J. Farm Sci., 34(2): (217-219) 2021

RESEARCH PAPER

Influence of packaging material and storage conditions on the oxidative stability of stabilized wheat germ

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(Received: January, 2021 ; Accepted: April, 2021)

Abstract: Wheat germ is a valuable by-product derived from the milling industry, as it is a good source of essential amino and fatty acids, minerals, vitamins, tocopherols and phytosterols. It gets rancid very quickly during storage due to presence of large amount of unsaturated fats and also the presence of hydrolytic and oxidative enzymes. An experiment was conducted to study the influence of packaging and storage conditions on the oxidative stability of stabilized wheat germ.Wheat germ was stabilized by fluidized bed drying. Stabilized wheat germ was stored in different packaging materials *viz*., low density polyethylene (LDPE) pouch, laminated zip lock pouch, glass bottle and vacuum packed bags, were replicated three times in both refrigerated (4 ± 1°C) and ambient storage (25 ± 2°C) conditions using factorial completely randomized design. Changes in oxidative parameters were analyzed during the storage at 2 weeks interval for a period of 10 weeks. The results of the study revealed that the oxidative parameters *viz*., peroxide value and free fatty acid content increased with increase of storage period. The peroxide value of stabilized germ packed in LDPE pouch in ambient condition exceeded the acceptable limit after 8 weeks of storage. Whereas in other packaging materials the peroxide value of stabilized wheat germ were still less than 10meqO_2/kg during storage period. It was observed that stabilization of wheat germ followed by refrigerated storage will extend the shelf life of wheat germ up to 10 weeks. Vacuum packing with refrigerated storage condition is considered as best method to store the germ for longer period (up to 20 weeks).

Key words: Peroxide value, Storage, Vacuum packing, Wheat germ

Introduction

Wheat (*Triticumaestivum* L.) is one of the most important cereal crop belonging to the grass family Poaceae.The wheat grain comprises of endosperm (81-84%), germ (2-3%) and the bran (14-16%). Wheat is mainly processed for obtaining whole wheat flour, maida and semolina. Commercial processing of wheat into flour focuses on the extraction of the endosperm from the grain. Germ and bran are the major by-products of the wheat milling industry and are commonly used as cattle feed. Wheat germ is the heart of the wheat grain containing embryo and scutellum isolated from the endosperm. The embryonic axis comprises of plumule and radicle, scutellum is the storage organ (Yu *et al*., 2015). During wheat processing most scutellum is rejected and the recuperated germ is particularly the embryo. Presence of germ in the flour leads to unfavourable baking properties and is susceptible to oxidation. Hence, during milling, the germ is removed. Wheat germ is considered as the nutritive portion of wheat kernel as it contains good amount of nutrients such as unsaturated fatty acids, proteins, B complex vitamins, vitamin E, minerals, essential amino acids, dietary fibre, flavonoids and sterols (Sun *et al*., 2015; Zhu *et al*., 2015).

The extensive utilization of wheat germ is restricted due to its very short shelf life. Wheat germ is rich in polyunsaturated fatty acids that tend to oxidise and become rancid when stored (Li *et al*., 2016). The presence of hydrolytic and oxidative enzymes also favours wheat germ speedy deterioration (Xu *et al*., 2013).The mechanical treatments involved in wheat processing favours the dispersion of oil and as soon as the lipids exposed to the air and oxidation rises dramatically (Gili *et al*., 2017). Stabilization of wheat germ is necessary to extend the shelf life. After stabilization packing with suitable packaging material and storage under appropriate condition helps in extending the shelf life of wheat germ. Keeping the above factors in view, it was felt to study the oxidative stability of stabilized wheat germ as influenced by different packaging materials and storage temperatures to extend its storage period.

Material and methods

The study was carried out in the Department of Food Processing and Technology, University of Agricultural Sciences, Dharwad in the year 2019-20. Wheat grains were passed through break rolls, where wheat grain was crushed and shorts, flour and middlings were formed. Then middlings containing germ particles are passed through a pair of smooth rolls where the germ is flattened (its high lipid content allows flaking under compression) and separated by sifting. Then wheat germ subjected to fluidized bed drying in Roxy flour mill, Bengaluru, Karnataka, at a temperature range of 128-130ºC for 240-300s with an average air velocity of 0.50±0.05 ms^{-1} and 30mm bed thickness. The stabilized wheat germ was then allowed to cool to room temperature.

