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Preparation of β -Carotene Enriched Pearl Millet Based Cookies

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K e y w o r d s

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A B S T R A C T

Cookies were prepared by substituting *maida* with pearl millet flour (PMF) (60:40) and enriched with microencapsulated β-carotene (MBC) powder at 2, 4 and 6% levels. Cookies were evaluated for physico-chemical, sensory and textural quality parameters. Incorporation of MBC in pearl millet based cookies resulted in considerable improvement in β-carotene and total antioxidant activity of cookies when compared to *maida* with PMF, whereas calorific value was found to be slightly decreased. The spread ratio and spread factor were more or less same as compared to control sample. The colour values *L** and *a** decreased while *b** increased with the addition of MBC to the cookies. The hardness, breaking strength and cutting strength of cookies were decreased with the incorporation of MBC in pearl millet based cookies. The supplementation of 4 % MBC was found to be excellent for preparation of β-carotene enriched pearl millet based cookies without affecting the overall quality.

Introduction

Today, in the 21st century, the existence of vitamin A deficiency or VAD, is a major blow to most of us. Its mere existence in both controlled and uncontrolled form is a sorrow in itself. Vitamin A which is an important nutrient for the proper functioning of the eyes, heart, lungs, kidneys, the immune system, and the reproductive system, is also very vital for pregnant women. It is mostly found in fish, meat, poultry, eggs, fruits and vegetables (the most common dietary supplements being β-carotene in fruits and vegetables) is in controlled form in almost all the North American countries, most of the European nations. On the other hand, many Asian countries apart from Japan and Russia (the part falling in Asia), seriously suffer from VAD. In a shockingly sad manner, India has been categorized as "clinical" by WHO, when it comes to VAD. In simpler words, India has serious vitamin A deficiency (Singh, 2014). Therefore, one of the great challenges today is to develop inexpensive foods that are nutritionally superior and at the same time highly acceptable to intended consumer.

In recent years, there is a trend towards a healthier way of living, which includes a growing awareness by consumers of what they eat and what benefits certain ingredients

have in maintaining good health. Preventing illness by diet is a unique opportunity for innovative so-called functional foods (Sheehy and Morrissey, 1998). β-carotene which is a coloured substance having potential for use in food and nutraceutical preparations. However, creating water dispersible form of carotenoids is difficult because of limited solubility of pure carotene crystals. Encapsulation is a potential approach to transform liquids into stable and free flowing powders which are easy to handle and incorporate into dry food systems.

With the increasing knowledge of the positive functions of β-carotene, more and more people take interest in some foods or pharmaceuticals containing β-carotene ingredients, such as beverages, baked goods, oils, capsules and tablets. Lipid-soluble vitamins such as vitamin A, β-carotene and vitamins D, E or K are much easier to encapsulate than water-soluble ingredients (Kowalski *et al.,* 2000).

Hence, seeing the severity of nutritional deficiency diseases particularly vitamin A, the present study was undertaken to evaluate enrichment of pearl millet based cookies with microencapsulated β-carotene powder and study its effect on the physico-chemical, sensory and textural characteristics of cookies.

Materials and Methods

Materials: The raw materials such as *maida*, pearl millet flour, sugar, *vanaspati*, sodium bicarbonate, ammonium bicarbonate, etc. were purchased from local market of Rahuri. Microencapsulated β-carotene powder was prepared in the laboratory by spray drying.

Preparation of cookies: Cookies were prepared using the traditional creamery method. The ingredients included (g) wheat *maida* 60, pearl millet flour 40, sugar 50, *vanaspati* 50, ammonium bicarbonate 0.5, sodium bicarbonate 0.5, and required amount of water. Cookies were enriched with microencapsulated β-carotene (MBC) powder at 2, 4 and 6%. The cookies were evaluated for physico-chemical, sensory and textural quality.

Sensory evaluation: The cookies were evaluated for sensory attributes by a panel of 14 semi-trained judges, using a 9 point Hedonic scale system for different parameters like colour and appearance, texture and grain, flavour, crispiness, taste and overall acceptability. The mean values of 6 semi-trained judges were considered for evaluating the quality.

