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Effect of Packaging Materials, Storage Methods, and Durations on Functional Qualities of Red-Hot Pepper Powder

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ABSTRACT

The current study aimed at determining how red pepper pericarp powder's functional properties are affected by packaging material and storage duration. Low-density polyethylenes (LDPE), high-density polyethylene (HDPE), aluminum poach (AlP), and BLDPE (black-coloured low-density polyethylene) bags were heat-sealed. The samples were stored at ambient conditions for ten months. Data on moisture content (MC)(%), total carotenoids (TCC) (µg/g), pungency index (PI) (abs/g), oleoresin content (OLEO)(%), and total antioxidant capacities (TAOC) (AAE mg/100g) were collected at two-month interval. A significant ($p<0.001$) interaction effect of packaging material and storage duration was observed in all studied response variables except for MC and pungency index. Samples packed in aluminum pouches could maintain high functional qualities at the end of the storage period which could be due to the lower permeability of aluminum pouches to water vapor and oxygen under both room and refrigerated storage methods. The findings suggest further studies on the effect of these packaging materials and storage durations on other nutritional variables and the product's safety.

Keywords: Red hot pepper; Temperature; Total carotenoids; Pungency Oleoresin.

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INTRODUCTION

Hot red peppers (*Capsicum annum* L.) has unique pungency, aroma, color, nutritional, and medicinal values (Sarafi et al.,2017; Singh et al.,2018). It is used as vegetable and spice product. According to Central Statistical Agency (CSA), red pepper took a share of 73.13% of the area covered by vegetable production, followed by kale which took 17.81% in Ethiopia (CSA,2020). Despite the large production, 27.56% loss was reported during marketing, transportation, and storage of 10%, 10%, and 7.56%, respectively (Yeshiwas and Tadele (2021)). Additionally, the use of inappropriate packaging materials and the high cost of hermetic packaging materials are reported as causes of loss during postharvest period (Satheesh et al.,2023). These improper postharvest handling practices increases the susceptibility of the product to higher temperatures, humid air, oxygen and light enhancing degradation of colour, oleoresin, pungency and other antioxidant contents (Khobragade and Borkar, 2018). Therefore, this study aimed to investigate the effects of packaging material, storage method, and storage duration on the functional qualities of red-hot pepper powder.

MATERIALS AND METHODS

The commercially available hot pepper variety that has wide acceptance, namely *Mareko Fana*, was selected for this study. The was cleaned and the pods were dried under the sun until the pod got constant weight. Then milled using KARLBOLB D-6072, Dreich, West Germany Miller, and sieved by 0.5mm mesh wire to obtain uniform particle size. The powder was packed in Aluminum foil laminate pouches, high-density polypropylene, transparent and black low-density polyethylene bags. Samples were stored for later analysis at ambient (25±2°C) and refrigerated (4±2°C) temperatures. A three-factor factorial design with three replications was used. The baseline data used to assess the trend of functional quality indicators was the initial values measured at time zero before the commencement of storage (Table 1).

Finally, the moisture content, Total carotenoid content, pungency index, oleoresin content, and total antioxidant capacity were determined according to the method AOAC (2012); Carvalho *et al*. (2015); Hossain and Bala (2007); Wesolowska *et al.* (2011) and, Prieto *et al.*(1999), respectively. The initial MC, TCC, PI, OLEO and TAOC were 10.6%,4158.96(µg/g), 5.01(abs/g), 12.25(%), and 752.96 (AAE mg/100g), respectively. The statistical analysis was conducted using Minitab version 21 software. For interaction effects, multiple means comparison of the 40 treatment combinations was made using Tukey's multiple range test at the 5% level of significance to generate letter grouping.

RESULTS

The interaction effect of packaging materials, storage temperature, and storage duration significantly affected the total carotenoid content, oleoresin content and total antioxidant capacity of red-hot pepper powder during ten months storage except for moisture content and pungency index (Table 1).

Table 1. Mean MC, TCC, PI, OLEO and TAOC values obtained from the 40 combinations of Packaging material (Pack), Storage temperature (Temp), and Storage period (Month).

