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Development of Apple Pomace Enriched Oat Flour Biscuits and its Quality Evaluation during Storage

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A B S T R A C T

This study was conducted to investigate the physico-chemical characteristics of oat flour and apple pomace enriched oat flour biscuits. Biscuits were prepared with different level of oat flour and apple pomace powder and the physico-chemical properties were examined after the evaluation of sensory characteristics. Total phenols and crude fibre content of apple pomace enriched biscuits are more than the control biscuits. Among different combinations tried 70% oat flour and 30% apple pomace powder forbiscuits was optimized for the preparation of acceptable and palatable bakery products. The study suggested that oat flour along with apple pomace powder can successfully be utilized in biscuit due to their enhanced nutritional, functional and sensory characteristics.

Introduction

Oat is an important cereal crop of developing world, belongs to family Poaceae (Butt *et al.*, 2008). The common oat (*Avena sativa* L.) is most widely used species for food and feed purpose, has a hulled grain and depending on the colour of hull can be divided into white, yellow and black varieties (Kourimska *et al.*, 2018).It is a cereal crop of Mediterranean, Middle East origin and domestication of oats occurred much later than for wheat and barley (Q and Hoffman, 1992).

Oat is also known as "Super grain" due to its rich nutritional profile (Kaur *et al.*, 2019). It has been reported that the grains contain high dietary fibre content and bioactive compounds. Chemically, it consists of 8.22 per cent moisture content, 66.27 per cent carbohydrates, 16.89 per cent protein, 9.70 per cent fibre and 6.90 per cent lipids (Sterna *et al.*, 2016). The oat is considered to be a good source of polyunsaturated essential fatty acid (Biel *et al.*, 2009). The proportion of unsaturated fatty acids i.e. oleic, linoleic and linolenic acid in oat is about 75 per cent of all fatty acid. Rybicka and Swiglo (2017) have

observed 5 mg/100 g manganese, 7 mg/100 g iron, 140 mg/100 g magnesium, 95 mg/ 100 g calcium, 460 mg/ 100 g potassium and 340 mg/100 g phosphorous in oat grains. It also contains carotenoids, betaline, choline, phytic acid, lignins, lignane, alkyl resorcinols and micronutrients such as vitamin E, folates, zinc, iron, selenium, copper, manganese along with sulphur containing amino acids (Flander *et al.*, 2007).

Oat is known for an unique group of antioxidants known as aventhramide (Dimberg *et al.,* 1993 and Meydani, 2009). It is involved in controlling blood pressure, helps in lowering of serum cholesterol level and postprandial glycemic response. Oat β-glucan is a plant polysaccharide resistant to digestion, absorption in the small intestine and it attenuates blood cholesterol and blood glucose level. Oat based food products like bread, biscuit, cookies, pre- and pro- biotic drink, flakes and infant food are gaining popularity owing to their high nutritional value. Further, incorporation of fruits or their by-products in oat based processed products provide greater potential in increasing phyto-chemical compounds like phenolic acid and flavonoids having antioxidant properties. Owing to high bioactive content, utilization of apple pomace seems to be an advantageous step because they are less expensive and non-caloric bulking agents which enhance the oil and water retention capacity of the oat-based products besides, improving the oxidative and emulsion stabilities (Elleuch *et al.*, 2011).

Apple (*Malus domestica* Borkh.) belonging to the Rosaceae family and Pomoidae sub-family, is a perennial long lived woody fruit crop (Hussain *et al.,* 2014). An English proverb initially originated from Wales says that ‘An apple a day keeps the doctor away’ and thus refers to the high nutritional and therapeutic properties of the fruit. The trend of apple processing from entire production along the globe, 71 per cent of the fruit is consumed for table purposes as fresh apple while about 20 per cent is processed into value added products, of which 65 per cent are processed into apple juice concentrate and 35 per cent processed into RTS apple juice, apple wine, cider, apple purees, jams and dried apple products (Downing, 1989).

