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Effects of packaging and storage conditions on stability of Indian horse chestnut flour

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Abstract
Indian horse chestnut is a wild nut that is high in starch and has numerous medicinal properties. It contains toxic compounds known as saponins, which make it bitter and unfit for human consumption. Pre-treatments removed the saponin content of Indian horse chestnut mass. The edible mass of Indian horse chestnut was dried and milled into flour before being packed in various packaging materials and stored for six months under refrigerated (4-7 °C) and ambient (18-25 °C) storage conditions. The flour was packaged in aluminum laminated pouches with moisture and oxygen absorber. Aluminium laminated pouches with moisture and oxygen absorber in refrigerated condition showed minimum changes in physico-chemical, rheological and sensory characteristics.

Keywords: Indian horse chestnut, saponins, ALP, storage, sensory characteristics

Introduction

Indian horse chestnut (*Aesculus indica* C.) is a fast growing tree mainly found in temperate regions of Asia particularly in India, Nepal, Pakistan and Afghanistan. In India, the tree occupies moist and shady ravines of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh (Syed *et al*., 2016) [23]. The tree comes into flowering in the months of May to June depending upon climatic conditions of the locality. The trees at lower altitudes start flowering in late May and at higher altitudes flowering occurs by early June (Majeed *et al*., 2009) [12]. Nuts mature during the month of October-November to the first week of December in Himachal Pradesh (Parmar and Kaushal, 1982) [15]. The fruit is a brown capsule with a very shiny polished skin, showing a dull, rough, pale-brown scar where it has been attached to the inside of seed-vessel. The biochemical composition of the horse chestnut differs widely, and composed of various chemical compounds including polysaccharides (starch), proteins, lipids, minerals, many minor constituents. Due to rising consumer demand, horse chestnut presents a remarkable opportunity for natural foods with excellent therapeutic benefits. Its nutritional significance is also due to unique crude protein composition, oil content, fatty acid composition (oleic acid, arachidonic acid, linoleic acid, linolenic acid, myristic acid, palmitic acid) and mineral elements including nitrogen, phosphorus, potassium, calcium, sulphur, copper, iron, zinc, and manganese (Majeed *et al.*,2010) [11]. Besides its high nutritional composition, anti-nutritional factors called saponins are the major bottle neck in its consumption as food ingredient. These anti-nutritional factors are chemical compounds that are synthesized in natural foods and/or feedstuffs through normal species metabolism and various mechanisms (for example, inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of food/feed) which have an anti-nutritional effect (Soetan and Oyewol, 2009) [20].

The presence of oxygen in a package can trigger or accelerate oxidative reactions that result in food deterioration. Oxygen facilitates the growth of aerobic microbes and moulds. Oxidative reactions result in adverse qualities such as off-odours, off-flavours, undesirable colour changes, and reduced nutritional quality. Oxygen scavengers remove oxygen (residual and/or entering), thereby retarding oxidative reactions. Moisture control agents help control water activity, thus reducing microbial growth; remove melting water from frozen products and blood or fluids from meat products; prevent condensation from fresh produce; and keep the rate of lipid oxidation in check. Desiccants such as silica gels, natural clays and calcium oxide are used with dry foods while internal humidity controllers are used for high moisture foods (for example, meat, poultry, fruits, and vegetables).

Desiccants usually take the form of internal porous sachets or perforated water-vapour barrier plastic cartridges containing desiccants. They can also be incorporated in packaging materials. Therefore, the present investigations were aimed to study the physico-chemical characteristics changes in the pretreated horse chestnut flour during storage.

Materials and Methods

Indian horse chestnuts harvested at optimum maturity were procuredfrom Kasauli area of district Solan (HP) and brought to the Department of Food Science and Technology, UHF, Nauni, Solan (HP) for conducting the studies and then nuts were dehulled manually and grated with the help of mechanical grater and the grated mass was treated by the treatments and further drying of pre-treated mass was done as suggested earlier. The best dried mass was ground into flour in a grinding mill. Fig. 1 shows the steps used in preparation of Indian horse chestnut flour. A sample of 100 g lot each was packed in four different packaging material *viz*. aluminium laminated pouch T_1, ALP with moisture absorber T_2, ALP with oxygen absorber T_3, ALP with moisture and oxygen absorber T_4. The packed flour was stored in ambient temperature (25-28 °C) and refrigerated temperature (4 °C-7 °C) upto a period of six months for storage studies. The observations for different quality parameters were recorded at 0, 3 and 6 months interval of storage.

