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RESEARCH ARTICLE

Effect of Packaging Materials on Storage Stability of Protein rich flour from deoiled Sesame cake

[1,*]Angam Raleng, [2]M. R. Manikantan, [3]Atul Anand Mishra

1 Department of Processing & Food Engineering, Punjab Agricultural University, Ludhiana, India, 141004

2 Division of Food Grains & Oil Seeds,Central Institute of Post Harvest Engineering & Technology, Ludhiana, India

3 Department of Food Process Engineering, SHIATS, Allahabad, India

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Corresponding Author

Angam Raleng

Abstract

Flour from de-oiled sesame cake produced from white sesame seed was packed in aluminum (Al) foil and low density polypropylene (LDPE) packaging film, stored in ambient and refrigerated conditions and tested every 15 days for a period of 75 days for changes in moisture, protein, fat, fiber, ash, water solubility index (WSI), water absorbency index (WAI), viscosity, color, pH and oxalic acid. An increase in moisture content, protein, pH and oxalic acid with corresponding decrease in fat and fiber were observed in all stored packs; more pronounced under ambient conditions as compared to refrigerated condition of storage. Among packaging materials Al foil was found to be the best packaging material for storage of flour from de-oiled sesame cake followed by LDPE. Flour from de-oiled sesame cake can be stored safely for 75 days in ambient and in refrigerated conditions.

INTRODUCTION

Sesame is one of the most important oil seed crops cultivated in Asia, Central America and Tropic areas of Africa. Sesame seeds and oil are widely used in food and pharmaceutical industries. Sesame cake is a byproduct obtained after extraction of oil. The growing interest for utilization of the sesame oil is due its high content of antioxidant lignans and unsaturated fatty acids, which have been reported to have hypocholesterolemic effect in humans (Hirata et al., 1996). The cake which is a rich source of protein is indigenously used as a cattle feed or manure. Utilization of sesame meal or defatted meal into food products can serve as an excellent vehicle for enhancing the utilization of sesame protein in the diets of malnourished people in developing countries (El-Awady, 1997). It has a potential to be used as low fat sesame concentrate, composite flour, in bakery products, breakfast cereal flakes, snack foods, multipurpose supplement, infant and weaning foods, extruded foods or fabricated food. Utilization of mild treated defatted sesame meal is becoming increasingly popular in other countries. However, in India because of the unhygienic processing conditions that prevail in many small-scale oilseed processing factories/units, the residual cake/meal is generally not fit for human consumption, but is only suitable for animal feed or as an ingredient of nitrogenous fertilizer. Hence this study was carried out to obtain hygienically extracted defatted sesame cake and to study the effect of different packaging materials on storage stability of protein rich flour from de-oiled sesame cake.

2. Materials and Methods

2.1 Materials

Local variety of sesame (Sesamum Indicum) was procured from the local market of Ludhiana, Punjab. Sesame seeds were cleaned thoroughly using CIAE model screen cleaner cum grader using appropriate sieves to remove all foreign matter such as dust, dirt, stones, chaff as well as immature and broken seeds.

2.2 Methods

2.2.1 Preparation of raw material

Pearling was conducted for 20 minutes using multi crop pearler of 35 kg/h capacity to remove the hull and dust from the seeds. Water soaking was employed for 15 minutes for the removal of hull from the sesame seeds and the water was drained out along with the floating hulls. Steaming was carried in a lab model autoclave (Vertical Laboratory Autoclave, Bells India Ltd.) for 15 minutes at a pressure of 1 ksc/14.22 psi to expand the oil globules and break the nexus between oil globules and surrounding protein matrices in order to enhance the oil recovery. The steamed seeds were dried in a recirculatory tray dryer maintained at 60ºC for regular interval of 2 hours till the moisture content of the seeds was in the range of 8 to 10% (wb).