In apple processing industries, two types of waste are generated. The first type is the partially bruised or spoiled fruits discarded into sorting belt while second type is the apple pomace obtained after juice extraction. The residue left after extraction of apple juice is termed as pomace which is generally thrown as waste. In India, about 1.00 million tonne apple pomace is produced per annum and only approximately 10,000 tonnes are being utilized (Shalini and Gupta, 2010).

Apple pomace is considered as a potential food ingredient as it contains 4.22-8.67mg/ g phenolics, 0.45-1.19 mg/ g flavonoids and 2.27- 9.51 mg/ g flavan-3-ols (Cetkovic *et al*., 2008). The consumption of apple and apple products has been reported to have several health benefits on humans such as prevention of cancer, reduced risk of cardiovascular diseases, decrease in asthma and diabetes. Further, malic acid in apple facilitates the dissolution of lime deposits in body to guard it against rheumatism, fibrosis and arthritis. Apple pomace has been reported to be a superior water binder to wheat and oat bran (Chen *et al.,* 1988).

Recently, health awareness amongst the common people around the globe has increased the demand of certain foods which provide necessary nutrients, prevent nutrition related disorders and improve physical and mental wellbeing of consumer (Sharma *et al.*, 2015). Such foods and food products are popularly known as functional foods or health foods. In the development of functional foods,

researchers are looking for new sources and carriers of the bioactive substances. Therefore, both oat as well as dried apple pomace powder being a rich source of dietary fibre and antioxidants can easily be utilized in the development of various food products particularly to improve the quality of baked products besides, enhancing the disease preventive properties and ultimate health benefits.

Materials and Methods

Oat flour was procured from Flour and Oil Industries, Ludhiana however, apple of Red Delicious and Golden Delicious variety was purchased from local fruit and vegetable market, Solan, Himachal Pradesh. The other material such as sugar, salt, baking powder, cumin, fat and polyethylene pouches etc were procured from local market at Solan. The apple fruits were sorted, washed thoroughly with water and sliced. The slices were then passed through a grater and juice was extracted by hydraulic press (Sharma *et al.*, 2014). At last, the pomace obtained was dried in the cabinet drier at 50 ± 2˚C for 24 h. Dried pomace was then ground in Willey grinder and passed through 30 mesh sieve (500µm). Ground apple pomace was packed and stored in refrigerated conditions for further use.

Standardization of different proportion of oat and apple pomace powder for preparation of biscuit

For preparation of biscuits, standard method described by Baljeet *et al.,* (2010) with some modifications was used and formulations of biscuit shown in Table 1 and pictorial representation in figure 1. Different combinations of the ingredients were tried (Table 2), got sensory evaluated and best recipe was selected for further study. The powdered sugar was mixed with refined oil and the mixture was beaten until it becomes light and fluffy. The sieved oat flour and sodium bicarbonate along with salt and skim milk powder were added to the fluffy mass and mixed thoroughly to form soft dough. The dough was kneaded properly for 10 min and wrapped in an aluminium foil.

The dough was allowed to stand at room temperature for 30 min. The dough was converted into small balls and the balls were flattened into sheets. The flattened sheet was cut into a shape by using biscuit cutter. The cut shapes were placed on a baking tray lined with butter paper and baked in an oven 190˚C for 15 min. The best treatment/ combinations was selected based on sensory evaluation for further studies.

Physico-chemical and sensory evaluation

Moisture content, ash, carbohydrate, total soluble solid, titratable acidity and ascorbic acid was estimated by standard procedures of Ranganna (Ranganna, 2019). Whereas, crude fibre and fat of biscuit can be estimated by according to standard procedures by AOAC (2012). The total dietary fibre could be calculated by AOAC (1997), total phenols by Bray and Thorpe (1954) total sugars by Lane and Eynon (1923) and antioxidant activity by Williams *et al.*, (1995).

Sensory evaluation

Nine-point hedonic scale method proposed by Amerine *et al.,* (1965) was followed for conducting the sensory evaluation of product. A panel of ten judges comprising of faculty members and post graduate students of the department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) were selected with care to evaluate the product for various sensory parameters such as color, texture, taste and overall acceptability.