Nuts
↓
Dehulling
↓
Grating
↓
Treatment of grated mass
↓
Grated mass blanched for 4 min for followed by soaking in water for 6 hours at 60 °C
↓
Replacing water in three cycles of every 2 hours
↓
Pre-treated mass further soaked in ethanol: water solvent (30:70) for 6 h at 60 °C
↓
Replacing solvent every 2 h
↓
Ultrasound assisted extraction (15 minutes at 50±1 °C) 30% ethanol concentration
↓
Replacing solvent every 2 hours
↓
Mechanical cabinet drying (60±2 °C)
↓
Milling of dried mass
↓
Sieving (325,225,125 µm)
↓
Flour, Packaging

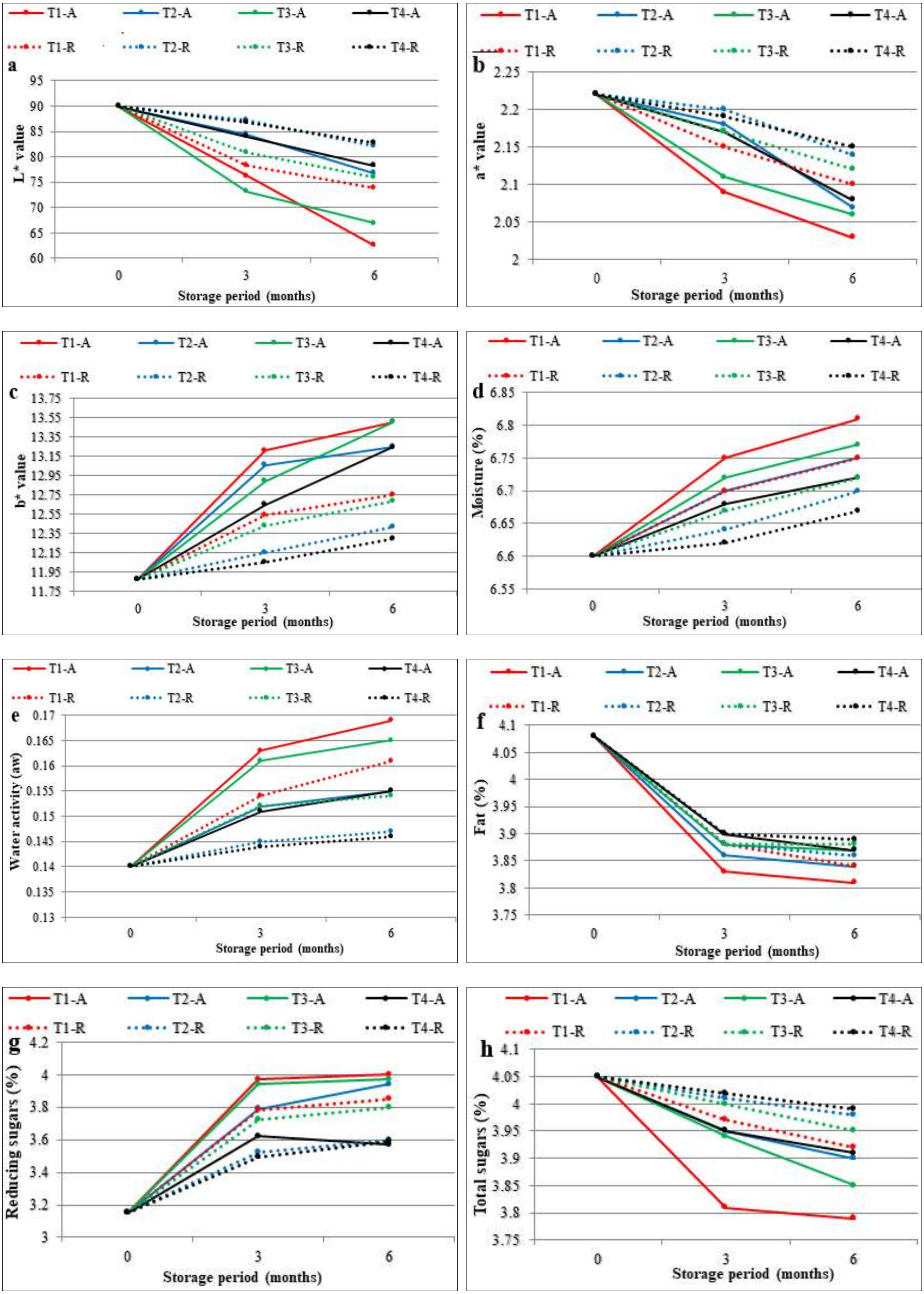
Fig 1: Unit operations of the preparation of edible Indian horse chestnut flour