Packaging materials	Storage Method	Storage Duration	MC (%)	TCC (µg/g)	PI (Abs/g)	OLEO (%)	TAOC (AAE mg/g)
ALP	T1	2	10.24	4011.67 [a]	4.92	11.85 [a]	485.67[a]
ALP	T1	4	10.4	4005.34 [a]	3.88	11.54 [b]	432.52 [bc]
ALP	T1	6	10.79	3909.1 [b]	3.4	10.69 [f]	414 [bcd]
ALP	T1	8	11.29	3905.43 [b]	3.33	10.46 [g]	407.43 [cde]
ALP	T1	10	11.71	3809.03 [c]	3.27	10.26 [h]	400.85 [def]
ALP	T2	2	10.19	3807.78 [c]	4.87	11.66 [ab]	435.48 [b]
ALP	T2	4	10.42	3807.76 [c]	3.64	11.22 [de]	394.56 [def]

ALP	T2	6	10.91	3737.03^{d}	3.37	10.28^{gh}	378.07^{fgh}
ALP	T2	8	11.1	3714.76^{e}	3.07	9.76^{j}	349.83^{i-l}
ALP	T2	10	11.25	3705.34^{e}	2.77	9.24^{k}	321.59^{m-p}
HDPE	T1	2	10.9	3694.54^{e}	4.73	11.64^{ab}	461.22^{bcd}
HDPE	T1	4	11.12	3694.12^{e}	3.66	10.81^{f}	384.93^{efg}
HDPE	T1	6	11.45	3580.74^{f}	3.2	8.63^{l}	361.78^{g-k}
HDPE	T1	8	11.98	3576.54^{f}	3.2	8.57^{l}	345.02^{j-m}
HDPE	T1	10	12.33	3568.67^{f}	3.18	8.470^{lm}	328.26^{l-o}
HDPE	T2	2	10.49	3511.97^{g}	4.57	11.54^{bc}	416.78^{a}
HDPE	T2	4	11.05	3510.3^{g}	3.34	10.29^{gh}	352.89^{h-l}
HDPE	T2	6	11.41	3507.87^{g}	3.17	8.09^{no}	258.26^{u}
HDPE	T2	8	11.75	3492.4^{g}	3.18	7.63^{p}	251.68^{vW}
HDPE	T2	10	12.18	3424.87^{h}	2.87	7.17^{qr}	245.11^{w}
LDPE	T1	2	11.18	3411.25^{h}	4.35	7.32^{cd}	409.93^{b-e}
LDPE	T1	4	11.48	3406.98^{h}	3.34	10.10^{hi}	315.48^{n-p}
LDPE	T1	6	11.91	3366.87^{i}	3.01	8.01^{o}	287.89^{rst}
LDPE	T1	8	12.6	3315.92^{j}	2.94	7.66^{o}	271.13^{tu}
LDPE	T1	10	13.03	3275.96^{k}	2.88	7.32^{p}	254.37^{vW}
LDPE	T2	2	11.01	3257.54^{k}	4.35	11.12^{e}	344.28^{j-m}
LDPE	T2	4	11.42	3218.57^{l}	3.14	9.64^{j}	301.22^{p-s}
LDPE	T2	6	11.93	3214.84^{l}	3.01	7.94^{o}	259.00^{u}
LDPE	T2	8	12.4	3155.63^{m}	2.66	7.04^{r}	248.07^{vW}
LDPE	T2	10	12.83	3118.83^{n}	2.31	6.19^{s}	237.15^{w}
BLDPE	T1	2	11.15	3106.78^{n}	4.37	11.26^{de}	418.44^{bcd}
BLDPE	T1	4	11.48	2994.25^{o}	3.42	10.27^{gh}	375.48^{f-i}
BLDPE	T1	6	12.04	2975.12^{o}	3.07	8.30^{mn}	338.63^{k-n}
BLDPE	T1	8	12.59	2894.78^{p}	3.02	8.18^{no}	314.18^{n-q}
BLDPE	T1	10	13.02	2882.78^{p}	2.97	8.09^{o}	289.74^{q-t}
BLDPE	T2	2	10.88	2712.87^{q}	4.32	11.17^{de}	368.63^{g-j}
BLDPE	T2	4	11.2	2712.25^{q}	3.26	10.02^{i}	338.07^{k-n}
BLDPE	T2	6	11.67	2426.87^{r}	3.13	8.01^{o}	307.52^{o-r}
BLDPE	T2	8	12.38	2011.9^{s}	2.75	7.53^{p}	280.39^{stu}
BLDPE	T2	10	12.88	1995.56^{s}	2.36	7.01^{r}	253.26^{vW}