Statistical analysis

Data on physico-chemical characteristics of biscuits before and during storage was analyzed by Completely Randomized Design (CRD) suggested by Cochran and Cox (1967). While Randomized Complete Block Design (RBD) as described by Mahony (1985) was used to analyze the data pertaining to sensory evaluation.

Microbial evaluation

Total plate count (TPC) was calculated by aseptically inoculating 0.1g of serially diluted samples in total plate count/standard plate count agar medium prepared according to Ranganna (1997). One mL of the sample after serial dilution (10^{-2}, 10^{-4}, 10^{-6} and 10^{-8}) was aseptically inoculated in pre-sterilized plates followed by pouring total plate count agar (10-15 mL) under sterilized environment of laminar air flow. The plates were then inoculated at 37˚Cfor 72 h prior counting of microbes. The results of the TPC were expressed as log CFU/ mL of sample.

Results and Discussion

In this research, different chemical characteristics of oat flour and apple pomace enriched biscuits were analyzed using standard procedures. Table 3 shows the chemical characteristics of oat flour which is used in this study. The oat flour has 7.46 ± 0.78% moisture content, 68.28 ± 2.01 % carbohydrate content and 13.90 ± 0.09 % total dietary fibre. These results were satisfied with Ashok (2011), Tiwari *et al.,* (2018), Sandhuet al., (2017), Wang *et al.,* (2011) and Purhagen *et al.,* (2012). Whereas, Table 4 shows the chemical characteristics of dehydrated apple pomace powder. The composition of apple pomace powder consist moisture content 6.86 ± 1.48%, total dietary fibre 44.32 ± 0.06% and crude fibre 20.50 ± 0.05%. Sudha *et al.,* (2007) and Gazalli *et al.,* (2014) observed the same results.

Sensory evaluation

Sensory evaluation of biscuits containing different levels of oat flour and apple pomace powder is shown in Table 5. The biscuits which have 70% oat flour and 30% apple pomace powder got the highest scores and after that on the basis of sensory score storage study has done i.e. biscuits which have (T_5) 70% oat flour and 30% apple pomace powder and control (T_0) 100% oat flour.

Chemical composition of apple pomace enriched oat flour biscuit

The data of chemical characteristics of selected treatments of biscuits on the basis of sensory evaluation pertaining in table 6. The chemical characteristics where moisture content of whole oat flour biscuits are 3.15%, fat 28.05%, total sugars 15.61%, total phenols 5.17 mg/g and crude fibre 3.82%. Whereas, the chemical characteristics of selected treatment i.e. 70% oat flour+ 30% apple pomace powder biscuits are 4.96% moisture, 21.46% fat, 19.72% total sugars, 6.24mg/g total phenols and 8.52% crude fibre.

Storage studies of biscuits

The biscuits are packed in polyethylene pouches and stored for further studies at ambient and refrigerated conditions. The overall effect of storage period of 90 days on moisture content of biscuits reveals an increase with the increase in time interval and also achieved higher value under ambient conditions and lower in refrigerated conditions which may be due to the presence of dietary fibre in apple pomace powder (Fig. 2a). Our findings are conformity with the results of Pasha *et al.,* (2002) and Sharma *et al.,* (2016) in dietary cookies. The overall

effect of storage period of 90 days depicts decrease which may be due to hydrolysis of triglycerides or increase moisture content (Fig. 2b). The overall effect of storage conditions recorded the higher value under refrigerated condition and low value under ambient condition. During the storage of 90 days fat content decrease with time interval. A similar trend was followed by Butt *et al.*, (2008) and Mushtaq *et al.*, (2010) in their studies.

The oat flour and apple pomace enriched biscuits showed a significant increase in total sugars and also the data higher under ambient and lower under refrigerated condition in polyethylene pouches during storage of 90 days (Fig. 2c). The increase in total sugars might be due to partial hydrolysis of starch. Almost the same trend of change in total sugars has been observed by Penfield and Campbell (1990).

A significant difference was recorded in total phenols of biscuits under ambient and refrigerated conditions and also decreased during 90 days (Fig. 2d). The changes might have occurred due to phenolic compounds getting oxidized during storage in the presence of light or other environmental conditions. Similar results were also reported by Kannan and Thirumaran (2001) in their results. Similarly, data of crude fibre reflects in figure 2e which shows the crude fibre content decrease during storage for 90 days. The changes may have occurred due to moisture absorption by the biscuit. A similar trend was followed by Pasha [36] and Mushtaq [38] in their findings.