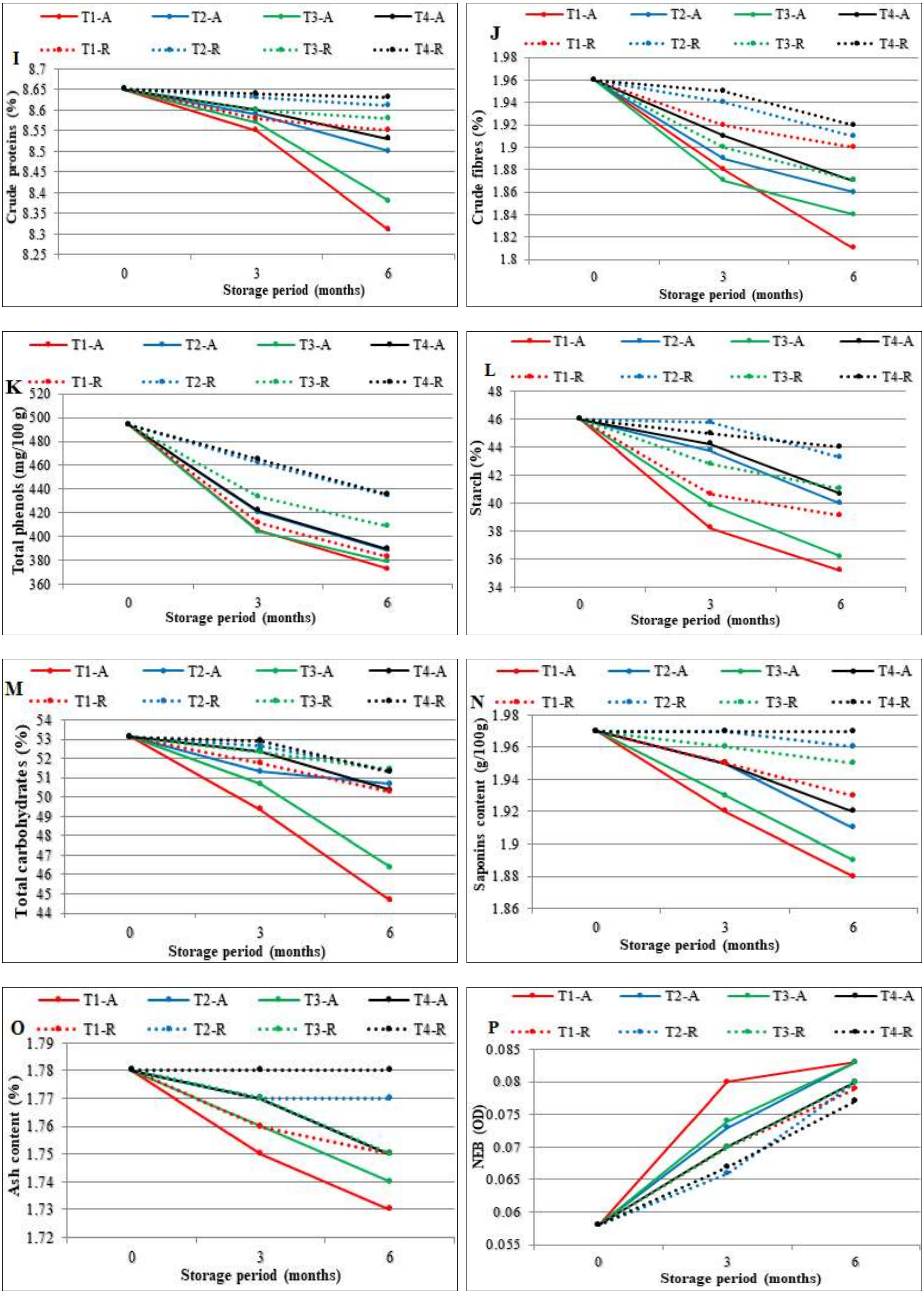
1. Physico-chemical, sensory analysis

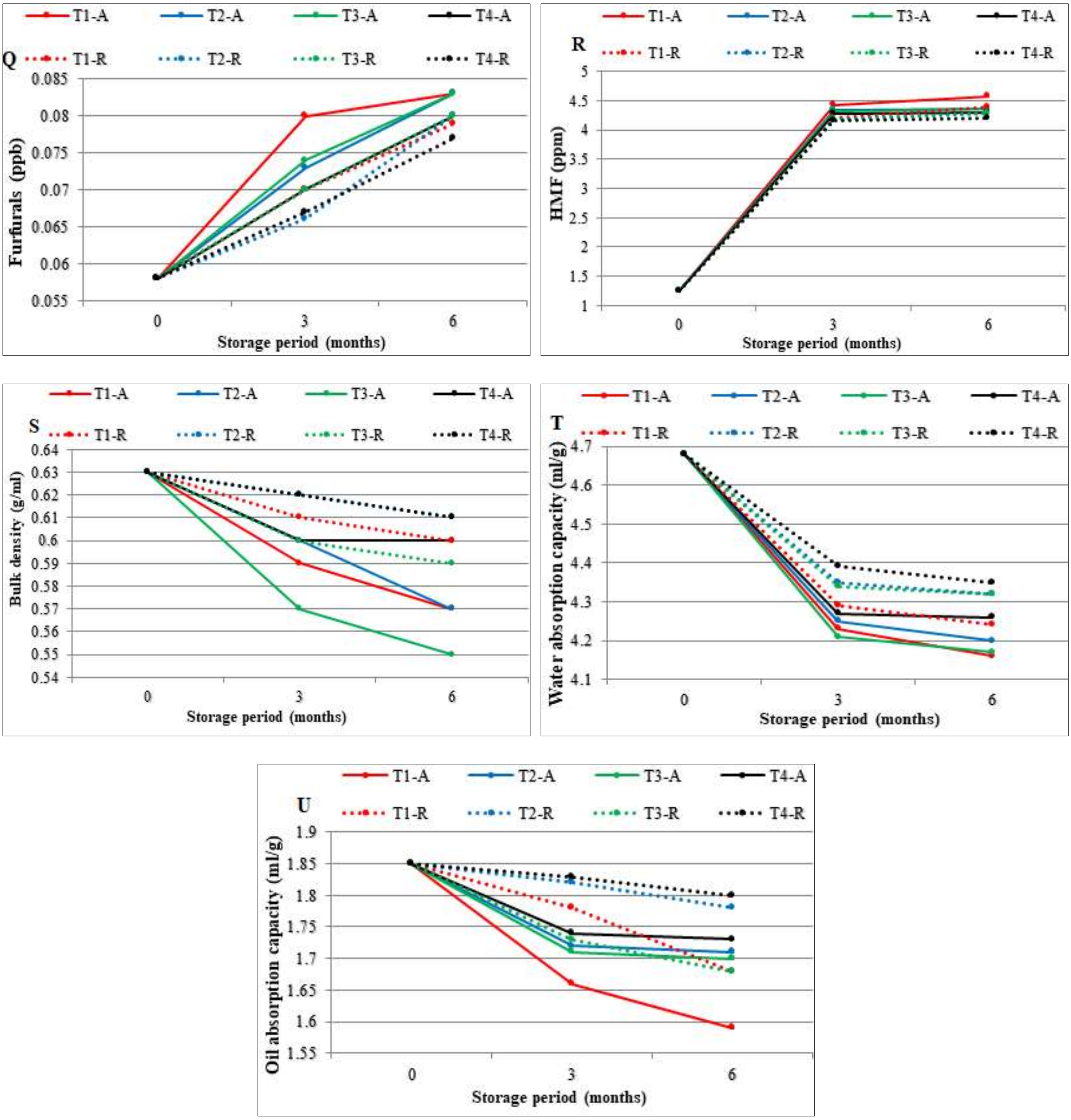
Lovinbond Colour Tintometer Model PFZ-i series spectrocolourimeter was used to observe the colour of the powder in which RYBN colour units were obtained along with CIE readings that involves L*, a*and b* values. Moisture content, crude protein, fiber, fat, total carbohydrate and ash content of nut were determined according to the method of AOAC (2010) [10]. Total phenols content was determined by Folin-Ciocalteu procedure given by Singleton and Rossi (1965) [19] in which absorbance was measured at 765 nm in a spectrophotometer (Model UV-1650 PC Shimadzu, Japan) against water blank.Starch content of the flour was determined by the method given by Ranganna (2009) [16].The total carbohydrate content was determined by the procedure given by Ranganna (2009[16]). Saponins content was determined by Vanillin-Sulphuric Acid method given by Hiai *et al.* (1976) [7] Ash content was determined by using muffle furnace at temperature of 550 °C as given by Ranganna (2009) [16]. The Non-enzymatic browning was determined by using the method mentioned by Ranganna (2009) [16].The bulk density was determined according to the method described by Oladele and Aina (2007) [14].The water holding capacity and oil absorption of flour was determined by a method suggested by Sosulski *et al*. (1976) [22].

