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Effect of pumpkin powder incorporation on the physico-chemical, sensory and nutritional characteristics of wheat flour muffins

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Abstract

Muffins are ready-to-eat snack foods largely consumed by children. They are usually made with wheat flour which contains a limited amount of β-carotene which is a precursor of vitamin A. Pumpkin is a rich source of β-carotene, which is responsible for its yellow or orange colour. The objective of this study was to determine the optimum level of substitution of carotene rich pumpkin powder in the formulation of muffins and to assess the quality of muffins. The prepared pumpkin powder was assessed for proximate parameters. Muffins were prepared by replacing wheat flour with pumpkin powder at different levels (viz. 10%, 20%, 40%, 60% and 80%) and were assessed for their proximate, texture and sensory parameters by packing in polyethylene (PE) and metallised polyester polyethylene (MPE) pouches. Pumpkin powder contained 6.9% moisture, 2.6% protein, 4.8% ash, 8.9% fibre, and 312.4 mg/100 g of total carotene (on dry basis). The influence of replacement of wheat flour with pumpkin powder in the formulation of muffins resulted in changes in the sensory quality of muffins. Sensory evaluation indicated that muffin with pumpkin powder incorporated at the level of 20% was found to be more acceptable. Substitution beyond 20% affected the colour and overall acceptability of the product. Adding pumpkin powder not only increases the nutritive value of muffins, but also brings about a value addition to pumpkin.

Introduction

Pumpkin belongs to the family Cucurbitaceae that includes gourds, melons and squashes. They are of three common types worldwide, namely *Curcurbita pepo, Curcurbita maxima* and *Curcurbita moschata* (Lee *et al*., 2003). Pumpkins generally weigh 9-18 lbs (4-8 kg) with the largest of the species *(Cucurbita maxima)* which is capable of reaching a weight of over 75 lbs (34 kg). Pumpkin pulp is edible when ripe; it could be eaten raw but is usually cooked (Purseglove, 1974). Pumpkin seeds are a popular snack food in several countries. They are consumed either raw or roasted (salted or not) and used in cooking and baking as an ingredient of bread, cereals, salads and cakes. The yellow-orange characteristic colour of pumpkin is due to the presence of carotenoids which are the primary source of vitamin A for most of the people in the developing countries (Boileau *et al*., 1999) where vitamin A deficiency is still common (Chakravarty, 2000). Incorporation of β-carotene rich foods in diets is the best measure to improve vitamin A nutrition of individuals to overcome the problems and diseases caused by Vitamin A Deficiency (VAD) (Chandrashekhar and Kowsalya, 2002; Siems *et al*., 2005). Consumption of foods containing carotene helps prevent skin diseases, eye disorders and cancer (Bendich, 1989). These facts lead to the processing of pumpkin into various food products. The β-carotene content of pumpkin varies from 1.6 to 45.6 mg/100g (Danilchenko *et al*., 2000) and 2.8 to 3.4 mg/100g (Wills, 1987). Indian cultivars of pumpkin have 132 to 527 mg/100 g (on dry weight basis) of β-carotene content (Gopalakrishnan *et al.*, 1980). Furthermore, pumpkins contain several biologically active components including polysaccharides, proteins and peptides, para-aminobenzoic acid, phenolic compounds and terpenoids and sterols (Kuhlmann *et al*., 1999).

Pumpkin has a vast scope for diversification and can be utilized in the production of processed products like jam, pickle, beverage, candy, bakery products and confectionary. Pumpkin puree is an intermediate product that is mainly used for the manufacture of jams, jellies, sweets, beverages and other products. Pumpkin flakes were developed to act as a carotene source for infant (weaning) foods by Fernandez *et al*., 1988. Pumpkin can be processed into flour which has a longer shelf-life. Pumpkin flour is used because of its highly-desirable flavour, sweetness and deep yellow-orange colour. It has been reported to be used to supplement cereal flours in bakery products

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like cakes, cookies, bread, soups, sauces and instant noodles as well as a natural colouring agent in pasta and flour mixes (Ptitchkina *et al*., 1998). It was found that noodles made from pumpkin powder were more attractive with their yellow colour and were more popular in terms of their appearance, taste, texture and acceptability (Pongjanta *et al.*, 2006). It has been used as a source of β-carotene and natural colourant (yellow colour) with most favourable in appearance, taste, texture and acceptability when supplemented in bakery products (Corrigan *et al*., 2001). In Asian countries, synthetic β-carotene has been used for providing colour and vitamin A in a variety of bakery products including sweet rolls, danish pastries, frozen waffles, bagels, soft cookies and snack foods (Gordon *et al.*, 1985).

