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Effect of Different Packaging Materials on Sensory Attributes of Fibre Rich Cookies during Storage

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ABSTRACT

In present investigation the effect of different packaging materials (LDPE, PET jar, LDPE pouch in PET jar and metalized pouch) on sensory attributes of fibre rich cookies prepared using apple, carrot and beetroot pomace powder was studied during storage period of 90 days. Cookies packed in LDPE pouch showed significant decrease in colour and appearance followed by PET jar as compared to other two packaging materials. Pronounced change in the colour was observed in cookies with beetroot pomace powder. However, cookies packaged in metalized pouch showed least changes in colour and appearance. Crispness of the control and oat cookies decreased in all packaging materials as compared to fibre rich cookies with pomace powders. Texture and crispness of cookies with beetroot pomace powder showed least changes as compared to other cookies. Cookies packed in the LDPE pouch showed more decrease in the taste score during 90 days storage as compared to other packaging materials. Cookies with apple pomace powder stored in LDPE pouch showed least scores for taste as compared to cookies with carrot and beetroot pomace powder. Cookies with pomace powders showed less flavour changes in LDPE as compared to oat and control cookies. Flavour score was highest in cookies with beetroot pomace powder. Pronounced effect on overall acceptability of the cookies was found in LDPE pouches and it was observed that overall acceptability of the cookies stored in LDPE significantly decreased with the passage of time. Cookies with pomace powders maintained better overall acceptability as compared to control and oat cookies.

Key words: *Cookies, Fibre, Packaging material, Sensory attributes, Storage study*

INTRODUCTION

Dietary fibre in diet is gaining lot of importance looking at the present scenario where modern life style has resulted in substantial reduction in the intake of roughage in the diet leading to many chronic diseases[16]. Large quantity of waste obtained after juice extraction from fruits and vegetables is inexpensive source, containing high amount of dietary fibre[17]; which can be used for fibre enrichment of food products.

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Cookies are ideal for supplementation with fibre due to palatability, compactness and convenience, long shelf life of the product[23] and being liked by array of consumers.

Fruits and vegetable possess bountiful of pigments and bioactive compounds including antioxidants; and in some cases major part of which can be present in pomace left after juice extraction. Apple, carrot and beetroot pomace are rich in bioactive compounds and pigments viz. phenolic compounds, flavonoids, carotenoids and betalains[10, 20]. Carrot pomace obtained during carrot juice processing contains even up to 80% of carotene[4]. Thus, it is not only important to understand the effect of the supplementation with pomace powders on the physico-chemical and sensory properties; but it is also important to understand its behaviour during storage and the resultant effect on the quality of the food product.

Present investigation was aimed to study and compare the effect of different packaging materials on sensory attributes of fibre rich cookies prepared using apple, carrot and beetroot pomace powder during storage period of 90 days.

MATERIALS AND METHODS

Preparation of flour blends

Blends of 5%, 10%, 15%, 20% and 25% were prepared by substitution of refined wheat flour with apple, carrot and beetroot pomace powder.

Preparation of cookies

Cookies were prepared, using creamery method for making biscuit dough. The ingredients (g) used in preparation of cookies were flour blends 100, fat 45, sugar 60, baking powder 1.5, sodium bicarbonate 1.5, ammonium bicarbonate 1.5 and water as per requirement for making dough. Dough was rolled in sheet of 0.5 cm thickness and cut into circular shape with dye. The pieces were placed in the baking tray smeared with fat and baked at 160°C for 20 min. The cookies were allowed to cool, packed and stored at ambient temperature.

Storage Study

Storage study was conducted for cookies with 10 % apple, carrot and beetroot pomace powder (based on highest sensory score) along with control cookies and cookies with 25 % oat flour for comparison. Cookies were stored in LDPE, PET jar, LDPE pouch in PET jar and metalized pouch. The packaged product was stored for 90 days and sensory evaluation of product was conducted using ten semi trained panel members on 9 point hedonic rating[15]. The results are presented in Table 1-5.

Statistical analysis

The data obtained was analyzed statistically to determine statistical significance of treatments. Completely Randomized Design (CRD) was used to test the significance of results[14].