Table.1 Formulations of biscuit

Ingredient	Composition (g)
Oat flour	100.00
Fat	35.00
Sugar powder	35.00
Skim milk powder	20.00
Sodium bicarbonate	2.50
Cumin	2.40
Salt	2.00

Table.2 Detail of treatments for the preparation of biscuit

Treatment	Proportion (%)	
	Oat flour	**Apple pomace powder**
T_0	100	0
T_1	90	10
T_2	85	15
T_3	80	20
T_4	75	25
T_5	70	30
T_6	65	35

Table.3 Chemical composition of oat flour

Characteristics	Oat flour (Mean ± S.E.)
Moisture (%)	7.46 ± 0.78
Carbohydrate (%)	68.28 ± 2.01
Protein (%)	10.15 ± 0.13
Fat (%)	8.80 ± 0.07
Total dietary fibre (%)	13.90 ± 0.09
Crude fibre (%)	4.07 ± 0.02
Ash (%)	1.24 ± 0.04

Table.4 Chemical composition of dehydrated apple pomace powder

Characteristic	Dehydrated apple pomace powder (Mean ± S.E.)
Moisture (%)	6.86 ± 1.48
Total solids (%)	93.14 ± 1.89
Total sugars (%)	22.75 ± 0.20
Total dietary fibre (%)	44.32 ± 0.06
Crude fibre (%)	20.50 ± 0.05
Total phenols (mg/ g)	8.72 ± 0.04
Total soluble solids (^{0}B)	25.36 ± 0.03
Titratable acidity (as % malic acid)	1.05 ± 0.02
Ascorbic acid (mg/ 100 g)	10.07 ± 0.27
Ash (%)	1.39 ± 0.08

Table.5 Sensory evaluation of oat-based apple pomace powder enriched biscuit

Treatment	Color	Texture	Taste	Overall acceptability
T_0 (100% OF)	8.01	7.50	7.40	7.50
T_1 (90% OF + 10% APP)	7.83	7.70	7.60	7.71
T_2 (85% OF + 15% APP)	7.75	7.80	7.71	7.80
T_3 (80% OF + 20% APP)	7.67	7.86	7.84	7.89
T_4 (75% OF + 25% APP)	7.59	7.93	7.98	7.97
T_5(70% OF + 30% APP)	7.46	8.05	8.10	8.08
T_6 (65% OF + 35% APP)	7.30	8.03	7.90	8.01
CD $_{(0.05)}$	0.10	0.03	0.10	0.02

Table.6 Chemical characteristics of biscuits

Chemical characteristics	Oat flour biscuit (100%)	Oat flour + apple pomace powder biscuit (70% + 30%)
Moisture (%)	3.15	4.96
Fat (%)	28.05	21.46
Total sugar (%)	15.61	19.72
Total phenols (mg/g)	5.17	6.24
Crude fibre (%)	3.82	8.52