Chemical parameters: The β-carotene content of cookies was determined by spectrophotometric method as suggested by Srivastava and Kumar (2009). The total antioxidant activity of cookies was determined FRAP assay.

Physical parameters: Weight, diameter, thickness, spread ratio and % spread factor of cookies were estimated as per AACC (1976) methods.

Colour values: The colour scanning machine (Model: Colour Flex EZ) was used for the measurement of colour of cookies. The colour was measured by using CIELAB scale at 10° observer at D65 illuminant. The cookies sample was placed in the sample cup and the reading in terms of *L**, *a** and *b** were measured. The deviation of the colour of the sample to standard was observed and recorded in the computer interface.

Textural characteristics of cookies: Textural characteristics of cookies such as hardness, breaking strength and cutting strength of cookies were measured using

Instron Universal Texturometer (Shimadzu AG-Xplus). Each cookie was placed on the loading cell and compressed as per the standard procedures given by Singh *et al.*, (1993).

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 (Panse and Sukhatme, 1967).The analysis of variance revealed at significance of $p<0.05$ level, S.E. and C.D. at 5 % level was mentioned wherever required.

Results and Discussion

β-carotene content and total antioxidant activity of cookies:

The data about β-carotene content and total antioxidant activity of cookies incorporated with 40 % PMF (var. *Dhanshakti*) and varying levels of MBC powder is presented in table 1. Incorporation of MBC resulted in considerable improvement in β-carotene content of cookies. The statistical analysis of β-carotene content revealed that there was significant increase in the β-carotene content ($p>0.05$) of cookies from 0.49 to 3.92 mg/100g after addition of 6 % MBC. It is clear that sample C_3 contains the highest amount of β-carotene as compared to the other samples. β-carotene content of sample C_0, C_1, C_2 and C_3 was 0.49, 1.18, 2.56 and 3.53 mg/100g, respectively which was found in consistent with the added amount of MBC. The freshly baked MBC incorporated cookies retained about 79 % of β-carotene. This showed that processing of cookies did not much affect the final β-carotene of cookies prepared with addition of microencapsulated powder.

Bauernfeind *et al.*, (1958) and Bunnel *et al.*, (1958) reported 74-95% retention of total β-carotene in cookies, pie crust and yellow cakes. Rogers *et al.*, (1993) reported 30% β-carotene losses during baking of cookies. They also observed that prebaking processing steps had little or no adverse effect on the stability or isomeric distribution on added β-carotene to baked products (yellow layer cake, sugar cookies and bagels) rather loss was during baking. Park *et al.*, (1997) observed similar results for β-carotene retention in white bread fortified with cold water-dispersible β-carotene. Gayas *et al.*, (2012) reported linear increase in β-carotene content from 0.10 to 2.49 mg/100g due to increase in the level of carrot pomace powder up to 10% in defatted soy flour fortified biscuits.

It was clear that sample C_3 has the highest level of total antioxidant activity. It was found that control sample had the lowest total antioxidant activity (11.76 mMol/kg). Total antioxidant activity of sample C_1, C_2 and C_3 was 14.84, 16.18 and 19.43 mmol/kg, respectively. Thus the addition of MBC resulted in increased total antioxidant activity of cookies from 11.76 to 19.43 mmol/kg, which provided the prominent health benefits. Total antioxidant activity was expressed in TEAC i.e. Trolox Equivalent Antioxidant Activity. Thus total antioxidant activity of sample C_0, C_1, C_2 and C_3 was equivalent to that of a solution 11.76, 14.84, 16.18 and 19.43 mmol of Trolox calculated experimentally by the FRAP method.

The antioxidant activity of control sample was attributed to the phenolic compounds present in PMF. The addition of MBC contributed to high content of β-carotene, thus resulting in high total antioxidant activity in cookies. The incorporation of PMF and MBC into cookies increased health benefits by increasing antioxidant properties and dietary fiber content. The results obtained are in good agreement with the results reported by the

Volker *et al.*, (2002). Ajila *et al.*, (2008) reported increase in total antioxidant activity of biscuits incorporated with mango peel powder. Moore *et al.*, (2009) reported that baking improved the antioxidant availability in whole-wheat pizza crust.