Muffins are ready-to-eat snack foods largely consumed by children. They are normally made with wheat flour. They are similar to cupcakes, although they are usually less sweet and lack icing. Muffins are often eaten for breakfast; alternatively they may be served for tea or at other meals (Deeptanshu *et al*., 2012). Muffins may be varied by adding fruits, nuts, herbs, cheese, chopped meats or spices to the batter. Sudha *et al*., 2007 reported that bakery products are varied by addition of value added ingredients. One such recent trend is to increase the fibre content in food products to overcome health problems such as hypertension, diabetes, and colon cancer, among others. Attempts have been made to increase the fibre intake of the diet by inclusion of fibre sources in high consumption foods, particularly bakery products. Study was carried out by Martínez-Cervera *et al.* (2011) to include Cocoa husks, a waste product generated from the chocolate industry and an under-utilized source of dietary fibre, as a fat replacer in the preparation of chocolate muffins. Increasing the fibre content of the foods is challenging since it may negatively affect the sensory and physical properties of the foods. Wine grape pomace (WGP) a good source of polyphenols and dietary fibre was incorporated into baked goods as a functional ingredient by Rebecca *et al*. (2014).The study reported increase in polyphenols and dietary fibre without impacting consumer acceptance of the products. Majzoobi *et al.* (2015) determined the potential of oat fibre in the preparation of sponge cakes. In the study on incorporation of mango dietary fibre in muffins, the amount of dietary fibre was doubled (David, 2014). Studies on development of muffins using dates have been reported (Yaseen *et al*., 2012). It was observed that increasing concentrations of date syrup in date muffins increased level of protein, fibre, higher softness and more colour development while calorific value decreased. Khetan *et al*. (2015) explored the application of cowpea protein isolates in development of gluten-free rice muffins. The Protein-enriched gluten free muffins could be useful in nutritional improvement of diets of gluten intolerants. In the present study, an attempt was made to enhance the level of carotene in muffins by using pumpkin powder as a source of carotene. The objective of this study was to determine the optimum level of substitution of pumpkin powder in the formulation of muffins and to assess the effect of pumpkin powder on the nutritional and sensory characteristics of muffins.

Materials and Methods

Raw materials

Pumpkins used in the present study for the preparation of pumpkin powder (PP) were purchased from local market in Hyderabad, Telengana, India. Raw materials for the preparation of muffins like wheat flour (WF), butter, eggs, sugar, baking powder and vanilla essence were procured from local super market. Xanthan gum, soya lecithin and calcium propionate were procured from SD Fine Chemicals Ltd.

Preparation of pumpkin powder (PP)

Mature pumpkins were peeled and the fibrous matter and seeds were removed. The pumpkins were made into slices of 5mm thickness using a vegetable slicer. The slices were blanched in hot water for 2 minutes followed by soaking in 0.2% potassium metabisulphite for 45 minutes. The slices were dried in a tray drier at 55 ± 5^{o}C for 16 hrs. Dried slices were pulverized and sieved through a standard 72 BS mesh and stored in MPE pouches for further analysis. Chemical composition of the pumpkin powder (Table 1) such as moisture, protein, crude fibre, sugars, colour and ash was determined according to standard methods (Ranganna, 2010). The pumpkin powder was incorporated at levels of 20%, 40%, 60%, 80% and 90% in muffins by replacing the wheat flour.