Stabilized wheat germ was packed to 300 g each in LDPE pouches (7º×10º size and 55 micron thickness, laminated zip lock pouches (polyethylene and polyester laminated, 6.5º×9º size and 100 micron thickness), glass bottles (Transparent and air tight bottles) and vacuum packages (Polyethylene bag with 300 micron thickness). They were stored at ambient (25 ± 2ºC) and refrigerated (4 ± 1ºC) condition. Wheat germ oil was extracted using solvent extraction method using petroleum ether

as a solvent. The observations on peroxide value (Anon., 2017) and free fatty acid (Anon., 2017) content were recorded at every 2 weeks interval for a period of 10 weeks. The data recorded during storage study on oxidative properties were subjected to Fisher's method of analysis of variance (Factorial completely randomized design with 3 replications). Level of significance used in 'F' test was 'p' at 5 per cent. Interpretation of data was carried as per the guidelines suggested by Panse and Sukhatme (1961).

Results and discussion

Data regarding change in peroxide value of stabilized wheat germ during storage is presented in Table 1. Stabilized wheat germ packed in LDPE pouch shows a highest increase in peroxide value from 6.51 to 11.37 meqO_2/kg in refrigerated condition and 6.51 to 12.97 meqO_2/kg in ambient condition. Whereas, the peroxide value of germ packed in laminated zip lock pouch increased from 6.51 to 9.59 meqO_2/kg in refrigerated condition and 6.51 to 10.74 meqO_2/kg in ambient condition. The peroxide value of stabilized wheat germ stored in glass bottle increases from 6.51 to 9.72 meqO_2/kg and 6.51 to 8.03 meqO_2/kg in ambient and refrigerated storage condition. The germ enclosed by vacuum packing shows relatively lower rate of increase in peroxide value compared to other types throughout the storage. The increase in peroxide value was 6.51 to 7.67 meqO_2/kg and 6.51 to 9.34 meqO_2/kg in refrigerated and ambient storage conditions, respectively.

Data regarding change in free fatty acid content (as per cent oleic acid) of stabilized wheat germ during storage is presented in Table 2. Stabilized wheat germ packed in LDPE pouch shows a highest increase in free fatty acid content in both the storage conditions. Free fatty acid content increased from 1.54 to 2.66 and 1.54 to 3.59 per cent in refrigerated and ambient storage condition, respectively. Free fatty acid contentof stabilized wheat germ packed in laminated zip lock pouch increased from 1.54 to 2.44 percent in refrigerated storage and 1.54 to 2.42 per cent in ambient storage. In case of glass bottle storage and vacuum packing the per cent increase in free fatty acid contentwas low compared to other types. Per cent increase in glass bottle was 467.53 and 480.05 in refrigerated and ambient condition, respectively. In vacuum packing free fatty acid content increased from 1.54 to 1.93 per cent in refrigerated and 1.54 to 2.02 per cent in ambient condition, respectively.

Table 1. Peroxide value of stabilized wheat germ during storage

Treatments	Storage period (weeks)					
	0	2	4	6	8	10
T_1 - S_1P_1	6.51	7.68	8.55	9.39	10.90	11.37
T_2 - S_1P_2	6.51	7.20	7.83	8.21	8.81	9.59
T_3 - S_1P_3	6.51	6.82	7.13	7.31	7.62	8.03
T_4 - S_1P_4	6.51	6.76	6.87	7.03	7.25	7.67
T_5 - S_2P_1	6.51	7.93	9.00	10.52	12.09	12.97
T_6 - S_2P_2	6.51	7.42	8.61	9.48	10.03	10.74
T_7 - S_2P_3	6.51	7.22	7.77	8.43	8.96	9.72
T_8 - S_2P_4	6.51	6.85	7.64	8.19	8.76	9.34
S. Em. ±	0.01	0.026	0.032	0.088	0.175	0.044
C.D. (at 5 %)	NS	0.07*	0.09*	0.25*	0.51*	0.12*

