African Journal of Food Science Vol. 5(5), pp. 305 – 312, May 2011
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 ©2011 Academic Journals

Full Length Research Paper

Physico-chemical and sensory characteristics of β-carotene rich defatted soy fortified biscuits

Mridula D.

Central Institute of Post Harvest Engineering and Technology, Ludhiana –141 004 (Punjab), India.
E-mail: mridulads4@yahoo.co.in.

Accepted 2 February, 2011

β-Carotene rich defatted soy flour fortified biscuits were prepared using different levels of carrot powder only, carrot powder with egg, and carrot powder with ascorbic acid, and evaluated for its physical properties, nutritional composition and sensory characteristics. Expansion in diameter (1.059 to 1.280) and spread ratio (5.73 to 6.78) was decreased with increased proportion of carrot powder in all three types of biscuits. The breaking hardness of biscuits with carrot powder only and with carrot powder and ascorbic acid was at par while biscuit samples with carrot powder and egg were softer as showed by significantly lower breaking hardness as compared to the former two types of biscuit samples. Minimum lightness (L* values) and maximum redness (a* values) was observed in the biscuits samples with ascorbic acid than the other two types of biscuits. With increasing proportion of carrot powder in flour blends, protein content (7.43 to 8.02%) was decreased while ash, crude fibre and β-carotene content were enhanced. β-carotene content in all three types of biscuits was in the range of 0.56 to 3.72 mg/100 g biscuits. Although all three types of biscuits were well accepted in sensory evaluation but overall mean acceptability scores more than 8 were observed for biscuits samples prepared from flour blends containing carrot powder up to 7.5%, which will also be helpful in providing daily dietary requirement of β-carotene to the consumers at 100 g consumption level of these carotene rich biscuits.

Key words: Carrot powder, β-carotene rich biscuits, defatted soy flour fortified biscuits, ascorbic acid, biscuit colour, breaking hardness, sensory acceptability.

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the important nutritious root vegetables. It is the richest source of β-carotene, precursor of vitamin A. Fresh carrot on an average contains (g/100g) 86 moisture, 0.9 protein, 0.2 fat, 1.1 total minerals, 1.2 crude fiber, 10.6 carbohydrates, 48 Kcal, 1890 µg β-carotene, 0.08 calcium, 0.53 phosphorous and 0.001 iron (Gopalan et al., 2007). β-carotene, having high vitamin A activity (Biesalski, 1997), constitute 60 to 90% of carrot carotenoids (Simon and Wolff, 1987). Carotenes act as antioxidants by light filtering (Fakourelis et al., 1987), singlet oxygen quenching (Lee and Min, 1988; Jung and Min, 1991; Beutner et al., 2001), and free radical scavenging effects (Burton and Ingold, 1984; Terao, 1989; Kennedy and Liebler, 1992; Tsuchihashi et al., 1995; Miller et al., 1996). Vitamin A deficiency (VAD) is one of the major nutritional public health problems in many developing countries including India. VAD is primarily caused due to inadequate intake of vitamin A and vitamin A precursors (provitamin A carotenoids) and diseases (WHO, 1996). A very high prevalence of vitamin A deficiency particularly bitot's spot (4.71%) and night blindness (5.17%) was reported amongst children (<6 years) (Toteja et al., 2002). Being rich in carotene content, carrot and its processed products can serve an easiest mean in reducing the vitamin A deficiency and improving the health of vulnerable groups.

In recent years, the consumption of carrot and its related products has increased steadily due to the recognition of antioxidant and anticancer activities of β-carotene in carrot, which is also a precursor of vitamin A (Speizer et al., 1999; Dreosti, 1993). Impact of fortified

biscuits resulted in a significant improvement in the vitamin A status in primary school children from a poor rural community and also appeared to have a favourable effect on anthropometric status (Stuijvenberg et al., 1999; Stuijvenberg et al., 2001). Carrots are processed into products such as dehydrated carrots, juice, beverages, candy, preserves, and halwa. Biscuit is one of the oldest bakery snack item, consumed by all age groups and at all times. This is the product with good shelf life and one of the most liked bakery product by the urban as well as rural consumers. The total market of biscuits in India had been estimated about 1.1 million ton annually. Biscuit, which is one of the most commonly accepted snack foods amongst children and adult, may be considered as one of the good supplementary food for distributing to the undernourished children through developmental agencies. If biscuits are enriched with carrot and thus β-carotene, it will be very helpful in enhancing the carotene intake in consumers and can fulfill dietary requirement of 2400 µg/day of β-carotene as per recommended dietary allowances for Indians (Gopalan et al., 1989). Incorporation of defatted soy flour (DSF) in a small quantity will improve the protein quality of cereal based products without causing significant difference in the acceptability of the developed product. It was observed that the flavour and taste of full fat soy flour incorporated biscuit at 5% level was comparable with the biscuits prepared from refined wheat flour only (Mridula and Wanjari, 2006).