Moisture sorption studies of pumpkin powder

Known quantities of pumpkin powder was taken in petri dishes and were exposed to different levels of relative humidity (RH) ranging from 11 to 92% in built in desiccators using appropriate saturated salt solutions (Lopez *et al.*, 1995). The samples were periodically weighed till they attained practically constant weight or showed signs of mould growth whichever was earlier. After equilibration, the moisture content (MC) of the product at different RHs was calculated by adding/subtracting % pick up/

Table 1. Proximate analysis of Fresh pumpkin, pumpkin powder and muffins stored in MPE pouches

S. No.	Fresh pumpkin and pumpkin powder			Composition of muffins stored in MPE pouches	
	Analysis	Fresh pumpkin	Pumpkin powder (PP)	Control	20% PP incorporated muffins
1	Moisture (%)	86.7 ± 0.12	6.9 ± 0.09	19.98 ± 0.01	19.33 ± 0.02
2	Colour				
	L*	59.4 ± 0.01	71.2 ± 0.01	79.42 ± 0.0	69.58 ± 0.01
	a*	21.7 ± 0.05	23.8 ± 0.0	1.77 ± 0.01	13.87 ± 0.02
	b*	52.5 ± 0.01	51.6 ± 0.02	29.56 ± 0.01	58.44 ± 0.00
3	β- carotene (mg/100g)	12.9±0.02	138.96 ± 0.52	-	6.172 ± 0.03
4	Reducing sugars (%)	1.9 ± 0.015	14.2 ± 0.01	-	-
	Total sugars (%)	4.3 ± 0.01	21.2 ± 0.01		
5	Crude fiber (%)	0.6 ± 0.015	8.9 ± 0.02	-	-
6	Protein (%)	1.8 ± 0.01	2.6 ± 0.01	5.36 ± 0.02	6.64 ± 0.02
7	Ash (%)	0.6 ± 0.02	4.8 ± 0.03	1.226 ± 0.02	1.495 ± 0.00
8	Iron (mg/100g)	11.0 ± 0.03	12.0 ± 0.02	2.586 ± 0.03	3.109 ± 0.02
9	Phosphorous (mg/100g)	27.8 ± 0.02	249.7 ± 0.03	91.303 ± 0.03	101.381 ± 0.07
10	Dietary fibre (%)	-	-	8.234 ± 0.06	14.763 ± 0.04
11	Fat (%)	-	-	23.74 ± 0.01	21.43 ± 0.03

loss to/from the initial moisture content. The initial moisture content was determined by drying known weight of the product taken in petri dish at 100±5°C till constant weight (AACC, 1983). The sensory remarks on their quality were taken and critical moisture content was fixed.

Extraction and quantification of β-carotene by high performance liquid chromatography (HPLC) in PP

β-carotene standard (1 mg/ml) was freshly prepared in hexane and stored in an amber coloured volumetric flask prior to use. 200 µl of this stock solution was further diluted with hexane (1 ml). A sample volume of 10 µl (2 µg) was injected. The extraction of β-carotene in PP was carried out with acetone and further purification with hexane and distilled water. The sample (1.0 g) was extracted with acetone until the residue became colourless. The extracts were transferred to a separating funnel followed by addition of hexane and water. The Hexane extract was collected and its volume adjusted. The solution was then filtered with anhydrous sodium sulphate. The β-carotene in the pumpkin powder was identified using the HPLC system software by comparing Retention time (RT) of unknown peak with reference standard. The system consisted of Shimadzu prominence LC-20AD binary gradient fitted with an ultra restek HPLC C18 analytical column (25 cm x 4.6 mm ID) 5 µ particle size. Detection was done by SPD 20A series variable wavelength detector at wavelength of 450.0 nm. The gradient mobile phase consisted of acetonitrile and chloroform with a flow rate of 1ml/min. The elution program involved a linear gradient from 80 to 20% of acetonitrile for 0-5 min and 20 to 80% of chloroform from 5-15 min and again 80% of acetonitrile for 15-20 min followed by 5 min equilibrium. Total run time was of 25 min, compounds were quantified using LC solution software.