RESULTS AND DISCUSSION

Colour and Appearance

It is evident from the results of sensory scores for colour and appearance that cookies packed in LDPE pouch and PET jar showed decrease in colour and appearance as compared to other two packaging materials. Decrease in colour and appearance score was less in PET jar as compared to LDPE pouch. The migration or absorption of moisture results in loss of colour during storage[3]. There is also natural tendency of colour fading with progressive storage which ultimately affects the appearance[11].It is evident from Table 3 and 4 that pronounced decrease in the colour score was in cookies with beetroot pomace powder followed by carrot pomace powder which can be attributed to degeneration of the pigments.

The conjugated polyene chain that is characteristic of carotenoids makes these compounds susceptible to degradation from a number of agents[5]. Carotenoids are susceptible to oxidative loss caused by heat and light which could be responsible for the losses during storage[21]. Hence, colour of carrot pomace cookies stored in metalized pouch was found to be least affected.

It can be observed from Table 4 that there was pronounced effect on the colour and appearance of cookies with beetroot pomace powder which can be attributed to sensitivity

of betalains to number of agents viz. light, water activity and oxygen[22,1]. pH, temperature and light has great impact to degradation of betalain pigment during storage and light has been the major factor of colour deterioration[24]. Hence, beetroot cookies stored in metalized pouch showed least changes in colour due to good moisture, light and oxygen barrier properties of metalized pouch.

LDPE is having low moisture, light and oxygen barrier property which contributed to more colour changes during 90 days of storage studies.

Texture

Texture of the control and oat cookies decreased in all packaging materials as compared to fibre rich cookies with pomace powders. The decrease in texture score was due to absorption of moisture that has negative effect on texture[12, 18]. It can observed from Table 1 and 5 that decrease in the texture scores of control and oat cookies was pronounced in LDPE pouches as compared to LDPE plus PET Jar and metalized pouches due to poor moisture barrier property of LDPE. Decrease in texture score was more in oat cookies as compared to control cookies which might be due to less initial moisture in oat cookies which leads to more absorption of moisture through atmosphere during storage.

Passages of openings of various sizes were present in the material forming main structure of cookies that influenced the interaction between the inside of the biscuit and the atmosphere[6]. Addition of pomace powder rendered the structure of cookies compact and resulted in less development of these passages which might be responsible for less ingress of moisture by cookies resulting in better texture and crispness.

It is evident from Table 2, 3 and 4 that texture of cookies with beetroot pomace powder showed least changes as compared to cookies with apple and carrot pomace powder during the storage of 90 days. It can be attributed to lesser top graining in cookies with beetroot pomace which might have resulted in comparatively less ingress of moisture as compared to cookies with apple and carrot pomace powder.

Taste

It can be observed from the results that cookies packed in the LDPE pouch showed pronounced decrease in the score during 90 days of storage as compared to other packaging materials. Taste was found to be affected probably due to lipolytic changes; hastened by increase in moisture content of cookies[23].

Table 1 and 5 indicates that oat cookies packed in PET jar exhibited more changes in taste followed by control cookies as compared to cookies with pomace powder. Oat cookies stored in metalized pouch exhibited good taste. Study has shown that free fatty acid content of oat bran incorporated biscuit stored in laminate was within permissible limits[13].

It is evident from Table 2, 3 and 4 that cookies with apple pomace powder stored in LDPE pouch showed least scores as compared to cookies with carrot and beetroot pomace and were found to be excessively sweet. This might be because of development of reducing sugars during the storage period[19]. Beetroot and apple pomace cookies packed in PET jar, LDPE plus PET jar and metalized pouch showed lesser decrease in taste score and found to maintain peculiar taste of beetroot and fruity taste of apple respectively.

Flavour

Storage period had pronounced effect on the flavour of the cookies and greatly affected the sensory quality of the cookies. Flavour score for all cookies was found to be progressively decreasing in LDPE. More pronounced effect was observed in oat cookies followed by control cookies which might be due to oxidation of fats.