Fig.1 Pictorial representation of preparation of biscuit

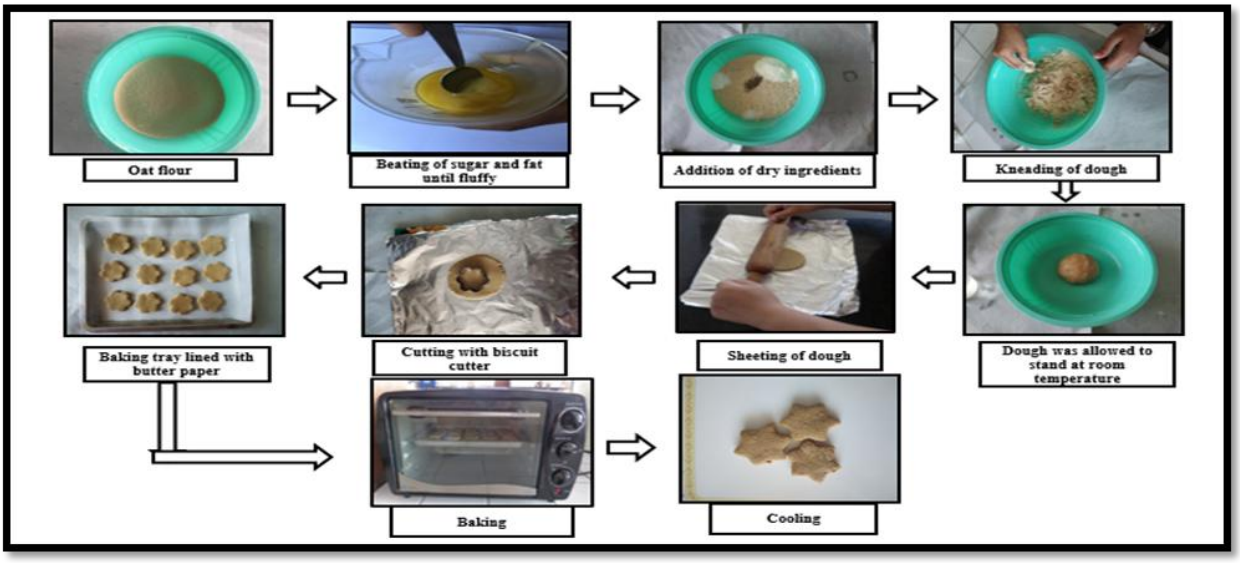
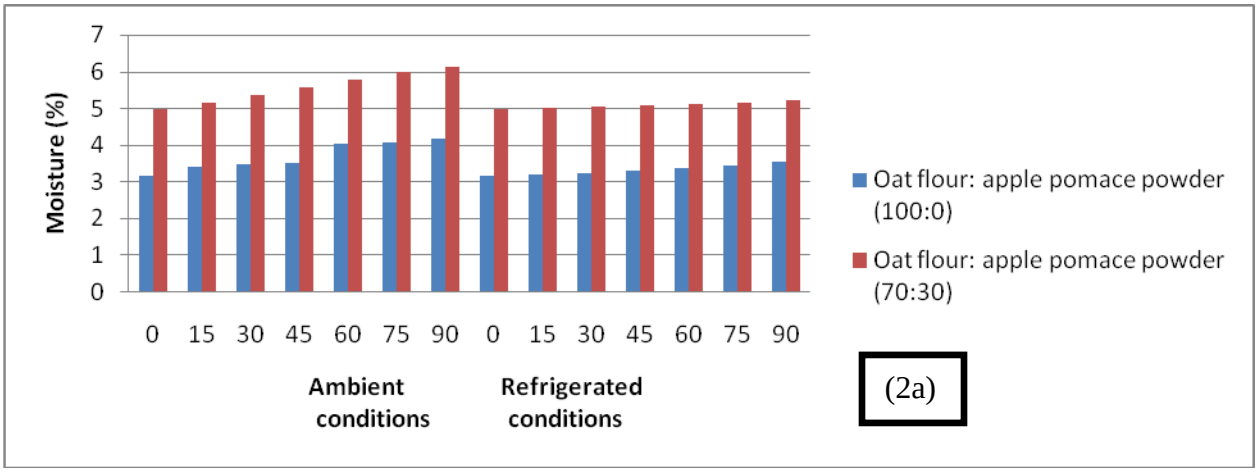