2.2.2 Extraction of oil

Oil was expelled from the seeds using oil expeller (Komet, Germany) maintained at a speed of at 40 rpm and using a die of size 8. The deoiled cake was dried in a recirculatory tray dryer maintained at 40ºC for 4-6 hours till the moisture content ranged from 4 to 7 % w.b. The deoiled cake was milled using a Mini Mill (INALSA, Tuareg Pvt Ltd., India) and sieved (Sieve number IS 30) to obtained fine flour. Flour was sealed and stored in different packaging materials (LDPE 125 microns and Al foil 75 microns) and kept under ambient conditions (25-35ºC, 45-55% RH) and refrigerated conditions (6-10ºC, 25-35% RH) until further use for analysis. The samples were analyzed every 15 days for a period of 75 days.

2.2.3 Physicochemical Analysis

Moisture content, crude protein, fat content, ash content, and fiber content were estimated by A.O.A.C, 2000 methods.

Water absorption index (WAI) and Water solubility index (WSI) of flour were determined by slightly modifying the method of Singh et al. (2003). The flour samples (1.5 g) were mixed with 18 ml distilled water, using a glass rod, and cooked at 90°C for 15 min in a water bath. The cooked paste was cooled to the room temperature and transferred to centrifuge tubes and centrifuged at 3000× g for 10 minutes. WAI and WSI were calculated by using the following expressions.

$$\text{WAI} = \frac{\text{Weight of sediment}}{\text{Weight of Dry Solids}}$$

$$\text{WSI} = \frac{\text{Weight of dissolved solids in supernatant}}{\text{Weight of Dry Solids}}$$

pH and oxalic acid of the samples were estimated by AACC (2000) methods.

Colour of the defatted sesame flour was assessed using Hunter-Lab colorimeter (Optical Sensor, Hunter Associates Laboratory Inc., Reston Virginia, USA). In the Hunter-Lab colorimeter, the colour of the sample is denoted by the three dimensions, L*, a* and b*. The L*, a* and b* readings were taken from the digital display unit (Model D 25-2). The L* value gives a measure of the lightness of the product colour from 100% for perfect white to 0 for black, as the eye would evaluate it. The redness/greenness and yellowness/blueness are denoted by the a* and b* values, respectively.

The viscosity of the defatted sesame flour was investigated according to Carvalho, Takeiti, Onwulata, and Pordesimo (2010), in triplicate. A Rapid Visco Analyser (RVA, Newport Scientific Pty Ltd., Warriewood, Australia) was used to measure the viscosity of samples as a function of temperature. Approximately 3g of defatted sesame flour (14% of water content, wb) adjusted to 10% solids concentration was added to 25 g distilled water and this was loaded into the RVA. The time-temperature profile included initially mixing and holding the specimen with the paddles rotating at 160 rpm at 25°C for 4 min (to investigate the cold-swelling starch peak), heating to 95°C at a constant rate of 14°C/min, holding at 95°C for 3 min, and then cooling at 25°C in 5 min at the same rate. The readings from the paste curve generated were cold viscosity (CV) (maximum viscosity reading at 25°C), peak viscosity at 95°C (PV) (first viscosity reading data when the temperature reached 95°C), breakdown viscosity and setback viscosity following the methodology described by Duarte et al. (2009).

2.2.4 Statistical Analysis:

Data reported are average of triplicate observations (n=3). Means, standard deviation and analysis of variance (ANOVA) along with comparison of means using Duncan's multiple range test with a significance of 5% ($P \leq 0.05$) was done using commercial statistical package SPSS (16.0, Chicago, IL, USA).