The present study was carried out to find out the effect of addition of different proportion of carrot powder, egg, and ascorbic acid and fortified with 5% DSF on baking characteristics, texture, colour, nutritional composition and sensory characteristics of carotene rich biscuits.

MATERIALS AND METHODS

Preparation of biscuits

Biscuit samples were prepared, using creamery method for making biscuit dough. The ingredients (g) used in preparation of biscuits were flour blends 100, fat 40, sugar 40, baking powder 0.8, sodium bicarbonate 0.3, ammonium bicarbonate 0.25 and milk as desired to make dough softer. Five flour blends, prepared with wheat flour and defatted soy flour (DSF) were 95:5 (control), 92.5:5, 90:5, 87.5:5, and 85:5. With these flour blends, the levels of carrot powder (on flour basis) used for making biscuit samples were 0, 2.5, 5.0, 7.5, and 10%, respectively. Each biscuits sample was prepared from 500 g of flour blend. Keeping these flour blends as base, three types of biscuits were prepared by the addition of carrot powder only, carrot powder and egg (20 g/100 g flour blend), and with carrot powder and ascorbic acid (100 mg/100 g of flour blend). Carrot powder was prepared by drying the steamed carrot at 60°C. The particle size of carrot powder was 65 mesh size of ASTM standard. The average particle size of wheat flour and DSF used for making biscuits was 0.254 and 0.429 mm, respectively. The particle size of the flour was determined by using sieve shaker machine (Sahay and Singh, 2001).

Biscuit dough was prepared in a Spar Quart Mini Mixer (SP-800) and sheeted to a thickness of 5 mm approximately, cut into round shape of 45 mm diameter, transferred to baking tray and baked at 180°C for 12 min. The biscuits, after attaining the room temperature were packed in LDPE bags and evaluated for all different quality parameters.

Physical properties

Expansion in diameter and thickness was the ratio of biscuit diameter and thickness before and after baking. Spread ratio of biscuit samples was calculated as per standard AACC methods (AACC, 1967). Fifteen biscuit samples were considered for determining the physical properties of different types of biscuits.

Proximate composition

Moisture, crude fat, protein (using the factor 6.5 x N), ash and crude fiber content and β-carotene in different biscuit samples were determined as per standard methods (AOAC, 2000). Total carbohydrates value was obtained by subtracting the total of moisture, protein, fat, crude fiber and ash content from 100. Total calories were calculated by multiplying protein, carbohydrates and fat content by the factor 4, 4 and 9, respectively.

Textural properties

Breaking test of biscuit samples was conducted using texture analyzer (TA-Hdi), Stable Micro systems (U.K.). The individual sample of biscuits was placed over two points of the blade. The blade HDP/BS was attached to the crosshead of the instrument. This test simulates the evaluation of hardness by consumer holding the biscuit in hands and breaking by bending. The peak force from the resulting curve was considered as breaking hardness of the biscuit and the area under the peak force on the graph was considered as breaking toughness. TA settings were kept as pre-test speed 1 mm/s, test speed 1 mm/s, post test speed 2 mm/s, distance 7 mm and 50 kg load cell.