Photosensitivity has influence on the oxidation of oat lipids and resultant production of volatile oxidation products leading to poor sensory attributes[8]; hence, oat cookies were found to be maintaining good flavour only in metalized pouch.

Cookies with pomace powders showed less flavour changes in LDPE as compared to oat and control cookies. Better flavour retention in cookies with pomace

powders can be attributed to natural antioxidants present in the pomaces which might have delayed the onset of rancidity. It is evident from Table 2, 3 and 4 that flavour score was highest in cookies with beetroot pomace powder followed by apple and carrot. Same trend was observed in cookies with pomace powders stored in other packaging materials. This could be attributed to strong antioxidant activity of beetroot pomace[2].

Carrot pomace cookies have significantly higher levels of total phenolic content as compared to control cookies[9]. Incorporation of relatively large percentage of carrot dietary fibre in the dry fermented sausage was found to affect the lipolytic process during the storage[7]. Hence, cookies with pomace powders maintained better flavour as compared to control and oat cookies owing to their inherent antioxidants.

Overall acceptability

Pronounced effect on overall acceptability of the cookies was found in LDPE pouches and it was observed that overall acceptability of the cookies stored in LDPE significantly decreased with the passage of time. Beetroot pomace cookies showed comparatively better overall acceptability in PET jar as compared to control cookies, oat cookies and cookies with carrot and apple pomace powder. Better overall acceptability in cookies with beetroot pomace powder could be attributed to lesser deteriorative changes like development of rancidity and ingress of moisture.

Cookies with apple, carrot and beetroot pomace powder showed better overall acceptability in LDPE plus Pet jar as compared to control and oat cookies. All cookies stored in metalized pouch showed good score for overall acceptability.

Table 1: Effect of different packaging materials on sensory attributes of the control cookies during storage

Parameter	Packaging Material	Days				SE±	CD at 5%
		0	30	60	90		
Colour and Appearance	**P_1**	8.3	7.9	7.2	6.7	0.052	0.150
	P_2	8.3	8.1	7.4	6.9	0.062	0.180
	P_3	8.3	8.3	7.7	7.2	0.047	0.135
	P_4	8.3	8.3	7.9	7.5	0.047	0.135
Texture	**P_1**	8.4	7.5	6.7	6.0	0.069	0.199
	P_2	8.4	8.1	7.2	6.7	0.085	0.245
	P_3	8.4	8.3	7.6	7.1	0.071	0.204
	P_4	8.4	8.3	7.9	7.3	0.069	0.199
Taste	**P_1**	7.9	7.4	7.0	6.4	0.065	0.187
	P_2	7.9	7.4	7.2	6.8	0.063	0.181
	P_3	7.9	7.9	7.5	7.2	0.043	0.124
	P_4	7.9	7.9	7.7	7.5	0.051	0.147
Flavour	**P_1**	7.9	7.0	6.3	5.8	0.039	0.112
	P_2	7.9	7.2	6.5	6.2	0.067	0.193
	P_3	7.9	7.4	7.1	6.2	0.047	0.131
	P_4	7.9	7.6	6.9	6.6	0.014	0.040
Overall Acceptability	**P_1**	8.0	7.5	6.8	6.5	0.041	0.118
	P_2	8.0	7.7	7.0	6.5	0.031	0.089
	P_3	8.0	7.7	7.1	6.7	0.024	0.069
	P_4	8.0	7.7	7.2	6.9	0.039	0.112

*P_1-LDPE pouch, P_2-PET jar, P_3-LDPE pouch in PET jar, P_4- Metalized pouch

* Each value is average of 10 determinations

Table 2: Effect of different packaging materials on sensory attributes of the cookies incorporated with apple pomace powder during storage