Over ten months of storage under both storage conditions, our study showed a progressive increase in the moisture content of all samples. For ALP, HDPE, LDPE, and BLDP bags, the moisture content increased under refrigerated conditions from 10.24-11.71%, 10.90-12.34%, 11.12-13.03%, and 11.15-12.59%, and under ambient conditions from 10.19-11.25%, 10.49-12.18%, 11.01-12.83%, and 10.88-12.88%, respectively, (Table 1) over two to ten months of storage. Samples kept in a refrigerator had a higher moisture content ($p<0.05$) than samples kept in an ambient environment, as a result of the porosity of packaging materials and the hygroscopic nature of red pepper powder (Alsebaeai et al.,2017).

The total carotenoid values ranged from 4158.95-3809.03, 4158.95-3568.67, and 4158.95-3275.9 and 4158.95-2882.78 under cold storage, and ranged from 4158.95-3705.34, 4158.95-3424.87, 4158.95-3118.83 and 4158.95-1995.56 under room temperature storage in AlP, HDPE, LDPE, and BLDPE, respectively (Table 1). The highest value of total carotenoid content was recorded for the samples packed in AlP bags after ten months of storage duration under cold storage temperature, followed by HDPE bags. The minimum value of TCC was recorded for the samples packed in BLDPE bags. The highest TCC loss is attributed to the high relative humidity, high temperature, increased moisture, and water activity of low-density polyethylene bags because of their higher permeability to moisture.

Moreover, the PI decreased by 60.30, 43.28, 50.11%, and 40.11% in LDPE, HDPE BLDPE, and ALP under refrigerated storage, whereas it decreased by 65.2, 49.11, 55.01, and 45.24% in LDPE, HDPE BLDPE, and ALP at ambient temperature (Table 1). The samples stored at ambient temperature showed a higher decrease in PI than at refrigerated temperatures. The degradation of pungency index could be resulted from deterioration of capsaicin attributed to oxidation and moisture absorption from the atmosphere.

Oleoresin content was decreased across the storage durations in all packaging materials under both storage conditions. Oleoresin content loss was 44.34, 37.82, 37.25, and 20.77% at ambient temperature and 32.27, 27.25, 28.16, and 13.42% loss at refrigerated temperature in LDPE, HDPE, BLDPE, and ALP respectively(Table 1). Anjaneyulu and Sharangi (2022) reported a loss of oleoresin endorsed by the oxidative deterioration of the active ingredients in chilli peppers at higher temperatures.

The degradation of TAC in all packing materials at both storage conditions with advanced storage duration was recorded. The total antioxidant activity values ranged from 752.96-400.85, 752.96-328.26, and 752.26-254.37 and 752.96-289.74 under cold storage, and decreased from 752.96-321.59, 752-245.11, 752.9-237.15 and 752.26-253.26 under room temperature storage in ALP, HDPE, LDPE, and BLDPE, respectively (Table 1). This is due to that antioxidant capacity is associated with red pepper phenolic compounds, capsaicinoids, and carotenoids which can be degraded at elevated moisture content (Varastegani et al.,2019), pH, and exposure to oxygen and light (Chandra et al.,2021).

CONCLUSION

Cold storage temperature retained more functional qualities and recorded the greatest moisture content across the storage durations. Aluminium pouch laminate preserved more functional qualities as compared to other packaging materials. All packaging materials can alternatively be used for up to six months storage duration while aluminium pouch laminate can be used to ten months duration under both storage conditions. A study on the impact of packaging materials, storage methods, and storage duration on safety and nutritional quality parameters and cost benefit analysis are recommended.

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