Colour determination

Colour; L*, a* and b* values (CIE LAB scale) of the biscuits was determined by using Hunter Colorimeter (model no. 45/0L, made in U.S.A). L * is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates a * and b * represents redness (+ a* values) to greenness (- a* values) and yellowness (+ b* values) to blueness (-b* values), respectively. h^o (Hue angle) is the attribute of the colour by means of which the colour is perceived. C* (chroma) is the attribute of colour used to indicate the degree of departure of the colour from gray of the same lightness. h^0 and C* are computed by using the following formula:

$$h^0 = \tan^{-1}(b^*/a^*),\ C^* = \sqrt{a^2 + b^2}$$

Where, $b = b^*$, $a = a^*$

Sensory characteristics

Sensory characteristics of biscuits were evaluated for its different sensory attributes by a group of nine panelists. Sensory attributes like appearance and colour, texture, odour, flavour and taste and overall acceptability for all biscuit samples were assessed using nine point hedonic scale. Hedonic scale was in the following sequence: like extremely - 9, like very much - 8, like moderately -7, like slightly - 6, neither like nor dislike - 5, dislike slightly 4, dislike moderately - 3, dislike very much - 2, dislike extremely – 1 (Indian Standard, 1971).

Table 1. Effect of carrot powder, egg, and ascorbic acid on physical properties of DSF fortified biscuits.

Proportion of WF: DSF: CP in flour blend	Expansion in diameter	Expansion in thickness	Spread ratio
With carrot powder only			
95:5:0	1.114	1.493	6.03
92.5:5:2.5	1.110	1.523	6.04
91:5:5.0	1.095	1.552	5.98
89:5:7.5	1.082	1.60	5.90
87:5:10	1.059	1.56	5.76
R^2	0.99	0.83	0.99
With carrot powder and egg			
95:5:0	1.128	1.546	6.76
93:5:2.5	1.120	1.558	6.78
91:5:5.0	1.096	1.614	6.34
89:5:7.5	1.099	1.615	5.98
87:5:10	1.083	1.582	5.92
R^2	0.90	0.80	0.91
With carrot powder and ascorbic acid			
95:5:0	1.111	1.494	6.08
93:5:2.5	1.109	1.518	5.98
91:5:5.0	1.096	1.596	5.91
89:5:7.5	1.097	1.609	5.89
87:5:10	1.061	1.567	5.73
R^2	0.90	0.86	0.94
F value			
%CP	73.96***	19.36***	40.69***
Treatments	15.53***	5.90*	40.70***
%CP + Treatments	2.31^{ns}	0.74^{ns}	4.12**
CD (0.05)			
%CP	0.006	0.026	0.155
Treatments	0.005	0.020	0.121
%CP + Treatments	0.011	0.449	0.270
CV%	1.36	4.12	6.24

WF, Refined wheat flour; DSF, defatted soy flour; CP, carrot powder. Treatments: with carrot powder only, with carrot powder and egg, and with carrot powder and ascorbic acid; *p<0.05; **p<0.01; ***p <0.001; SOC: second order equation; R^2 values

Statistical analysis

Data were analyzed as per two factor analysis of variance using LSD of AgRes software statistical package. R^2 values were computed using MS-Excel 2003 software.

RESULTS AND DISCUSSION

The effect of carrot powder, egg, and ascorbic acid on physical properties (expansion in diameter and thickness, and spread ratio) of different biscuit samples is presented in Table 1. Expansion in the diameter of all three types of control biscuits (without carrot powder) was slightly higher than the biscuits with different levels of carrot powder. Expansion in diameter of biscuits with different levels of carrot powder was in the range of 1.114 to 1.059, 1.128 to 1.083, 1.111 to 1.061, respectively in all three types of biscuits that is, with carrot powder only, with carrot powder and egg, and with carrot powder and ascorbic acid. Maximum and minimum expansion in diameter was observed at 2.5 and 10% levels of carrot powder in all three types of biscuits. Significant reduction in expansion in diameter with increasing levels of carrot powder in all three types of biscuits may be due to increased fiber content in the samples, which affected the expansion in the diameter of biscuit samples. Similar