3. Results and discussion:

There was a significant ($p<0.5$) increase in moisture content in all the samples during storage (Table 1). The rate of increase was more significant under ambient storage conditions and varied with the type of packaging material used. The moisture increase in samples packed in LDPE packaging material was most eminent and increased from 3.9 % (w.b.) to 6.20 % (w.b.) (ambient condition) and 5.33% (w.b.) (refrigerated condition) followed by samples packed in Aluminum foil 4.50% (w.b.) (ambient condition) and 4.42% (w.b.) (refrigerated condition) after 75 days. All the moisture levels are however, within standards as the moisture content should be below 9% as per IS 7836 Indian standards (Dipika and Jha, 2011). Accordingly, ambient and refrigerated samples can be kept for two months. Sesame flour packed in aluminum foil can be kept for more than 75 days in ambient and in refrigerated condition. The variation in moisture content of these products could be directly related to the water vapour transmission rate of the packaging materials. The aluminum foil packages kept in refrigerated condition were most effective and least moisture could migrate through them. This was mainly due to the fact that aluminum foil is considered to have low water vapour transmission rate (WVTR) under humid condition (80% RH) (Bargale et al.1993).

Another reason could be due to the role of the microorganisms, which utilize the sesame carbohydrates as the source of energy; sesame protein as the source of nitrogen and ultimately hydrolyzing the lipids and releasing water indicating increase in moisture content. The moisture content is affected significantly due to storage, treatments, packaging, and their interaction and moisture increases due to hygroscopic properties of flour (Kirk and Sawyer 1991; Rehman and Shah, 1999).

A marginal insignificant increase in crude protein content was observed during the study period (Table 2). Similar results have been reported where the crude protein of the samples having higher moisture levels increased due to insect infestation and microbial growth (Leelavathy et al, 1984; Upadhyay et al, 1994; Dipika and Jha, 2011). There was a progressive decrease in the fat content of the samples with time, more pronounced under ambient conditions than refrigerated conditions (Table 3). The highest decrease in fat was seen in LDPE packed samples where the level decreased from 21.25% at 0 days to 20.40% (ambient) and 20.53% (refrigerated) after 75 days. Reduction in fat content was lesser in flour stored in aluminum foil 20.65% in ambient and 20.88% in refrigerated. The decrease may be attributed to the lipolytic activity of enzymes i.e. lipase and lipoxidase. Crude fibre and ash were not significantly affected by the treatments during the entire storage period (Tables 4 and 5).

The oxalic acid content increased gradually during the storage period (Table 6). The rate of increase was seen maximum in case of flour packed in LDPE packaging material under ambient condition and minimum in aluminum foil package under refrigerated condition.