2. Statistical analysis

Completely Randomized Design was used to analyze the statistical data on physicochemical characteristics before and during storage (Cochran and Cox, 1957)[5]. OPSTAT was used to analyze the data pertaining to the sensory evaluation of the samples using the Randomized Block Design (RBD) as using one factor, two factor, and three factor analysis of variance (ANOVA).


T1-A
T2-A
T3-A
T4-A
T1-R
T2-R
T3-R
T4-R
a
L* value
b
a* value
c
b* value
d
Moisture (%)
e
Water activity (aw)
f
Fat (%)
g
Reducing sugars (%)
h
Total sugars (%)
Storage period (months)
0
3
6


I
T1-A
T2-A
T3-A
T4-A
T1-R
T2-R
T3-R
T4-R
Crude proteins (%)
Storage period (months)
J
Crude fibres (%)
Storage period (months)
K
Total phenols (mg/100 g)
Storage period (months)
L
Starch (%)
Storage period (months)
M
Total carbohydrates (%)
Storage period (months)
N
Saponins content (g/100g)
Storage period (months)
O
Ash content (%)
Storage period (months)
P
NEB (OD)
Storage period (months)



T_1: Aluminium laminated pouch (ALP),
T_2: ALP with moisture absorber,
T_3: ALP with oxygen absorber,
T_4: ALP with moisture and oxygen absorber A: ambient, R: refrigerated

Fig 2: (A to u): Effect of different packaging material and storage intervals on the physico-chemical characteristics horse chestnut flour

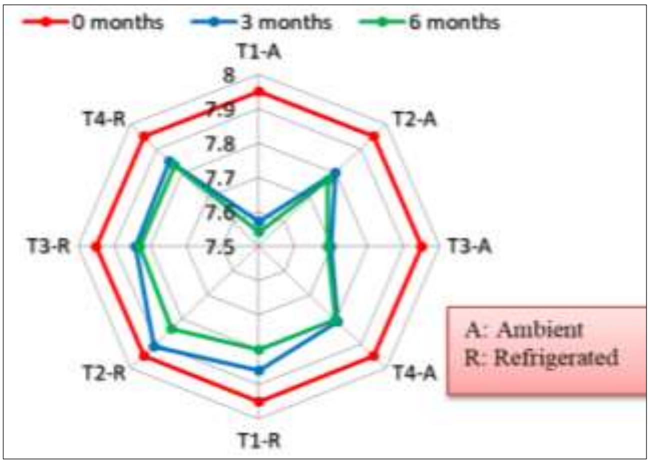


Fig 3: a) Effect of packaging on appearance scores of edible Indian horse chestnut flour