Parameter	Packaging Material	Days				SE±	CD at 5%
		0	30	60	90		
Colour and Appearance	P_1	8.0	8.0	6.7	6.2	0.023	0.066
	P_2	8.0	8.0	7.0	6.6	0.031	0.089
	P_3	8.0	8.0	7.0	6.8	0.011	0.031
	P_4	8.0	8.0	7.5	7.0	0.023	0.066
Texture	P_1	8.0	8.0	6.7	6.3	0.031	0.089
	P_2	8.0	8.0	7.1	6.4	0.023	0.066
	P_3	8.0	8.0	7.4	7.0	0.021	0.060
	P_4	8.0	8.0	7.4	7.2	0.031	0.089
Taste	P_1	8.6	8.2	7.5	6.7	0.059	0.170
	P_2	8.6	8.4	7.8	7.5	0.067	0.193
	P_3	8.6	8.6	8.0	8.0	0.053	0.152
	P_4	8.6	8.6	8.0	8.0	0.053	0.152
Flavour	P_1	8.6	8.1	7.2	6.8	0.057	0.164
	P_2	8.6	8.2	7.4	7.1	0.064	0.184
	P_3	8.6	8.6	7.7	7.3	0.071	0.204
	P_4	8.6	8.6	7.8	7.5	0.079	0.227
Overall Acceptability	P_1	8.5	8.0	7.0	6.5	0.067	0.193
	P_2	8.5	8.1	7.3	6.5	0.075	0.216
	P_3	8.5	8.3	7.5	7.2	0.077	0.222
	P_4	8.5	8.3	7.6	7.4	0.079	0.227

*P_1-LDPE pouch, P_2-PET jar, P_3-LDPE pouch in PET jar, P_4- Metalized pouch
* Each value is average of 10 determinations

Table 3: Effect of different packaging materials on sensory attributes of the cookies incorporated with carrot pomace powder during storage

Parameter	Packaging Material	Days				SE±	CD at 5%
		0	30	60	90		
Colour and Appearance	P_1	8.9	7.9	7.1	6.8	0.023	0.066
	P_2	8.9	8.3	7.2	7.0	0.039	0.112
	P_3	8.9	8.3	8.1	7.8	0.043	0.124
	P_4	8.9	8.8	8.3	8.3	0.067	0.193
Texture	P_1	8.0	7.6	6.9	6.2	0.043	0.124
	P_2	8.0	7.8	7.3	6.7	0.051	0.147
	P_3	8.0	8.0	7.7	7.1	0.024	0.069
	P_4	8.0	8.0	7.7	7.1	0.024	0.069
Taste	P_1	8.3	7.8	7.2	6.3	0.067	0.193
	P_2	8.3	8.0	7.5	7.2	0.071	0.204
	P_3	8.3	8.3	7.9	7.5	0.074	0.213
	P_4	8.3	8.3	7.9	7.5	0.074	0.213
Flavour	P_1	8.2	7.4	6.9	6.1	0.041	0.118
	P_2	8.2	7.6	7.1	6.6	0.063	0.181
	P_3	8.2	7.9	7.2	6.9	0.041	0.118
	P_4	8.2	8.0	7.7	7.4	0.052	0.150
Overall Acceptability	P_1	8.3	7.7	7.0	6.5	0.077	0.222
	P_2	8.3	7.9	7.2	6.8	0.063	0.181
	P_3	8.3	8.1	7.7	7.3	0.059	0.170
	P_4	8.3	8.2	7.9	7.5	0.067	0.193

Table 4: Effect of different packaging materials on sensory attributes of the cookies incorporated with beetroot pomace powder during storage

Parameter	Packaging Material	Days				SE±	CD at 5%
		0	30	60	90		
Colour and Appearance	P_1	7.7	7.1	6.6	6.0	0.067	0.193
	P_2	7.7	7.4	6.6	6.2	0.074	0.213
	P_3	7.7	7.4	6.8	6.4	0.075	0.216
	P_4	7.7	7.7	7.1	6.9	0.071	0.204
Texture	P_1	8.0	7.6	7.3	7.0	0.053	0.152
	P_2	8.0	7.8	7.5	7.3	0.067	0.193
	P_3	8.0	8.0	7.8	7.6	0.047	0.135
	P_4	8.0	8.0	7.8	7.6	0.047	0.135
Taste	P_1	8.4	8.0	7.9	7.1	0.051	0.147
	P_2	8.4	8.2	7.7	7.4	0.069	0.199
	P_3	8.4	8.1	8.0	8.0	0.047	0.135
	P_4	8.4	8.3	8.0	8.0	0.054	0.155
Flavour	P_1	8.6	8.4	7.7	7.3	0.077	0.222
	P_2	8.6	8.4	8.1	7.8	0.069	0.199
	P_3	8.6	8.4	8.1	7.9	0.067	0.193
	P_4	8.6	8.6	8.4	8.1	0.075	0.216
Overall Acceptability	P_1	8.2	7.8	7.4	6.8	0.067	0.193
	P_2	8.2	8.0	7.4	7.3	0.063	0.181
	P_3	8.2	8.1	7.7	7.5	0.069	0.199
	P_4	8.2	8.1	7.9	7.7	0.057	0.164

