natural and antioxidant rich ingredients (Bamji *et al.*, 2003; Singh and Singh, 2009; Tembhurne and Sakarkar, 2010; Gopalpura *et al.*, 2010; Priya *et al.*, 2011; Devatkal *et al.*, 2012; and Montenegro *et al.*, 2012). Thus application of these ingredients as edible coatings to foxtail millet can make up the loss due to dehusking. These edible coatings will not only impart their innate nutritional and health promoting qualities but also result in increasing the storability of the dehusked grain. Shelf life is an important criterion in determination of consumer acceptability and utilization in day to day life. The storage period, form of storage, packaging materials and ingredients used affect the shelf life of commodity. Thus, it is important to study the shelf life of a product for enhanced consumer acceptance.

## MATERIALS AND METHODS

The foxtail millet used for the study was Prasad variety (SiA 326) which was procured from the All India Coordinate Research Project on millets, UAS, GKVK, Bangalore.

### Edible Coatings

The edible coatings used in the study were gum acacia, fenugreek seed, curry leaf and aloe vera. Curry leaves and aloe vera were procured from the Dept. of Horticulture, UAS, Bangalore. Gum acacia was obtained from Qualigens, Division of GlaxoSmithKline pharmaceuticals Ltd., Mumbai, 400030. Fenugreek seeds were purchased from the local market in Bangalore. For 100 g of foxtail millet, 2.5 g gum acacia dissolved in 25 ml water was coated. 10 g of aloe vera gel was coated onto 100 g of the millet. Fenugreek seed was used in the form of paste (5 g seed powder dissolved in 20 ml water) and coated onto 100 g of millet. Curry leaf paste (5 g of powder, dehydrated by microwave oven, dissolved in 20 ml water) was coated on 100 g of millet. The coatings were thoroughly and evenly mixed with the grain making sure that no lumps were formed.

### Storage Condition

Five hundred gram of samples were packed in individual HDPE pouches and stored in ambient conditions at room temperature (25-30 ºC) and relative humidity (40-60%) for 3 months. Samples were drawn in triplicates for evaluation when fresh and after 30, 60 and 90 days of storage. Shelf life of coated foxtail millet was assessed through estimation of moisture content, total antioxidant activity, peroxide value, TBARS assay and colour by standard procedures.

### Moisture

Moisture was Determined by AOAC Procedure (AOAC, 1980).

### Total Antioxidant Activity

The total antioxidant activities of samples were quantified using the phosphomolybdenum reagent. Results were calculated and expressed as vitamin C equivalents per gram as per the method followed by Asharani *et al.* (2010).

### Peroxide Value and TBARS Assay

Peroxide value and TBARS were determined according to procedure by Raghuramulu *et al.* (2003). TBARS value was determined by estimating malondialdehyde concentration of the sample.

### Colour

Colour changes were recorded after matching with the Munsell colour chart (Anonymous, 1952) where the symbol for hue is written first and is followed by a symbol written in fraction form, the numerator indicating the value and the denominator indicating the chroma (H V/C). Hue indicates the name of the colour, value the lightness of the colour and chroma the purity of the colour. For example, a sample which is 5.0 Yellow in hue, 7 in value and 6 in chroma is written 5.0Y 7/6.

### Statistical Analysis

Data was subjected to two way analysis of variance. The data was analyzed using the SPSS version 13.0. Significant difference was defined as $p \leq 0.05$.

## RESULTS AND DISCUSSION

### Moisture

Moisture is an important factor responsible for the deterioration of quality of the product during storage. During the storage period significant differences were observed in the moisture content between the treatments (Table 1). In the present study it was observed that there was an increase in the moisture content of coated as well as uncoated foxtail millet throughout the storage period. Moisture content

**Table 1: Moisture Content (%) of Stored Foxtail Millet with Different Coatings**

| Treatments | Duration (Days) | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| Uncoated | 10.7 | 11.2 | 11.7 | 12.2 | 11.45 |
| Gum acacia coated | 11.1 | 11.9 | 12.5 | 13.1 | 12.15 |
| Fenugreek seed coated | 11.4 | 12.1 | 12.9 | 13.8 | 12.55 |
| Curry leaf coated | 11.5 | 12.1 | 12.7 | 13.3 | 12.4 |
| Aloe vera coated | 11 | 11.6 | 12.3 | 13.3 | 12.05 |
| Mean | 11.14 | 11.78 | 12.42 | 13.14 | |
| | F value | | SEm± | | CD |
| Treatments (T) | * | | 0.05 | | 0.14 |
| Duration (D) | * | | 0.05 | | 0.13 |
| Interaction (T×D) | * | | 0.1 | | 0.29 |