S_1: Refrigerated condition
S_2: Ambient condition
P_1: Low density polyethylene pouch
P_2: Laminated zip lock pouch
P_3: Glass bottle
P_4: Vacuum packing
Note: *Significant (p≤0.05), NS- non significant

Table 2. Free fatty acid content of stabilized wheat germ during storage

Treatments	Storage period (weeks)					
	0	2	4	6	8	10
T_1 - S_1P_1	1.54	1.81	1.92	2.09	2.47	2.66
T_2 - S_1P_2	1.54	1.78	1.83	1.91	2.13	2.44
T_3 - S_1P_3	1.54	1.69	1.80	1.89	1.96	2.26
T_4 - S_1P_4	1.54	1.59	1.67	1.78	1.85	1.93
T_5 - S_2P_1	1.54	1.98	2.38	2.81	3.12	3.59
T_6 - S_2P_2	1.54	1.81	1.85	1.93	2.13	2.42
T_7 - S_2P_3	1.54	1.74	1.86	1.92	2.13	2.28
T_8 - S_2P_4	1.54	1.61	1.69	1.84	1.92	2.02
S.Em.±	0.017	0.011	0.013	0.031	0.050	0.055
C.D. (at 5 %)	NS	0.03*	0.03*	0.09*	0.14*	0.16*

S_1: Refrigerated condition
S_2: Ambient condition
P_1: Low density polyethylene pouch
P_2: Laminated zip lock pouch
P_3: Glass bottle
P_4: Vacuum packing
Note: *Significant (p≤0.05), NS- non significant

Peroxide value and free fatty acid content of stabilized wheat germ increased significantly throughout the storage in all the packaging materials. This may be due to the chain reaction of oxidation process that was initiated during thermal processing and/or oxygen present inside the packaging material and/or transpiration of oxygen into packaging material from outside and also due to the residual enzyme activity (Smouse and Chang 1967; Jelen *et al.*, 2000). The oxidation rate in thermal oxidation is faster than auto-oxidation and hydroperoxides, the primary oxidation products are decomposed rapidly and produces secondary oxidation products such as aldehydes and ketones (Choe and Min, 2007).

Stabilized wheat germ stored in ambient temperature showed a greater increase in peroxide value and free fatty acid contentcompared to refrigerated condition. These results are in agreement with Sherwood *et al*. (1933), they used alcohol acidity as an indicator to measure the freshness or spoilage of germ during storage and concluded that increase in acidity is a function of storage temperature. Acidity increased eight times as fast at 29ºC as at -10ºC. Peroxide value of samples packed in LDPE pouch exceeded the limit (10 meqO_2/kg) after 6 weeks of storage in ambient condition. This may be due to the presence of oxygen in the pouch, poor barrier property of the polyethylene pouch and the high storage temperature. The germ stored in glass bottle retained its quality after 10 weeks of storage in both the storage conditions. This is because of good barrier properties of the glass bottle. Vacuum packed wheat germ in refrigerated condition retained its quality much better compared to other packaging materials. This is mainly because of complete evacuation gas from the package and low storage

temperature. The slight increase in peroxide value and free fatty acid contentin vacuum packed wheat germ could be due to diffusion of oxygen and moisture through the packaging material from surroundings. Similar results were observed by Sherwood *et al*. (1933), they concluded that the germ packed under vacuum or under nitrogen kept well over 43 weeks at -10ºC and only for 12 weeks at 29ºC.

At the end of the storage, fluidized bed dried wheat germ in all the packaging materials except in LDPE resulted in the acceptable oil quality (free fatty acid < 4 oleic acid g/100g and Peroxide value < 10 meqO_2/kg) with more than 8 weeks , based on the Codex Alimentarius (2001) for non-refined plant oils.

Conclusion

The oxidative degradation during storage was faster in case of wheat germ packed in LDPE pouch stored in ambient condition compared to other packaging and storage conditions. However, the values are in the acceptable range up to 8 weeks of storage in all the packaging types except in LDPE. Vacuum packing is considered as best packing method for long term wheat germ storage.

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