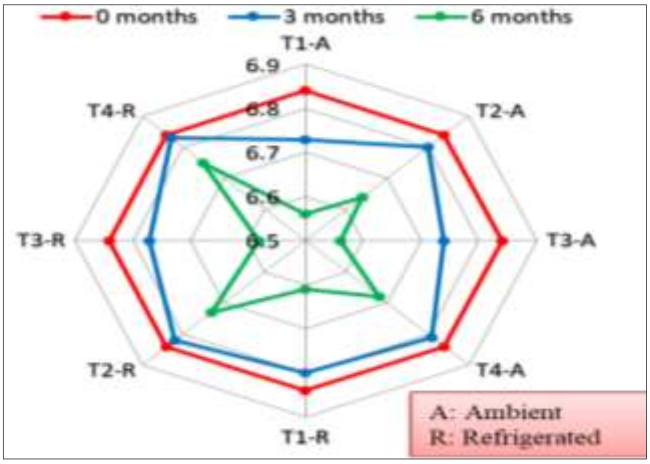


Fig 3: c) Effect of packaging on taste scores of edible Indian horse chestnut flour

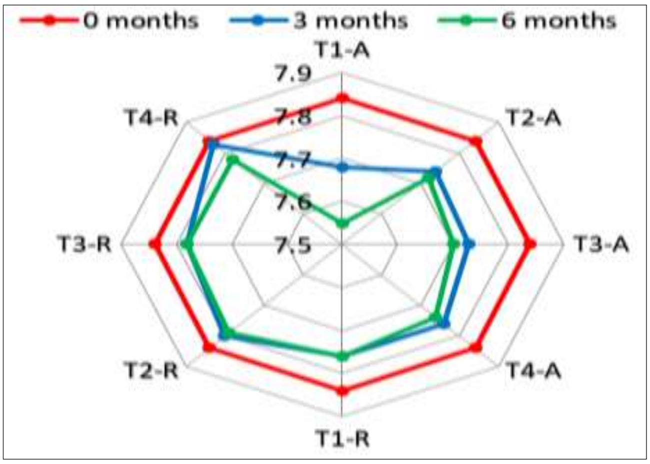


Fig 3: b) Effect of packaging on texture scores of edible Indian horse chestnut flour

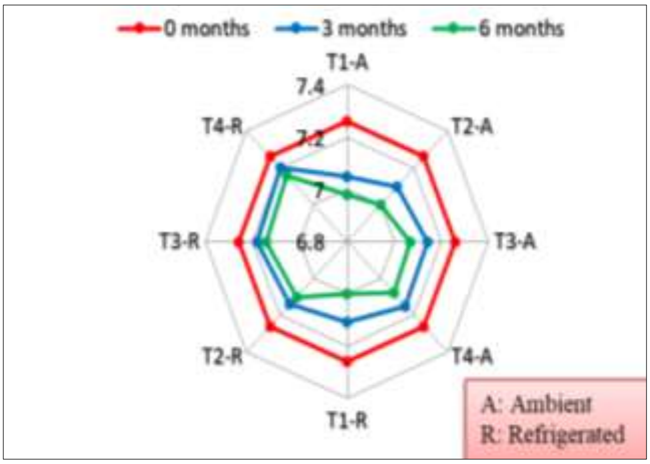


Fig 3: d) Effect of packaging on aroma scores of edible Indian horse chestnut flour