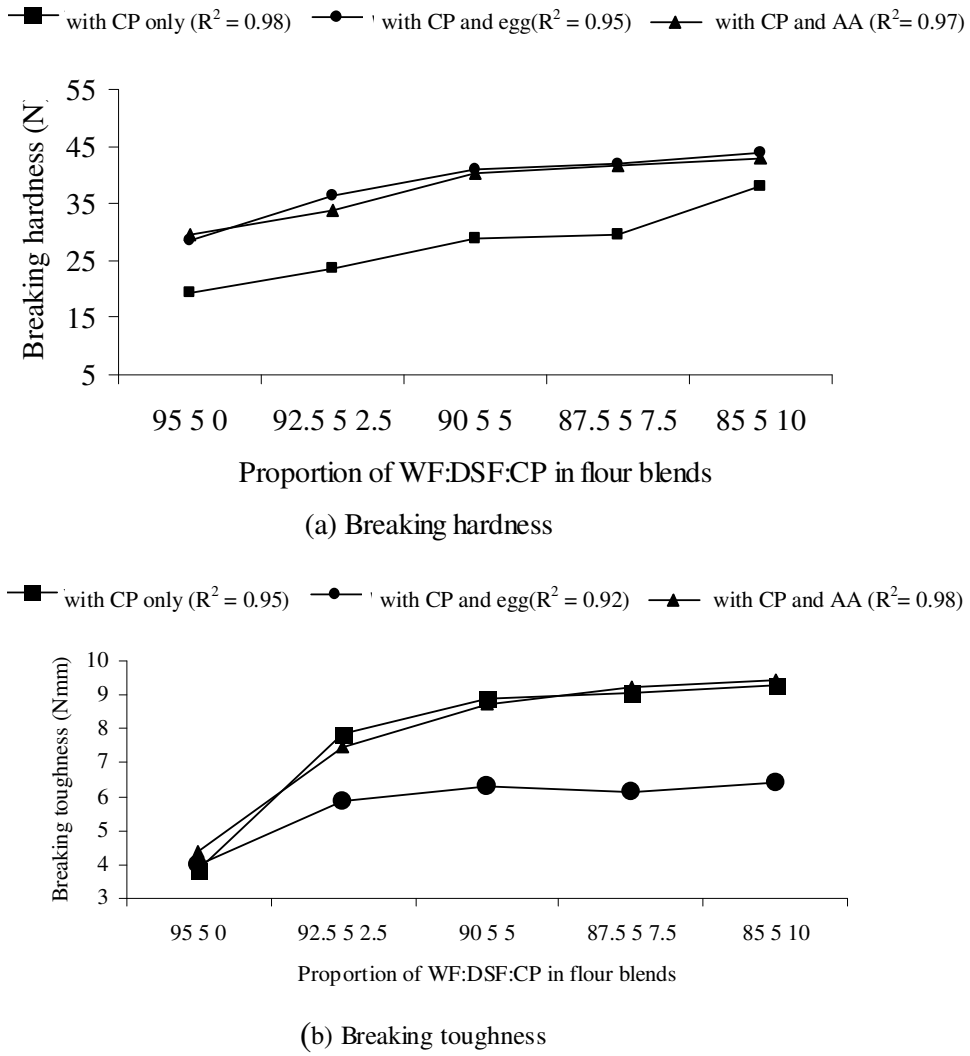

Figure 1. Effect of carrot powder (CP), egg, and ascorbic acid (AA) on textural properties (a and b) of DSF fortified biscuits.

trend in expansion in diameter was observed in biscuits with beetroot powder (Mridula et al., 2009). Although, expansion in diameter was decreased but expansion in thickness was slightly increased with increasing level of carrot powder up to 7.5% thereafter very slight reduction was observed.

Studies indicated that the crude fiber of the biscuit formulations affected the thickness development during cooking (Brennan and Samyue, 2004; Mridula et al., 2007). Significant effect of different levels of carrot powder was also observed in the spread ratio of biscuits with different carrot powder and treatment due to the different ingredients characteristics. Expansion in diameter and thickness and spread ratio of biscuit samples with carrot powder only and with carrot powder and ascorbic acid were at par while biscuits with carrot powder and egg showed significantly higher expansion in diameter, thickness and spread ratio (Table 1). Effect of carrot powder, egg, and ascorbic acid on textural properties of biscuits is presented in Figure 1. A significant increase in the breaking hardness (peak breaking force) was observed with increasing levels of carrot powder in all three types of biscuit samples and was also higher as compared to control samples that is, biscuits without carrot powder. The breaking hardness of biscuits with carrot powder only and with carrot powder and ascorbic acid was at par while biscuit samples with carrot powder and egg were softer as showed by significantly lower breaking hardness (F value 225.94***; $p<0.001$) value as compared to the former two types of biscuit samples.

Egg protein might play a role and resulted to softer biscuits. Similar trends were observed in breaking toughness of different biscuit samples due to the addition of carrot powder, egg, and ascorbic acid. Higher crude fiber and no gluten content in carrot powder than wheat flour may be attributed to the increased breaking hardness

Table 2. Effect of carrot powder, egg, and ascorbic acid on colour of DSF fortified biscuits.