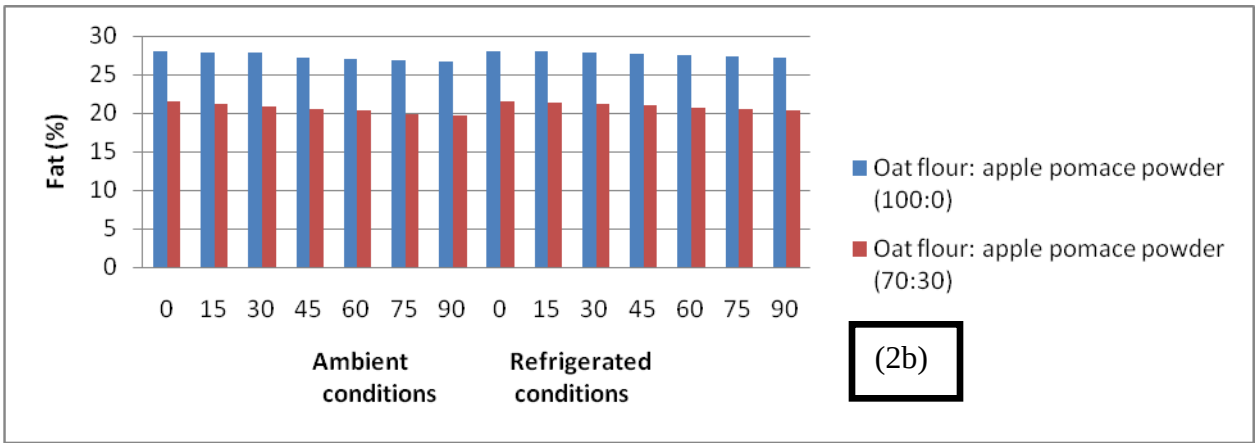
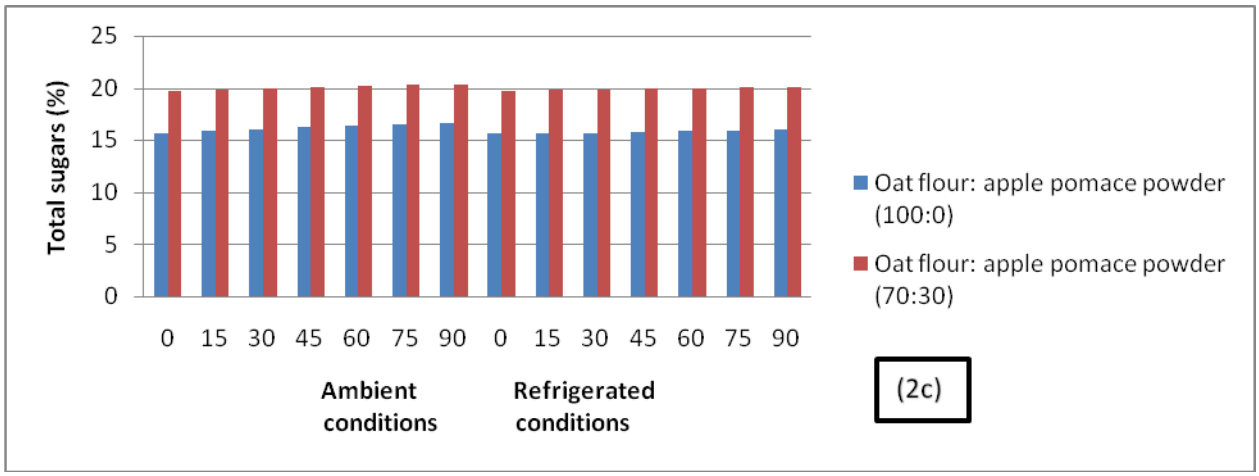
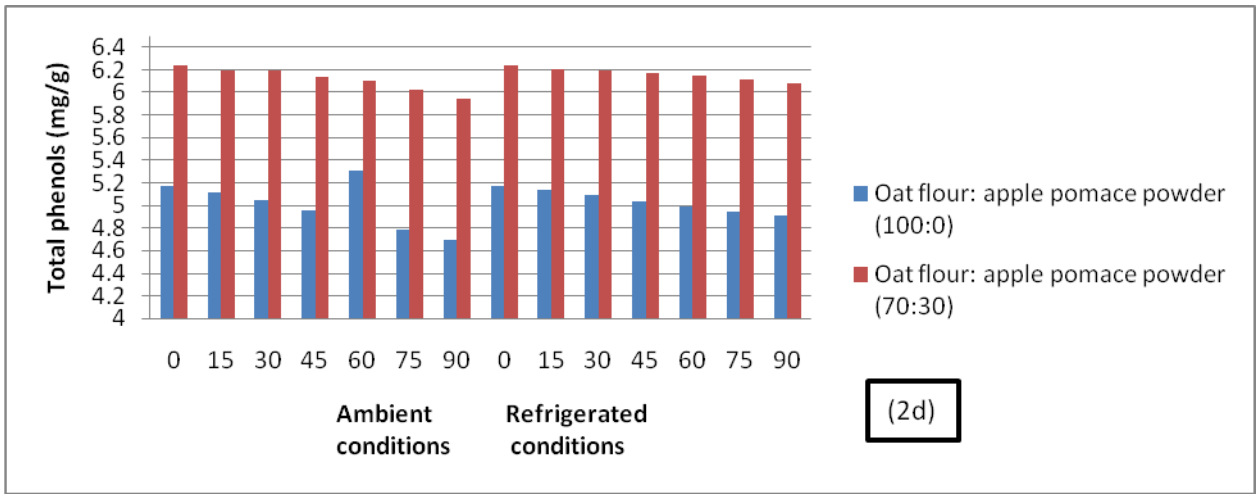