*P_1-LDPE pouch, P_2-PET jar, P_3-LDPE pouch in PET jar, P_4- Metalized pouch

* Each value is average of 10 determinations

Table 5: Effect of different packaging materials on sensory attributes of the oat cookies during storage

Parameter	Packaging Material	Days				SE±	CD at 5%
		0	30	60	90		
Colour And Appearance	P_1	8.5	7.9	6.9	6.5	0.075	0.216
	P_2	8.5	8.2	7.1	6.7	0.069	0.199
	P_3	8.5	8.5	7.4	7.0	0.079	0.227
	P_4	8.5	8.5	7.8	7.1	0.075	0.216
Texture	P_1	8.5	7.9	7.1	5.8	0.053	0.152
	P_2	8.5	7.3	6.9	6.1	0.077	0.222
	P_3	8.5	8.0	7.5	6.4	0.069	0.199
	P_4	8.5	8.2	7.8	7.3	0.073	0.210
Taste	P_1	8.3	7.2	6.3	5.8	0.067	0.193
	P_2	8.3	7.4	6.6	6.1	0.073	0.210
	P_3	8.3	7.4	6.8	6.4	0.073	0.210
	P_4	8.3	8.1	7.7	7.3	0.067	0.193
Flavour	P_1	8.1	6.8	5.9	5.3	0.031	0.089
	P_2	8.1	7.1	6.3	5.7	0.053	0.152
	P_3	8.1	7.3	6.9	6.3	0.053	0.152
	P_4	8.1	7.8	7.3	7.1	0.047	0.135
Overall Acceptability	P_1	8.0	7.4	6.5	5.9	0.067	0.193
	P_2	8.0	7.5	6.7	6.2	0.067	0.193
	P_3	8.0	7.8	7.1	6.7	0.055	0.158
	P_4	8.0	7.8	7.6	7.1	0.059	0.170

CONCLUSION

Fruit and vegetable pomace powders used for the fibre enrichment of cookies also exert strong influence on the sensory attributes of cookies during storage. Predominantly the detrimental effect was only observed in the colour of cookies which were incorporated with pomace powders; otherwise these cookies maintained better sensory attributes as compared to control and oat cookies. Thus, cookies incorporated with pomace powder have better storage stability compared to control cookies and oat cookies. Hence, fibre rich cookies prepared using fruit and vegetable pomace powder demand comparatively simple packaging requirements as compared to control and oat cookies. Metalized pouch and LDPE pouch in PET jar were found to be superior packaging materials for packaging of cookies.