**Note:** * Significant ($p<0.05$).

gradually increased in all the samples during the storage period. Increase in moisture percentage of fenugreek coated was 11.40, 12.10, 12.90 and 13.80 per cent during the storage. However, the increase was lower in case of uncoated foxtail millet during the storage which was 10.70, 11.20, 11.70 and 12.20 per cent. Even though there was an increase in the moisture content of the millet during storage but it was within the Codex standards for maximum moisture content for millets (McKevith, 2004). The order of increments was fenugreek seed>curry leaf>gum acacia>aloe vera>uncoated. The reason for the increase in the moisture content in the coated samples throughout the storage study could be due to the hygroscopic nature of the coated materials.

Ranjitha (2013) who also worked on edible coated foxtail millet reported similar results during storage period where an increase was seen in the moisture content of all the millet samples with higher percentages in the coated millets. An increase in moisture level of pearl millet meal was also observed by Lai and Varriano-Marston (1980) when stored at 19 °C for seven months. The increase in the moisture content was from 11.35 to 12.8%. Pushpamma and Vimala (1985) reported that the moisture content of sorghum and millets increased on storage. Therefore it can be inferred that ingredient used as edible coating influences the moisture increase.

## Colour

Changes in colour of the uncoated and coated foxtail millet are depicted in Table 2. There were no colour changes observed during the three months storage period in the uncoated, gum acacia coated, fenugreek seed coated and aloe vera coated foxtail millet samples. In the curry leaf coated samples, however, colour change was found after the 60$^{th}$ day of storage indicating that the lightness and the purity of the colour was affected during the storage period while the hue remained the same. Change in colour was observed only in the curry leaf coated sample due to change in the chlorophyll content of the leaves due to conversion of chlorophyll to pheophytin by chlorophyllase activity during storage (Singh and Sagar, 2010).

## Antioxidant Activity

During the storage period significant differences were observed in the antioxidant activity between the uncoated and the coated millet (Table 3). Storage brought about a reduction in the antioxidant activity. However, the reduction was lower in case of foxtail millet treated with the

**Table 2: Colour Change of Stored Foxtail Millet with Different Coatings**

| Treatments | | Fresh | 30 days | 60 days | 90 days |
|---|---|---|---|---|---|
| Uncoated | Hue | 5.0 Y | 5.0 Y | 5.0 Y | 5.0 Y |
| | V/C | 8/6 | 8/6 | 8/6 | 8/6 |
| Gum acacia coated | Hue | 5.0 Y | 5.0 Y | 5.0 Y | 5.0 Y |
| | V/C | 8/6 | 8/6 | 8/6 | 8/6 |
| Fenugreek coated | Hue | 5.0 Y | 5.0 Y | 5.0 Y | 5.0 Y |
| | V/C | 7/6 | 7/6 | 7/6 | 7/6 |
| Curry leaf coated | Hue | 5.0 Y | 5.0 Y | 5.0 Y | 5.0 Y |
| | V/C | 7/6 | 7/6 | 6/6 | 6/8 |
| Aloe vera coated | Hue | 5.0 Y | 5.0 Y | 5.0 Y | 5.0 Y |
| | V/C | 8/6 | 8/6 | 8/6 | 8/6 |

**Note:** Y-Yellow, H V/C-Hue Value/Chroma.

**Table 3: Total Antioxidant Activity (mM Vitamin C Equivalent/g) of Stored Foxtail Millet with Different Coatings**

| Treatments | Duration (Days) | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| Uncoated | 17.75 | 15.66 | 11.17 | 6.67 | 12.81 |
| Gum acacia coated | 36.44 | 32.5 | 26.7 | 23.54 | 29.79 |
| Fenugreek seed coated | 60.02 | 54.75 | 49.96 | 47.29 | 53 |
| Curry leaf coated | 71.1 | 65.97 | 61.63 | 58.35 | 64.26 |
| Aloe vera coated | 34.64 | 31.8 | 27.82 | 18.92 | 28.29 |
| Mean | 43.99 | 40.13 | 35.45 | 30.95 | |
| | F value | | SEm± | | CD |
| Treatments (T) | * | | 0.79 | | 2.25 |
| Duration (D) | * | | 0.70 | | 2.01 |
| Interaction (T×D) | * | | 1.57 | | - |