Proportion of WF: DSF: CP in flour blend	L*	a*	b*	h°	C*
With carrot only					
95:5:0	65.22	6.75	19.35	70.78	20.50
92.5:5:2.5	57.88	12.64	20.83	58.73	24.37
90:5:5.0	58.97	13.57	21.96	58.29	25.81
87.5:5:7.5	53.38	15.66	20.87	53.10	26.09
85:5:10	49.91	16.48	20.06	50.58	25.96
R^2	0.91	0.95	0.91	0.93	0.98
With carrot powder and egg					
95:5:0	69.60	6.00	19.32	72.78	20.24
92.5:5:2.5	64.99	10.31	22.16	65.45	24.49
90:5:5.0	60.77	13.87	23.04	58.96	26.89
87.5:5:7.5	60.85	14.95	23.87	57.96	28.17
85:5:10	57.87	16.69	23.79	54.94	29.07
R^2	0.96	0.99	0.98	0.98	0.99
With carrot powder and ascorbic acid					
95:5:0	65.93	6.78	19.45	70.80	20.60
92.5:5:2.5	56.28	13.05	19.93	56.77	23.82
90:5:5.0	56.07	14.96	21.53	55.22	26.21
87.5:5:7.5	52.74	15.78	20.86	52.88	26.16
85:5:10	50.44	16.90	20.47	50.45	26.54
R^2	0.92	0.96	0.77	0.92	0.98
F value					
%CP	815.32***	931.66***	87.48***	833.59***	376.55***
Treatments	625.72***	31.12***	147.25**	155.03***	36.81***
%CP + Treatments	23.73***	7.59**	18.07***	11.19***	9.26***
CD(0.05)					
%CP	0.518	0.367	0.328	0.729	0.402
Treatments	0.402	0.284	0.254	0.565	0.311
%CP + Treatments	0.898	0.635	0.569	1.264	0.696
CV%	1.70	5.72	3.11	2.45	3.26

All values are mean of four replicates.

and toughness of biscuits in proportion to the levels of carrot powder in biscuit samples. Although, the biscuit samples with higher levels of carrot powder were harder and tougher as compared to control (without carrot powder) biscuits but all three types of biscuits with different levels of carrot powder were found acceptable on sensory evaluation.

Effect of carrot powder, egg and ascorbic acid on colour values is given in Table 2. The L*, a* and b* values of wheat flour (maida), carrot powder and DSF, used for making biscuits were 89.04, -0.99, and 9.78; 55.51, 21.15 and 19.44 and 84.16, -1.96, and 14.14, respectively. The results indicated that, different levels of carrot powder significantly affected the colour of biscuits. L* values decreased significantly ($p<0.001$) while a* values increased with increasing levels of carrot powder in all the biscuit samples due to typical orange like colour of the carrot powder. Minimum lightness and maximum redness (a* values) were observed in the biscuits samples with ascorbic acid while biscuits with egg showed maximum lightness and minimum redness. h° of the biscuits samples 'with carrot powder only', with carrot powder and egg' and 'with carrot powder and ascorbic acid' was in the range of 50.58 to 70.78, 54.94 to 72.78 and 50.45 to 70.80, respectively. The difference in h° of these three types of biscuits was due to the different a* and b* values of these three types of biscuits, the different colour properties of carrot powder and egg and

Table 3. Effect of carrot powder, egg, and ascorbic acid on proximate composition (g/100 g) of DSF fortified biscuits.