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REFERENCES

1. Agrawal, A., Scope of betalains as a food colorant. *International J. of Advanced Scientific and Technical Research*, **3(3):** 22-36 (2013).
2. Attia, G. Y., Moussa, M. E. M., & Sheashea, E. R., Characterization of Red Pigments Extracted From Red Beet (Beta Vulgaris, L.) and Its Potential Uses As Antioxidant and Natural Food Colorants. *Egypt. J. Agric. Res*, *91***(3):** 1095-1110 (2013).
3. Bender, A. E., Nutritional effects of food processing. *International Journal of Food Science & Technology*, **1(4):** 261-289 (1966).
4. Bohm. V., Otto. K., Weissleder, F., Yield of juice and carotenoids of the carrot juice production, In: *Symposium Jena-Thuringen*, Germany,115–119 (1999).
5. Boon, C. S., McClements, D. J., Weiss, J., & Decker, E. A., Factors influencing the chemical stability of carotenoids in foods. *Critical reviews in food science and nutrition*, **50(6):** 515-532 (2010).
6. Dachana, K. B., Rajiv, J., Indrani, D., & Prakash, J., Effect of dried Moringa (Moringa Oleifera Lam) leaves on rheological, microstructural, nutritional, textural and organoleptic characteristics of cookies. *Journal of Food Quality*, **33(5):** 660-677 (2010).
7. Eim, V. S., Simal, S., Rosselló, C., & Femenia, A., Effects of addition of carrot dietary fibre on the ripening process of a dry fermented sausage (sobrassada). *Meat Science*, **80(2):** 173-182 (2008).
8. Heinio, R. L., Lehtinen, P., Oksman-Caldentey, K. M., & Poutanen, K., Differences between sensory profiles and development of rancidity during long-term storage of native and processed oat. *Cereal Chemistry*, **79(3):** 367(2002).
9. Hernández-Ortega, M., Kissangou, G., Necoechea-Mondragón, H., Sánchez-Pardo, M. E., & Ortiz-Moreno, A., Microwave dried carrot pomace as a source of fiber and carotenoids. *Food and Nutrition Sciences*, **4:** 1037-1046 (2013).
10. Lavelli, V., & Corti, S., Phloridzin and other phytochemicals in apple pomace: Stability evaluation upon dehydration and storage of dried product. *Food chemistry*, **129(4):** 1578-1583 (2011).
11. Manley, D., Technology of biscuits, crackers and cookies. 3rd ed.Woodhead Pub. Ltd., Cambridge, U.K. (2011).
12. McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V., Hung, Y. C., & Phillips, R. D., Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (Digitaria exilis) and cowpea (Vigna unguiculata) flours. *International journal of food science & technology*, **38(4):** 403-410 (2003).
13. Nagi, H. P. S., Kaur, J., Dar, B. N., & Sharma, S., Effect of storage period and packaging on the shelf life of cereal bran incorporated biscuits. *American Journal of Food Technology*, **7(5):** 301-310 (2012).

14. Panse, V. S. and Sukhatme, P. V., Statistical Methods for Agricultural Workers, I.C.A.R., New Delhi, 70-72 (1984).
15. Ranganna, S., Handbook of analysis and quality control for fruit and vegetable products, 2nd Edition, Tata Mcgraw Hill (2011).
16. Sahni, P., Why to waste 'The Waste'? Make fibre rich cookies!. *Daily Post, Daily Ludhiana*, pp. P4 (2017, January 13).
17. Serena, A. & Kundsen, B., Chemical and physicochemical characterisation of co-products from vegetable food and agro industries. *Animal Feed Science and Technology*, **139:** 109–124 (2007).
18. Sharif, K., Sadiq Butt, M., & Huma, N., Oil extraction from rice industrial waste and its effect on physico-chemical characteristics of cookies. *Nutrition & Food Science*, **35(6):** 416-427 (2007).
19. Sharma, K.D., Alkesh and Kaushal, B.B.L., Quality of apple powder affected by packaging material during storage. *Journal of Scientific and Industrial Research*, **62:** 609-615 (2003).
20. Shyamala, B. N., & Jamuna, P., Nutritional content and antioxidant properties of pulp waste from Daucus carota and Beta vulgaris. *Malaysian journal of nutrition*, **16(3):** 397-408 (2010).
21. Sra, S. K., Sandhu, K. S., & Ahluwalia, P., Effect of treatments and packaging on the quality of dried carrot slices during storage. *Journal of food science and technology*, **51(4):** 645-654 (2014).
22. Von Elbe, J. H., Stability of betalaines as foodcolors. *Food Technology*, **5:** 42-44. (2014).
23. Wade, P., Biscuit, cookies and crackers: The principles of the craft. **Vol. I.** Elsevier Applied Sci., London (1988).
24. Woo, K. K., Ngou, F. H., Ngo, L. S., Soong, W. K., & Tang, P. Y., Stability of betalain pigment from red dragon fruit (*Hylocereus polyrhizus*). *American Journal of Food Technology*, **6(2):** 140-148 (1988).