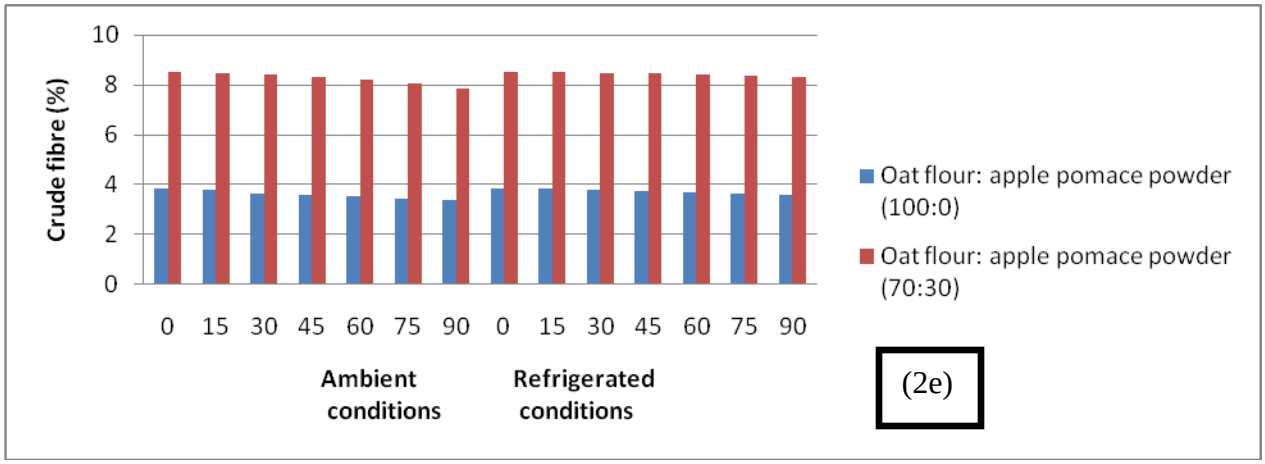
Fig.2 Storage studies of biscuits











Effect of storage on microbial load of biscuits

Microbiological quality measured as total plate count in biscuit observed the absence of any microbial growth at ambient condition (Appendix-II) on 0 day. Whereas, at 90 days of storage, the total plate count was comparatively more at ambient condition as compared to refrigerated condition however,

the growth of micro-organisms was within the safe limits as suggested under the Food Safety and Standards Act of India (FSSAI) and therefore, the biscuits after storage of 90 days were safe to consume.

In conclusion, the oat flour and apple pomace powder increase the nutritive properties of the product. The enrichment of oat flour with apple pomace powder is good for health and also improved the sensory characteristics of biscuits. This study, different combinations of oat flour and apple pomace powder tried but the treatment which has 70% oat flour and 30% apple pomace powder got the highest scores. The prepared products improved and retained higher amounts of functional constituents like fibre and total phenols. The apple pomace powder enriched oat flour biscuits could be stored safely under ambient and refrigerated conditions at 90 days. Therefore, it is concluded that oat flour along with apple pomace powder can successfully be utilized in bakery products resulting in enhanced nutritional, functional and sensory characteristics.

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