Proportion of WF: DSF: CP in flour blend	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Total carbohydrate (%)	Total calories (kcal)	β carotene (mg/100 g)
With carrot powder only								
95:5:0	3.52	7.67	21.30	0.65	0.47	66.38	487.96	0.56
92.5:5:2.5	3.53	7.63	21.29	0.76	0.63	66.16	486.76	1.11
90:5:5.0	3.54	7.56	21.03	1.02	0.87	65.87	482.98	1.44
87.5:5:7.5	3.53	7.45	21.38	1.04	0.95	65.55	484.42	2.23
85:5:10	3.51	7.44	21.43	1.09	1.08	65.38	484.25	2.39
With carrot powder and egg								
95:5:0	3.53	8.02	22.86	0.63	0.43	64.48	495.76	1.23
92.5:5:2.5	3.54	7.98	22.90	0.74	0.60	64.32	495.33	1.43
90:5:5.0	3.51	7.86	22.98	0.90	0.79	63.97	494.10	1.75
87.5:5:7.5	3.51	7.72	23.08	0.95	0.92	63.82	493.86	2.54
85:5:10	3.52	7.63	23.10	1.03	1.03	63.70	493.20	3.72
With carrot powder and ascorbic acid								
95:5:0	3.52	7.66	21.23	0.64	0.48	66.50	487.74	0.56
92.5:5:2.5	3.54	7.59	21.28	0.76	0.65	66.17	486.52	1.23
90:5:5.0	3.53	7.55	21.34	1.05	0.85	65.69	484.99	1.68
87.5:5:7.5	3.51	7.50	21.42	1.05	0.94	65.55	484.98	3.10
85:5:10	3.54	7.43	21.42	1.08	1.06	65.47	484.35	3.17
F value								
%CP	0.44^{ns}	76.83^{***}	3.71^{*}	684.33^{***}	4322.53^{***}	42.62^{***}	39.15^{***}	667.50^{***}
Treatments	0.30^{ns}	256.37^{***}	639.76^{***}	45.96^{***}	84.77^{***}	505.52^{***}	831.21^{***}	109.30^{***}
%CP + Treatments	0.48^{ns}	3.97^{*}	1.07^{ns}	6.20^{**}	4.56^{*}	0.62^{ns}	2.67^{ns}	23.69^{***}
CD (0.05)								
%CP	0.02	0.04	0.14	0.02	0.01	0.17	0.67	0.11
Treatments	0.02	0.03	0.11	0.02	0.01	0.13	0.52	0.08
%CP + Treatments	0.05	0.07	0.24	0.04	0.02	0.30	1.16	0.19
CV%	0.75	0.45	0.66	2.47	1.45	0.26	0.14	6.39

All values are mean of three replicates.

the effect of ascorbic acid on the final products. Slightly lower redness and higher brightness in biscuits with egg might be due to interaction of yellowness of egg with other ingredients of biscuit dough. The lower L* values and higher a* values in the samples with ascorbic acid showed that ascorbic acid might had played some role in the retention of redness in the biscuits as also found in other study too (Mridula et al., 2009).

The proximate composition (dry basis) of refined wheat flour, carrot powder and DSF used in the preparation of biscuits were protein 10.47, 6.84, and 56.31%; fat 1.4, 2.75, and 1.09%; ash 0.73, 8.14, and 5.42%; total crude fiber 0.42, 8.24, and 3.78%; and carbohydrates (by difference) 86.98, 74.03, and 32.40%, respectively. No significant difference was observed in the moisture content of different biscuit samples, baked at the same temperature and time ($p>0.05$). Addition of different levels of carrot powder lowered the total protein content of biscuit samples significantly, which might be due to lower protein content in carrot powder as compared to other ingredients of flour blends. The protein content of the biscuits with carrot powder only and with added ascorbic acid was at par while biscuits with egg showed the higher protein content because of the additional protein from egg in biscuit samples. Fat content in biscuits with egg was also higher than the other two types of biscuits due to additional fat from the egg. Different levels of carrot powder increased the ash and total crude fiber content significantly in all three types of biscuits (Table 3) due to the higher content of these nutrients in carrot powder. This brought about the slight reduction in total carbohydrates and total calories with increasing level of carrot

Table 4. Effect of carrot powder, egg, and ascorbic acid on sensory characteristics of DSF fortified biscuits.