Muffin formulation and preparation

The formulations and method of mixing of muffins was done according to Jyotsna *et al.* (2011) with slight modification. The following formulation was used for the preparation of muffins WF:PP ratio (100:0; 90:10; 80:20; 60:40; 40:60 and 20:80; w/w) 100g, Sugar 84 g, Butter 84 g, Eggs 84 g, vanilla essence 0.4 ml, Calcium propionate 0.4 g, Soya lecithin 0.5 g, xanthan gum 0.5 g and water 30 ml. Soya lecithin was used as an emulsifier and xanthan gum was used for improving the hydrocolloid properties of the dough. Wheat flour (Maida), pumpkin powder, baking powder, calcium propionate, xanthan gum and soya lecithin were sieved together. Sugar powder, butter and soya lecithin was creamed together for 1 minute using hand mixer (Philips, 300 W). Eggs and essence were whipped for 5 min. Whipped egg was added to the cream in parts while mixing for 3 min. Finally, the WF - PP was added and mixed for 2 min along with the addition of water. The muffin batter (65 g) was added to each cup and baked at 180°C for 30 min using the baking oven. After baking, muffins were cooled, packed air tight in PE and MPE pouches and stored at room temperature.

Colour measurement

The colour of muffins as influenced by different levels of PP was measured using Hunter Colorimeter (Hunter Associates Laboratory, USA). Among the three colour coordinates, *"L^*"* represents the lightness index, *"a^*"* represents red-green, while *"b^*"* represents yellow-blue colour components. The measurement of L^*, a^* and b^* values of colour was carried out in triplicate and the average values were reported.

Sensory evaluation of muffins

The muffins were evaluated for appearance, visual colour, flavour, taste sweetness and overall acceptability by a panel of 8 semi-trained judges (constituted from persons normally familiar with quality of products and capable of discriminating differences and communicating their reactions, though they may not have been formally trained) who were provided with commercial samples on a 9 point Hedonic scale (Amerine *et al*., 1965).

Analysis of muffins

The muffins were packed in PE and MPE pouches and stored at room temperature. The moisture, ash, fat, protein, dietary fibre and total carotene of control muffins and PP incorporated muffins were carried out. The iron and phosphorus content of the muffins were estimated according to the standard methods (Ranganna, 2010).

Dietary fibre

Dietary fibre was determined according to AOAC Method (AOAC International, 1997). Weighed muffin (1g) samples were treated with α-amylase (0.1 ml) and pH 6.0 phosphate buffer solution (50 ml) at 95 to 100°C for 15 min. The pH of the solution was adjusted to 7.5 ± 0.2 with 0.275N NaOH followed by a protease treatment (0.1 ml (5 mg)) at 60°C for 30 min. The pH of the solution was adjusted again to 4.0 to 4.6 with 0.325M HCl. The solution was treated with amyloglucosidase (0.1 ml) by heating at 60°C for 30 min. Four volumes of 95% ethanol were added and the solution was allowed to set overnight at room temperature for complete precipitation. The residue was washed onto whatman no 1 filter paper with three 20 ml portions of 78% ethanol, two 10ml portions of 95% ethanol and two 10ml portions of acetone. The residue was collected into crucibles and dried overnight in a 105°C air oven. After cooling, it was weighed and the residue was analyzed for protein and ash. The % TDF (total dietary fibre) was calculated by deducting the weight of protein and ash.

Results and Discussion

Assessment of nutrient content of fresh pumpkin and pumpkin powder showed that fresh pumpkin had higher moisture, lower protein, fibre and minerals as compared to PP (Table 1). The β-Carotene is eluted after 8 min and was identified with standard β-carotene (Figure 1a and 1b). The pumpkin powder was found to be a good source of β-carotene (138.96 mg/100g). Thus a small quantity of pumpkin powder would help alter the nutritive value of muffins to a considerable extent. The blanching and sulphitation treatments in the preparation of PP not only helped in accelerating the drying process, but also helped in maintaining the quality of the PP during processing and storage. Sulphitation retards browning and helps to retain the colour. The processing of vegetables has been found to increase the bio-availability of carotenoids since it breaks down cellulose structure of the plant (Vanhethoff *et al*., 2000). Increase in the nutritive values indicated that the incorporation of PP to muffins had a positive impact on variations.