Water absorbtion index (WAI), an indicator of the ability of flour to absorb water, depends on the availability of hydrophilic groups which bind water molecules and on the gel-forming capacity of macromolecules. From Table 7, in the first 15 days of storage period Water Absorbency Index (WAI) increased in all the flour samples packed in different packaging materials. The maximum was in case of material stored in LDPE packaging material stored at refrigerated condition, and minimum in aluminium foil under ambient storage. On the 30th day of storage, WAI decreased in LDPE (both condition) whereas it showed a gradual increase in aluminum foil (both condition). On the 45th day of storage, WAI decreased in case of LDPE and aluminum foil under ambient condition and increases in the other two cases. And further on the 60th day increases in WAI was observed in all the samples except in aluminum foil under refrigerated condition. Finally, on the 75th day of storage period flour packed in aluminum foil kept under ambient condition decrease while the rest of the samples show a gradual increase in WAI. Water solubility index (WSI) is used as a measure for starch degradation; it means that at lower WSI there is minor degradation of starch and such condition leads to less numbers of soluble molecules (Hernandez-Diaz et al, 2007). The nature of the increase and decrease in WSI in all the flour samples does not follow a regular trend during the entire storage period (Table 8). In the first 15 days of storage, the WSI decreases in all the samples. On 30th day, flour stored in LDPE packages decreased in both the condition whereas it increased in the aluminum foil packages and vice versa on the 45th day. Further on 60th day, WSI increased in all the samples and was maximum in case of LDPE (ambient, 19.02 %). On 75 day of storage, the WSI decreased in all the samples being maximum in Al foil under refrigerated condition (14.61 %). From the Table 9, it is seen that the pH in all the stored samples decreased marginally during the entire period of storage. The decrease in pH was maximum in case of flour stored in LDPE package under ambient condition and minimum was seen in aluminum foil package stored under refrigerated condition. The viscosity of a paste depends on to a large extent on the degree of gelatinization of the starch granules and the rate of molecular breakdown. Viscosity generally depends on solubility and water holding capacity as well as the structure of components in a food system. Viscosity profile can be thought of as a reflection of the granular changes in the starch granule that occur during gelatinization (Thomas and Atwell, 1997). The viscosity of the de-oiled sesame flour increased in all the samples packed under different packaging materials during the entire storage period (Table 10). The maximum value of viscosity was seen in case of aluminum foil package stored under refrigerated condition and the minimum value was seen in case of LDPE package under ambient condition. From the Table 11 it can be seen that in all the treatments, there was consistent decreased in whiteness (L) during the entire period of storage. In LDPE package under ambient condition, there was maximum loss of whiteness as compared to all the other treatments. The L-value of flour packed in aluminium foil under refrigerated condition shows a minimum loss in whiteness as compare to all the other treatments. From the Table 12, it can be seen that in all the treatments, there was consistent increase in redness (a value) during the entire period of storage. In aluminium foil under refrigerated condition, there was minimum gain of redness as compared to all the other treatments. The a-value of flour packed in LDPE under ambient condition shows a maximum gain in redness as compare to all the other treatments. From the Table 13, it can be seen that in all the treatments, there was consistent decrease in yellowness (b value) during the entire period of storage. In Al. foil under refrigerated condition, there was minimum loss of yellowness as compared to all the other treatments. The b-value of flour packed in LDPE under ambient condition shows a maximum loss of yellowness as compare to all the other treatments.

List of Tables

Table 1 Effect of packaging material and storage conditions on the mean moisture content (% wb) of defatted sesame meal along with standard deviation at 5% significance level

Treatment	**Storage period (days)**					
	0	**15**	**30**	**45**	**60**	**75**
T_1	3.90±0.034	4.42±0.053	4.50±0.015	5.38±0.055	5.40±0.091	6.20±0.016
T_2	3.90±0.034	4.36±0.012	4.39±0.048	4.50±0.012	4.83±0.018	5.33±0.680
T_3	3.90±0.034	4.30±0.012	4.34±0.029	4.39±0.059	4.41±0.066	4.50±0.045
T_4	3.90±0.034	4.28±0.012	4.30±0.012	4.36±0.012	4.39±0.060	4.42±0.050

T1 – Defatted sesame meal stored in LDPE packaging material at ambient storage condition.
T2 – Defatted sesame meal stored in LDPE packaging material at refrigerated storage condition.
T3 – Defatted sesame meal stored in Aluminium foil packaging material at ambient storage condition.
T4 – Defatted sesame meal stored in Aluminium foil packaging material at refrigerated storage condition.

Table 2 Effect of packaging material and storage conditions on the protein content (%) of defatted sesame meal along with standard deviation at 5% significance level

Treatment	**Storage period (days)**					
	0	**15**	**30**	**45**	**60**	**75**
T_1	39.20±0.067	39.20±0.117	39.20±0.101	39.43±0.583	39.66±0.210	40.08±0.101
T_2	39.20±0.067	39.25±0.117	39.49±0.210	39.73±0.175	39.90±0.101	40.53±0.101
T_3	39.20±0.067	39.38±0.101	39.55±0.101	39.66±0.210	39.78±0.154	40.36±0.154
T_4	39.20±0.067	39.38±0.106	39.55±0.202	39.78±0.058	40.13±0.058	40.48±0.058

Table 3 Effect of packaging material and storage conditions on the fat content of defatted sesame meal along with standard deviation at 5 % significance level