**Note:** * Significant ($p<0.05$), NS: Non significant.

curry leaf during the storage compared to other treatments. The least antioxidant capacity at the end of 90 days of storage was for the uncoated millet. The coated millet samples had higher antioxidant activity compared to the uncoated one because of the presence of certain compounds in all the coated ingredients contributing to their antioxidant activity. The reason for the higher antioxidant activity in the curry leaf coated millet could be due to the synergistic action of mahanimbine, murrayanoland and mahanine (which are carbazole alkaloids) present in the leaf. The antioxidant activity of these compounds is due to their reducing capacity whereby they act as electron donors and react with free radicals converting them into more stable products and terminating chain reactions (Devatkal *et al.,* 2012). Fenugreek seed antioxidant activity may be due to the presence of flavonoids and phenolic compounds which have free radical scavenging activity (Priya *et al.,* 2011; and Devatkal *et al.,* 2012). The antioxidant action of gum acacia has been associated with its protein fraction, mainly by amino acid residues such as histidine, tyrosine and lysine (Montenegro *et al.,* 2012). The antioxidant activity of aloe vera is attributed to phenolic compounds, 1, 8-dihydroxyanthraquinone derivatives (aloe emodin) and their glycosides (Miladi and Damak, 2008).

The highest antioxidant activity was found in curry leaf coated sample (71.10 mM vitamin C/g) followed by fenugreek seed coated sample (60.02 mM vitamin C/g). Gum acacia coated sample and aloe vera coated sample had similar antioxidant activity of 36.44 and 34.64 mM vitamin C/g. The uncoated sample had the lowest activity of 17.75 mM vitamin C/g. Fresh milled rice extracts possess greater antioxidative activity compared to stored samples (Thanajiruschaya *et al.,* 2010) due to the impact of storage on the phenolics and flavonoid content. Asghari *et al.* (2013) studied the effect of salicylic acid and aloe vera gel based edible coating treatment on storage life of grape and found out that the retention of antioxidant activity was higher during storage due to the edible coating. In another study, Ali *et al.* (2013) reported that coating of tomato fruit with gum arabic has been reported to delay the ripening process and maintain the antioxidant capacity. This happened due to the preservative effect of gum which delayed the ripening process by inhibiting the respiration rate and ethylene production in tomato fruit. The reduced rate of respiration and ethylene production in tomato fruit might be correlated with delayed senescence and a reduced susceptibility to decay. The better retention of antioxidant activity in the foxtail millet samples coated with different materials especially curry leaf and fenugreek seed could be due to the protective and add on effect of these materials on the antioxidant content of the millet.

## Peroxide Value and TBARS Assay

Hydroperoxides are the primary products of lipid peroxidation; therefore determination of peroxides can be used as oxidation index for the early stages of lipid oxidation. The hydroperoxide content is expressed as peroxide value in milliequivalent of hydroperoxides per kg of oil. This is based on the reduction of the hydroperoxide group (ROOH) by the iodide ion (I–). Peroxide value measures only hydroperoxide, which is a transient product of oxidation (Shahidi and Wanasundara, 2002). The TBARS assay has been widely used as an objective measure of secondary oxidation products of oils. It relates to the level of malondialdehyde formed during oxidation of lipids. It is assumed that accumulation of these products is responsible for the development of rancid odours and off-flavour of the oil (Gutierrez, 1998).

The peroxide values of the different treatments are shown in Table 4. In the present study there was an increase in the peroxide value of the millet samples throughout the storage period. The order of increments in the peroxide value of the coated sample is aloe vera>gum acacia>fenugreek seed>curry leaf. Statistically there was a significant difference for the peroxide value of stored foxtail millet with edible coatings throughout the storage period ($p \leq 0.05$), values being lower for coated grains. Table 5 depicts the TBARS values of the millet samples during the storage period. TBARS values of the coated millet were lower than the uncoated one during the storage period suggesting the protective role of the edible coatings against oxidation. Results in the present study indicated that TBARS values of all the treatments increased significantly throughout the storage period. The effectiveness of the ingredients used as coatings in retarding oxidation is fenugreek seed>curry leaf>gum acacia>aloe vera>uncoated. Therefore the present study indicates that coating of foxtail millet can improve its oxidative stability.