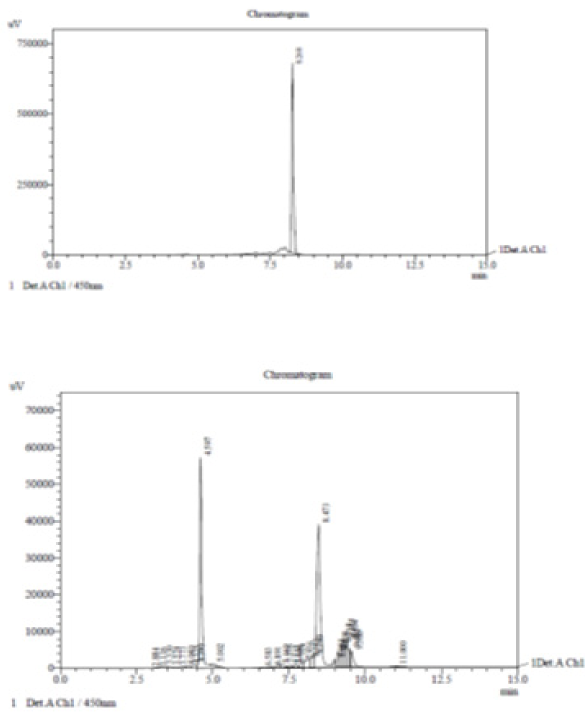

Figure 1 a. HPLC separation of standard β-carotene b. HPLC separation of β-carotene in pumpkin powder sample

Moisture sorption studies of pumpkin powder

Moisture sorption characteristics of PP were studied to design a functional and economical packaging for storage and distribution. The moisture sorption isotherm of the product was found to be typical sigmoid (Figure 2) indicating the product to be of a low fat-starch rich product. The sharp increase in moisture above 44% RH indicates deterioration of PP above 44% RH. The PP with an initial moisture content of 8.16% was found to equilibrate at 45% RH. The PP equilibrating to 56% RH with a moisture content of 11.67% showed tendency for caking. The loss of colour was higher in PP equilibrating to 64% RH with a moisture content of 14.32%. At higher RH (86 and 92% RH), the PP became soggy and developed mould growth. Hence the moisture content corresponding to 56% RH was taken as critical for the product. The critical RH being moderate, it requires a moderate moisture barrier such as polypropylene or

Table 2. Physical characteristics of muffins

Sl. No.	Analysis	100:0 (CONTROL)	90:10 (WF:PP)	80:20 (WF:PP)	60:40 (WF:PP)	40:60 (WF:PP)	20:80 (WF:PP)
1.	Total carotene as ß-carotene (mg/100g)	-	1.0960 ± 0.0	2.7426 ± 0.0	5.356 ± 0.0	5.7193 ± 0.0	6.678 ± 0.01
2.	Colour						
	L*	81.33 ± 0.05	74.93 ± 0.08	72.20 ± 0.02	70.25±0.04	67.95 ± 0.04	62.50 ± 0.02
	a*	0.71 ± 0.00	2.86 ± 0.01	5.67 ± 0.01	8.07±0.01	9.40 ± 0.10	10.48 ± 0.01
	b*	19.26 ± 0.01	31.20 ± 0.3	41.79 ± 0.01	44.45±0.03	45.32 ± 0.03	46.37 ± 0.54
3.	Weight (g)	42.06 ± 0.23	42.03 ± 0.11	42.8 ± 0.26	43.73 ± 0.32	43.66 ± 0.28	42.73 ± 0.20
4.	Height(mm)	49 ± 0.11	47 ± 0.05	43 ± 0.1	41 ± 0.1	41 ± 0.05	41 ± 0.2
5.	Diameter (mm)	67 ± 0.1	63 ± 0.11	60 ± 0.05	58 ± 0.15	45 ± 0.25	42 ± 0.25