Treatment	**Storage period (days)**					
	0	**15**	**30**	**45**	**60**	**75**
T_1	21.25±0.012	21.18±0.014	21.14±0.080	20.89±0.014	20.79±0.022	20.40±0.014
T_2	21.25±0.012	21.18±0.076	21.16±0.108	29.9±0.0144	20.75±0.024	20.53±0.022
T_3	21.25±0.012	21.19±0.065	21.15±0.065	21.00±0.022	20.65±0.101	20.65±0.101
T_4	21.25±0.012	21.26±0.058	21.20±0.014	21.1±0.0144	20.85±0.035	20.88±0.014

Table 4 Effect of packaging material and storage conditions on the fiber content (%) of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	15	30	45	60	75
T_1	3.60±0.024	3.57±0.126	3.56±0.003	3.48±0.004	3.42±0.020	3.32±0.009
T_2	3.60±0.024	3.58±0.002	3.57±0.003	3.50±0.007	3.45±0.002	3.36±0.003
T_3	3.60±0.024	3.58±0.007	3.57±0.008	3.55±0.002	3.47±0.003	3.42±0.020
T_4	3.60±0.024	3.60±0.029	3.59±0.025	3.56±0.005	3.49±0.003	3.48±0.004

Table 5 Effect of packaging material and storage conditions on the Ash content (%) of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	15	30	45	60	75
T_1	5.56±0.065	5.56±0.107	5.55±0.024	5.55±0.059	5.56±0.007	5.54±0.013
T_2	5.56±0.065	5.56±0.088	5.54±0.0306	5.55±0.018	5.55±0.020	5.55±0.007
T_3	5.56±0.065	5.55±0.042	5.54±0.0176	5.56±0.035	5.55±0.018	5.56±0.023
T_4	5.56±0.065	5.55±0.704	5.55±0.0116	5.56±0.012	5.54±0.018	5.55±0.018

Table 6 Effect of packaging material and storage conditions on the oxalic acid content of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	15	30	45	60	75
T_1	0.245±0.023	0.252±0.01	0.255±0.017	0.256±0.003	0.282±0.017	0.289±0.003
T_2	0.245±0.023	0.249±0.01	0.256±0.001	0.264±0.003	0.284±0.026	0.294±0.002
T_3	0.245±0.023	0.246±0.01	0.250±0.002	0.273±0.002	0.308±0.001	0.319±0.001
T_4	0.245±0.023	0.247±0.02	0.247±0.003	0.279±0.003	0.300±0.002	0.320±0.002

Table 7 Effect of packaging material and storage conditions on the water absorbance of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	15	30	45	60	75
T_1	2.31±0.082	2.97±0.060	2.94±0.068	2.80±0.032	2.91±0.033	3.64±0.021
T_2	2.31±0.082	3.15±0.021	2.94±0.115	2.97±0.175	3.33±0.044	3.55±0.055
T_3	2.31±0.082	2.95±0.147	3.17±0.027	3.16±0.081	3.45±0.150	3.48±0.058
T_4	2.31±0.082	3.11±0.004	3.27±0.435	3.62±0.030	3.29±0.026	3.50±0.018

Table 8 Effect of packaging material and storage conditions on the water solubility index of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	15	30	45	60	75
T_1	22.08±0.023	14.76±0.071	12.96±0.05	10.71±0.038	19.02±0.030	18.75±0.087
T_2	22.08±0.023	16.30±0.098	15.99±0.03	16.04±0.773	16.32±0.293	15.93±0.217
T_3	22.08±0.023	18.89±0.176	20.97±0.30	15.83±0.047	18.58±0.104	16.50±0.679
T_4	22.08±0.023	17.51±0.168	20.97±0.33	16.08±0.182	18.28±0.104	14.67±0.451