**Table 4: Peroxide Value (meq/kg) of Stored Foxtail Millet with Different Coatings**

| Treatments | Duration (Days) | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| Uncoated | 2.2 | 3.03 | 4.31 | 6.33 | 3.97 |
| Gum acacia coated | 1.54 | 2 | 2.75 | 3.39 | 2.42 |
| Fenugreek seed coated | 0.62 | 0.82 | 1.15 | 1.67 | 1.07 |
| Curry leaf coated | 0.6 | 0.72 | 0.99 | 1.43 | 0.94 |
| Aloe vera coated | 1.82 | 2.32 | 2.97 | 3.41 | 2.63 |
| Mean | 1.35 | 1.77 | 2.43 | 2.64 | |
| | F value | | SEm± | | CD |
| Treatments (T) | * | | 0.01 | | 0.04 |
| Duration (D) | * | | 0.01 | | 0.04 |
| Interaction (T×D) | * | | 0.03 | | 0.08 |

**Note:** * Significant ($p<0.05$).

**Table 5: TBARS Assay (µ Moles Malondialdehyde/kg) of Stored Foxtail Millet with Different Coatings**

| Treatments | Duration (Days) | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| Uncoated | 0.026 | 0.03 | 0.039 | 0.057 | 0.038 |
| Gum acacia coated | 0.021 | 0.024 | 0.028 | 0.032 | 0.026 |
| Fenugreek seed coated | 0.013 | 0.015 | 0.019 | 0.024 | 0.017 |
| Curry leaf coated | 0.018 | 0.02 | 0.025 | 0.03 | 0.023 |
| Aloe vera coated | 0.024 | 0.027 | 0.032 | 0.035 | 0.029 |
| Mean | 0.02 | 0.023 | 0.028 | 0.035 | |
| | F value | | SEm± | | CD |
| Treatments (T) | * | | 0.0005 | | 0.001 |
| Duration (D) | * | | 0.0004 | | 0.001 |
| Interaction (T×D) | * | | 0.0009 | | 0.003 |

**Note:** * Significant ($p<0.05$).

A peroxide value below10 meq/kg is considered safe in fresh oils. Between 20 and 40 meq/kg peroxide value, a rancid taste begins to occur in oils (Akubugwo and Ugbogu, 2007; and Enujiugha and Akanbi, 2008). In the present study the values are between 0.60 and 6.33 meq/kg which are within the safe levels. So it may be concluded that the samples can be stored for 90 days. From this it may be inferred that coatings will increase shelf stability.

A similar trend was found out by Ranjitha (2013) who reported that throughout the storage period, edible coatings brought about a reduction in the peroxide and TBARS values when compared to the uncoated ones in foxtail millet. Devatkal *et al.* (2011) also reported a difference in TBARS values of fresh samples of untreated chicken patties which had higher values than those treated with curry leaves (CLE) and fenugreek leaves (FLE) extracts and BHT. Pino *et al.* (2013) determined the effect of different natural antioxidants such as dry sage and dry oregano on pre-cooked chicken balls. In fresh samples the addition of natural antioxidants resulted in marked reduction in most of the oxidatively derived aldehydes. Haq *et al.* (2013) investigated the

efficacy of gum *Cordia* in comparison with Carboxy Methyl Cellulose (CMC) as edible coating to retard oxidation in Chilgoza (*Pinus gerardiana*). Results showed that the peroxide value increased significantly during storage in all the samples but the increase was low in coated samples. Thus the use of different natural ingredients as edible coatings on foxtail millet has led to a reduction in the formation of products of lipid oxidation.

## CONCLUSION

Thus due to the use of edible coatings, on storage the coated samples had lower increase in peroxide and TBARS values and a lower reduction in the antioxidant activity when compared to the uncoated millet inferring that these natural coatings improve the storage life of millet after dehusking.

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