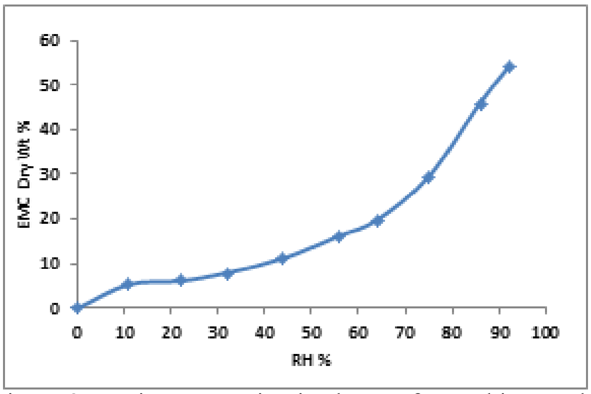

Figure 2. Moisture sorption isotherm of pumpkin powder analysis of muffins

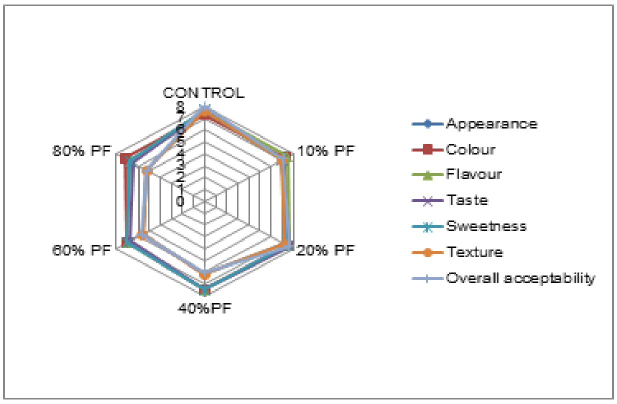

Figure 3. Sensory evaluation of control and PP incorporated muffins

low density polyethylene. However, since the product is rich in carotenes a light barrier is also necessary. Hence the metallised polyester polyethylene (47.5 µm) packaging material is recommended.

Sensory evaluation of muffins

Sensory evaluation showed that the appearance, colour, flavour, taste, sweetness of the muffins incorporated with 20% of PP was more acceptable than any other level (Figure 3). Beyond 20% incorporation of PP, muffins were not acceptable by the panellists. This was similar to the results obtained with the incorporation of pumpkin powder in bakery products (Pongjanta *et al*., 2006). With the increase in the level of pumpkin powder the carotene content increased. However, the hardness also increased and the taste was also not acceptable. Substitution beyond 20%, affected the colour and overall acceptability of the product and the adverse effects was more pronounced. A similar observation was made, where fenugreek seed husk was used to replace the wheat flour (Deeptanshu *et al*., 2012). Substituting a portion of wheat flour with pumpkin powder in muffins was acceptable up to 20% beyond which the physical characteristics like colour, height and diameter of the muffins were affected (Table 2).

Analysis of muffins

Table 1 shows the composition of control muffins and 20% PP incorporated muffins. The data showed that muffins with 20% PP had more dietary fibre than control muffins. Also an increase in iron and phosphorous was observed. The chemical composition of muffins showed that the muffins with 20% pumpkin powder were better in nutritive values as compared to the control muffins.

Effect of PP incorporation on muffin characteristics

For all samples, weight of the muffins after baking was almost the same, indicating that PP incorporation did not influence the weight of the final product. A similar observation was made by Ravi *et al.* (2010) in the study on formulation of dhokla mix with pumpkin flour incorporation. There was not much of difference in the values for weight among the control and different PP incorporation levels of muffins. However, the height and diameter of the muffins decreased gradually with the increase in the level of PP. A decrease in height of the muffins was observed by Jatinder *et al*. (2016) in the study on eggless gluten free muffins utilizing black carrot dietary fibre. As shown in Table 2, the control muffins had the highest height and diameter, while the lowest was observed for those containing 80% PP.

Conclusion

Incorporation of PP at different levels resulted in changes in the nutritional, physical and sensory properties of muffins. This study revealed that pumpkin powder enhanced β-carotene content in the supplemented bakery product. Pumpkin powder is a rich source of β-carotene and minerals like phosphorous. Since the bakery products prepared from refined flour are low in vitamins, minerals and dietary fibre, pumpkin powder incorporation can enhance the nutritive value of muffins. The pumpkin powder could be very well utilized to prepare the bakery products. On the basis of sensory characteristics, the replacement of PP at 20% level was found to be optimum for the preparation of carotene enriched muffins. Substitution beyond 20% had strong effect on the sensory properties of muffins

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