Table 9 Effect of packaging material and storage conditions on the pH characteristics of defatted sesame meal along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**
T_1	6.56±0.03	6.503±0.01	6.502±0.02	6.500±0.01	6.497±0.02	6.495±0.03
T_2	6.56±0.03	6.510±0.03	6.518±0.02	6.517±0.02	6.515±0.02	6.511±0.01
T_3	6.56±0.03	6.543±0.01	6.540±0.03	6.523±0.04	6.521±0.04	6.515±0.03
T_4	6.56±0.03	6.540±0.01	6.540±0.03	6.520±0.06	6.510±0.03	6.530±0.04

Table 10 Effect of packaging material and storage conditions on the viscosity characteristics of defatted sesame meals along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**
T_1	50.67±0.072	65.33±0.035	62.00±0.024	64.66±0.016	68.00±0.056	70.33±0.045
T_2	50.67±0.072	69.67±0.043	56.00±0.064	68.33±0.021	73.67±0.077	73.33±0.014
T_3	50.67±0.072	65.00±0.076	64.67±0.063	67.33±0.078	76.66±0.072	72.33±0.012
T_4	50.67±0.072	68.33±0.074	68.00±0.043	71.66±0.023	72.33±0.012	75.00±0.024

Table 11 Effect of packaging material and storage conditions on the Colour (L-value) of defatted sesame meals along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**
T_1	64.36±0.082	63.32±0.003	63.25±0.012	63.20±0.024	63.15±0.063	63.14±0.054
T_2	64.36±0.082	63.36±0.027	63.35±0.122	63.35±0.036	63.32±0.034	63.32±0.037
T_3	64.36±0.082	63.80±0.054	63.78±0.011	63.74±0.065	63.64±0.024	63.57±0.062
T_4	64.36±0.082	63.89±0.002	63.87±0.086	63.86±0.035	63.84±0.083	63.81±0.003

Table 12 Effect of packaging material and storage conditions on the Colour (a-value) of defatted sesame meals along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**
T_1	4.90±0.052	5.05±0.45	5.60±0.064	5.67±0.036	6.00±0.083	6.33±0.052
T_2	4.90±0.052	5.01±0.05	4.89±0.035	4.95±0.064	5.07±0.026	6.26±0.063
T_3	4.90±0.052	4.99±0.02	5.86±0.075	5.96±0.084	5.85±0.011	6.08±0.055
T_4	4.90±0.052	4.93±0.04	5.56±0.024	5.57±0.052	5.60±0.073	5.68±0.062

Table 13 Effect of packaging material and storage conditions on the Colour (b-value) of defatted sesame meals along with standard deviation at 5% significance level

Treatment	Storage period (days)					
	0	**15**	**30**	**45**	**60**	**75**
T_1	17.05±0.034	17.17±0.252	17.03±0.042	16.99±0.033	16.82±0.036	15.41±0.034
T_2	17.05±0.034	17.76±0.062	17.09±0.073	16.67±0.064	16.55±0.053	15.64±0.053
T_3	17.05±0.034	17.03±0.033	17.02±0.054	16.81±0.036	16.40±0.012	15.93±0.023
T_4	17.05±0.034	17.28±0.064	17.92±0.084	16.48±0.053	16.83±0.053	16.78±0.053

4. Conclusion

Sesame flour was produced from the de-oiled sesame cake after the expulsion of oil from the sesame seeds, followed by different pretreatments, drying and finally milling. The Physico-chemical characteristics of the flour samples packed in aluminum foil and stored under refrigerated condition were best in terms of moisture content, protein, fat, fiber, ash, color (Land a values) and pH whereas flour samples packed in LDPE and stored under ambient condition were better in terms of WSI, WAI, oxalic acid, color (b-value) and viscosity. The present study reveals that the de-oiled sesame flour can be kept best in aluminum foil packages stored under refrigerated condition followed by aluminum foil package stored under ambient condition and LDPE packages stored in refrigerated and ambient condition. The de-oiled sesame flour from sesame seeds could be kept safely for 75 days in ambient and in refrigerated conditions

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