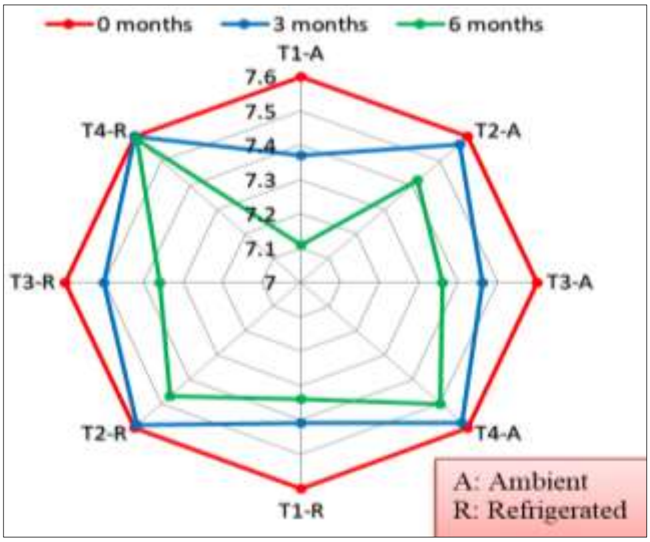


Fig 3: e) Effect of packaging on acceptability scores of edible Indian horse chestnut flour

Results

Results in Fig. 2 (A, b, d, e, g) indicates that there was a general increase in visual colour, moisture, water activity, reducing sugars, furfural, NEB, HMF was recorded during 6 months storage of flour of horse chestnut. Data presented in Fig 1 (h to u) indicates that there was a general decrease in total sugars, crude protein, crude fibre, total phenols, starch, carbohydrate, saponins, ash content, bulk density, water absorption capacity, oil absorption capacity recorded during six months of storage of flour. Results in Fig. 3 (A to E) reveal that there was a general decrease in sensory attributes during the six month storage of flour. Observations at the beginning and end of storage indicated that the flour packed in ALP with moisture and oxygen absorber underwent minimum changes in quality. Also, the flour kept in refrigerated conditions retained maximum quality. The various physico-chemical characteristics such as moisture, reducing sugars, water activity, furfural, NEB, HMF increased whereas, total sugars, starch, carbohydrate, phenol, protein, fibre, bulk density, water absorption capacity, oil absorption capacity and sensory parameter decreased during storage. The L* and a* value of flour decreased significantly from 89.93 to 74.89 and 2.22 to 2.09 during the storage. The moisture content, water activity and reducing sugars of flour increased significantly from 6.60 to 6.73 per cent, 0.140 to 0.156 per cent and 3.15 to 3.71 per cent respectively during storage. All mean scores differ significantly ($p \leq 0.05$). The fat and total sugars of flour decreased significantly from 4.08 to 3.85, 4.05 to 3.91 per cent, respectively during storage. A significant decrease in flour crude fibre, crude protein, total phenols of flour was also recorded as 1.96 to 1.87, 8.65 to 8.52 per cent and 494.00 to 399.08 mg/100g. The starch and total carbohydrates content of flour decreased significantly from 46.02 to 39.94 and 53.11 to 49.55 per cent during storage. Saponins and ash content decreased from 1.97 to 1.92g/100g and 1.78 to 1.75 per cent during the storage. A significant increase in non-enzymatic browning, furfurals and hydroxymethyl furfurals of flour was also observed as 0.058 to 0.081, 0.102 to 0.113 ppb and 1.25 to 4.34 ppm, respectively during storage. The bulk density, water absorption and oil absorption capacity of flour decreased significantly from 0.63 to 0.59 g/ml, 4.68 to 4.25 ml/g and 1.85 to 1.71 ml/g during the storage. The appearance, texture, aroma, taste, and overall acceptability scores of flour decreased during storage of six months. While comparing different packaging material, maximum total sugars, starch, carbohydrate, phenol, protein, fibre were recorded in T_4however, the minimum were recorded in T_1 during storage of 6 months. Among the different packaging material, minimum moisture, reducing sugars, water activity, furfural, NEB, HMF of flour was recorded in T_4 (ALP with moisture and oxygen absorber).Further, when the different packaging treatments were compared, maximum scores for sensory attributes was observed in the flour packed in T_4 (ALP with moisture and oxygen absorber) and minimum in T_1 (ALP) during storage. While comparing the storage condition refrigerated condition retained the highest physico-chemical characteristics compare to ambient condition.