Proportion of WF: DSF: CP in flour blend	Mean sensory score				
	Appearance and colour	Texture	Odour	Flavour and taste	Overall acceptability
With carrot powder only					
95:5:0	8.44	8.11	8.0	8.22	8.22
92.5:5:2.5	8.44	8.33	8.11	8.56	8.44
90:5:5.0	8.56	8.0	8.11	8.44	8.33
87.5:5:7.5	8.44	8.11	8.33	7.89	8.0
85:5:10	8.11	7.89	8.22	7.67	7.78
With carrot powder and egg					
95:5:0	8.11	8.0	8.33	8.44	8.33
92.5:5:2.5	8.0	7.89	8.0	8.22	8.22
90:5:5.0	8.33	7.89	7.89	8.0	8.33
87.5:5:7.5	8.0	8.22	7.67	7.89	8.11
85:5:10	7.44	7.44	7.44	7.89	7.78
With carrot powder and ascorbic acid					
95:5:0	8.44	8.0	8.44	8.22	8.33
92.5:5:2.5	8.44	8.22	8.0	8.56	8.44
90:5:5.0	8.33	8.11	8.11	8.44	8.33
87.5:5:7.5	8.44	8.0	7.89	8.11	8.11
85:5:10	8.11	7.78	7.33	7.44	7.67
F value					
%CP	2.38^{ns}	1.99^{ns}	1.93^{ns}	5.06*	0.01^{ns}
Treatments	5.15*	1.12^{ns}	1.54^{ns}	0.13^{ns}	20.41^{ns}
%CP + Treatments	0.31^{ns}	0.45^{ns}	$0.1.11^{ns}$	0.76^{ns}	0.12^{ns}
CD(0.05)					
%CP	0.37	0.35	0.43	0.39	0.39
Treatments	0.29	0.27	0.33	0.30	0.30
%CP + Treatments	0.640	0.60	0.74	0.68	0.67
CV%	7.98	7.90	9.40	7.58	7.91

carrot powder in biscuits. There was a linear increase in the β-carotene content in the biscuit samples with increasing level of carrot powder, which was obvious.

β-carotene in biscuits sample 'with carrot powder only', with carrot powder and egg' and 'with carrot powder and ascorbic acid' was in the range of 0.56 to 2.39, 1.23 to 3.72 and 0.56 to 3.17 mg/100 g, respectively. As per mean comparison by LSD, β-carotene content in the biscuit sample with added egg was maximum amongst all three types of biscuits which might be due to additional β-carotene of the egg yolk in these biscuits. The carotene content in biscuits with added ascorbic acid was significantly more than samples prepared with carrot powder only (Table 3). This showed some protective role of the ascorbic acid in preventing the losses of β-carotene even at high baking time and temperature of 180°C. Mean sensory scores for different sensory characteristics of all three types of biscuits prepared, using different levels of carrot powder, egg and ascorbic acid, were presented in Table 4. The mean sensory scores for different levels of carrot powder incorporated biscuits, for all the sensory characteristics were more than the minimum acceptable score of 6. The result thus indicated that, the biscuits prepared from different levels of carrot powder, with egg or ascorbic acid and fortified with 5% DSF were accepted by the panelist.

The overall acceptability scores for biscuit samples 'with carrot powder only', with carrot powder and egg' and 'with carrot powder and ascorbic acid' were in the range of 7.78 to 8.22, 7.78 to 8.33 and 7.67 to 8.33, respectively. Thus, the overall mean acceptability scores of more than 8 for different biscuits samples up to 7.5%

carrot powder indicates the commercial scope for manufacturing good quality vegetarian biscuits with carrot powder, which will also be helpful in providing daily dietary requirement of β-carotene to the consumers at 100 g consumption level of these carotene rich biscuits.

Conclusion

Defatted soy flour fortified biscuits were prepared using different levels of carrot powder only, carrot powder with egg, and carrot powder with ascorbic acid, and evaluated for its physical properties, nutritional composition and sensory characteristics. Although spread ratio decreased, hardness increased, brightness decreased with increasing levels of carrot powder in flour blends in all the three types of biscuits but all the three types of biscuits samples were accepted by the sensory panelist. The mean overall sensory acceptability scores of more than 8 for biscuits samples up to 7.5% carrot powder indicates the commercial scope for manufacturing good quality vegetarian biscuits with carrot powder, which will also be helpful in providing daily dietary requirement of β-carotene to the consumers at 100 g consumption level of these carotene rich biscuits.

REFERENCES

AACC (1967). Approved Method of American Association of Cereal Chemists. Cereal Laboratory Methods, St. Paul, Minnesota.

AOAC (2000). Official Methods of Analysis, 17th ed. The Association of Official Analytical Chemists, USA.

Biesalski HK (1997). Bioavailability of vitamin A. Eur. J. Clin. Nutr., 51(Suppl 1): 71-75.

Beutner S, Bloedorn B, Frixel S, Blanco IH, Hoffmann T, Martin HD, Mayer B, Noak P, Ruck C, Schmidt, M, Schulke I, Sell S, Ernst H, Haremza S, Seybold G, Sies H, Stahl W, Walsh R (2001). Quantitative assessment of antioxidant properties of natural colourant and phytochemicals: carotenoids, flavoinoids, phenols, and indigoids. The role of β-carotene in antioxidant function. J. Sci. Food Agric., 81: 559-568.

Brennan CS, Samyue E (2004). Evaluation of starch degradation and textural characteristics of crude fibre enriched biscuits. Int. J. Food Properties, 7(3): 647-657.

Burton GW, Ingold, KU (1984). β-carotene: an unusual type of lipid antioxidant. Science, 224: 569-573.

Dreosti IE (1993). Vitamin A, C, E, and β-carotene as protective factors for some cancers. Asia Pac. J. Clin. Nutr., 2(1): 21-25.

Fakourelis N, Lee EC, Min DB (1987). Effect of chlorophyll and carotene on the oxidation stability of olive oil. J. Food Sci., 52: 234-236.

Elizabeth v, Stuijvenberg M, Jane KD, Mieke F, Marita K, Diane G, Benade AJ Spinnler (1999). Effect of iron, iodine and β-carotene fortified biscuits on the micronutrient status of primary school children: a randomized controlled trial. Am. J. Clin. Nutr., 69(3): 497-503.

Gopalan C, Rama SBV, Balasubramanian SC (1989). Nutritive Value of Indian Foods- revised edition. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India. p. 50.

Indian Standard (1971). Guide for sensory evaluation of foods. (IS: 6273 Part I and Part II – 1971), Indian Standard Institution, Manak Bhawan, New Delhi,

Jung MY, Min DB (1991). Effects of quenching mechanisms of carotenoids on the photosensitized oxidation of soybean oil. J. Am. Oil Chem. Soc., 68: 653-658.

Kennedy TA, Liebler DC (1992). Peroxyl radical scavenging by β-carotene in lipid bilayers. J. Biol. Chem., 267: b4658-4663.

Lee EC, Min DB (1988). Quenching mechanism of b-carotene on the chlorophyll sensitized photooxidation of soybean oil. J. Food Sci., 53: 1894-1895.

Miller NJ, Sampson J, Candeias LP, Bramley PM, Rice-Evans CA (1996). Antioxidant activities of carotenes and xanthophylls. FEBS Lett., 384: 240-242.

Mridula D, Wanjari OD (2006). Effect of incorporation of full fat soy flour on quality of biscuits. Beverage Food World. 33(8): 35-36.

Mridula D, Gupta RK, Manikantan MR (2007). Effect of incorporation of sorghum flour to wheat flour on quality of biscuits fortified with defatted soy flour. Am. J. Food Technol., 2(5): 428-434.

Sahay KK, Singh KK (2001). Unit operations of agricultural processing. Vikas Publishing House Pvt. Ltd., New Delhi, pp. 207-213.

Simon PW, Wolff XY (1987). Carotenes in typical and dark orange carrots. J. Agric. Food Chem., 35: 1017-1022.

Speizer FE, Colditz GA., Hunter DJ, Rosner B, Hennekens C (1999). Prospective study of smoking, antioxidant intake, and lung cancer in middle-aged women. Cancer Cause Control. 10(5): 475-482.

Stuijvenberg ME, Dhansay MA, Lombard CJ, Faber M, Benade AJS (2001). The effect of a biscuit with red palm oil as a source of β-carotene from a synthetic source in a randomized controlled trial. Eur. J. Clin. Nutr., 55: 657-662.

Terao J (1989). Antioxidant activity of β-carotene-related carotenoids in solution. Lipids, 24: 659-661.

Toteja GS, Singh P, Dhillo, BS, Saxena BN (2002). Vitamin A deficiency in 16 districts of India. Indian J. Pediatr., 69 (7): 603-605.

Tsuchihashi H, Kigoshi M, Iwatsuki M, Niki E (1995). Action of β-carotene as an antioxidant against lipid peroxidation. Arch. Biochem. Biophys., 323: 137-47.

WHO (1996). Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. WHO/NUT/96.10. Geneva (available at: http://whqlibdoc.who.int/hq/1996/WHO_NUT_96.10.pdf).