Discussion

The results of above physico-chemical characteristics of horse chestnut flour shows general increase of moisture, reducing sugars, and water activity in the flour observed during storage of six months might be absorption of moisture from its surroundings due to its hygroscopic nature and moisture release during non-enzymatic browning. Furfurals, HMF and NEB of flour increased during the storage might be due to ascorbic acid degradation by reduction and oxidation or intermolecular rearrangement reactions, which leads to the formation of furfural, HMF formation involves a maillard reactions, in which the free amino group of lysine or other amino acids and the carbonyl groups of reducing sugars like maltose or glucose and non-enzymatic browning of Indian horse chestnut flour increased significantly over the course of six months of storage, which might be due to carbonyl-amino reactions like maillard reaction, ascorbic acid oxidative degradation, and the conversion of polyphenols to polycarbonyls through oxidation. Flour packed in ALP with moisture and oxygen absorber (T_4) recorded minimum changes in above physico-chemical characteristics during storage as compared to other packaging material where these were more. However, ALP (T_1) may have a higher increase in these quality characteristics because of their greater exposure to air and moisture. During flour storage, a general decrease in starch, total carbohydrate, total sugars, ash, proteins, oil absorption capacity, water absorption capacity, bulk density, saponins and sensory characteristics was observed. This decrease may be attributed to increased moisture and air uptake, flour exposure to light, use of sugars in non-enzymatic browning reactions, and loss of crude protein due to their denaturation as a result of increased moisture content. The 'L' and 'a' value of flour significantly decreased during storage, whereas 'b' values significantly increased. Change in colour values during storage could be attributed to an increase in water activity, which could have triggered browning reactions and resulted in the formation of brown coloured complexes in the product. Similar trend of reduction in a* value in wild pomegranate powder and Indian horse chestnut flour were recorded by some worker during storage (Sharma, 2019) [17]. Sornsomboonsuk *et al.* (2019) [20] has also reported increasing trend of moisture in Bael fruit powder during 14 weeks of storage period.Nasir *et al.* (2004) [13] have observed decrease in crude fat content in wheat flour during 60 days of storage. Baidoo *et al*. (2014) have found increasing trends of reducing sugars during storage of taro flour. Similar trend of reduction of total sugars content during storage in mango powder has also been recorded by Wilson *et al.* (2014) [24].Abugoch *et al.* (2009) [1] have found a decreasing trend of crude proteins in quinoa powder during storage. Honfo *et al.* (2022) [8] have reported similar decreasing trends of carbohydrates in plantain flour during storage.Similar decrease in saponins content was also recorded by Kumar *et al.* (2009) [12] in Indian horse chestnut flour. Thakur *et al.* (2018) [23] have also recorded increasing trend of NEB in *anardana* powder during storage. An increasing trend of HMF content during storage in wild pomegranate powder has been reported by Sharma (2019) [17].The decrease in sensory characteristics scores of flour during storage could be due to changes in various physico-chemical characteristics during storage, causing the judges to award the flour lower scores for the various sensory attributes. Sharma (2019) [17] has also recorded reduction in of sensory characteristics of wild pomegranate powder during the storage period of six months.It is clear that the decrease in these physicochemical and sensory properties was significantly lower in ALP with oxygen and moisture absorber (T_4) compared to ALP (T_1), ALP with moisture absorber (T_2), and ALP with oxygen absorber (T_3). This could be due to the opaqueness of the aluminum foil in the ALP with moisture and oxygen absorber to light and the packaging material's minute permeability to oxygen and water vapour which prevented photo-oxidation and oxidation reactions. As a result, horse chestnut flour retained higher quality than the other packages.

Conclusion

Among various packaging treatments, aluminum laminated pouch with oxygen and moisture absorbers was found to be the best in terms of better retention of various physico-chemical characteristics such as total proteins, and starch, as well as sensory characteristics such as appearance, texture, aroma, taste, and overall acceptability of flour. According to the findings of the preceding studies, Indian horse chestnut flour packed in an aluminum laminated pouch with moisture and oxygen absorber (99.8gsm) can be successfully stored under refrigerated conditions for 6 months with little change in quality when compared to ambient conditions. As a result, this flour can be used to create a variety of edible products in the future.

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