Sensory evaluation of cookies

The data (Table 2) clearly indicates that the average score for colour and appearance of β-carotene enriched pearl millet based cookies ranged from 7.00 to 7.75 whereas the minimum score 7.00 was observed in control sample (C_0). However maximum score 7.75 observed in samples C_3. This may be due to effect of addition of highest level of MBC powder containing maltodextrin. The treatment C_2 obtained higher scores of texture and grain (7.7), taste (8.00) and overall acceptability (7.64) as compared to control and other samples. It was observed that, the scores for colour and appearance, flavor and crispiness was higher i.e. 7.67, 7.50 and 7.71, respectively in C_3 sample. The treatment C_2 was found to be better and was mostly acceptable. Thus on overall acceptability score, C_2 was considered as standardized and used for further storage studies.

Sudha *et al.*, (2007) reported improvement in sensory qualities of biscuits containing maltodextrin and polydextrose. Gayas *et al.*, (2012) reported improvement in colour and other sensory characteristics of carrot pomace powder incorporated with defatted soy flour fortified biscuits.

Physical characteristics of cookies

It was observed that addition of MBC had very less effect on the physical parameters of cookies (Table 3). There was slight decrease in the diameter of cookies from 46.37 to 46.21 mm with increasing proportion of MBC. There was also increase in thickness from 11.37 to 11.42 mm. No trend was observed for weight of cookies because baking was not performed under strict conditions of temperature and humidity.

The spread ratio of cookies decreased significantly from 4.08 to 4.05 with increasing level of MBC. The spread factor of cookies decreased from 100 to 99.27 % with increased addition of MBC. The decreased spread ratio and spread factor may be due to dilution of gluten in cookies with maltodextrin. Also gluten influenced the diameter and spread onset time which is again dependent on the amount free water available to the non-gluten constituents (Bram *et al.*, 2008).

Sudha *et al.*, (2007) reported similar results for physical qualities of biscuits containing maltodextrin and polydextrose. They reported little effect of maltodextrin and polydextrose on thickness and spread of biscuits.

Colour evaluation of cookies

Addition of MBC showed improvement in the colour values of cookies (Table 4). The *L** value increased with the increase in the levels of MBC. Control cookies had the lowest brightness compared to the MBC enriched cookies. No specific trend is seen in the change in *a** value upon addition of MBC. The change in *b** value, which indicates the yellowness, gradually increased with increase in MBC level.

The colour of cookies was more attributed to the PMF rather MBC as the content of PMF was greater in comparison to MBC. Addition of MBC caused slight bleaching effect on the colour of the cookies. Slightly lower redness and higher brightness in cookies incorporated with MBC might be due to interaction of yellowness of MBC with other ingredients of cookie dough. Similar results were reported by Mridula (2011) for β-carotene biscuits fortified with defatted soy flour.

Table.1 β-Carotene content and total antioxidant activity of cookies*

Treatments	β-carotene content (mg/100g)	Total antioxidant activity (mmol/kg)
Control	0.49	11.76
C_1	1.18	14.84
C_2	2.56	16.18
C_3	3.53	19.43
SE±	0.387	0.261
CD at 5%	1.167	0.789

Each value is the average of three observations
*****Cookies (40 % PMF) from *Dhanshakti* variety
C_0 = Cookies without (MBC), C_1 = 2% MBC, C_2 = 4% MBC, C_3 = 6% MBC

Table.2 Sensory evaluation of cookies*

Treat-ments	Colour and appearance	Texture and grain	Flavour	Crispiness	Taste	Overall acceptability
C_0	7.00	7.50	7.00	7.29	7.36	7.23
C_1	7.17	7.67	7.17	7.33	7.50	7.37
C_2	7.67	7.71	7.33	7.50	8.00	7.64
C_3	7.75	7.50	7.50	7.71	7.83	7.57
SE±	0.387	0.261	0.397	0.265	0.219	0.229
CD at 5%	1.167	0.789	1.196	0.799	0.661	0.691

Each value is the average of three observations
*****Cookies (40 % PMF) from *Dhanshakti* variety
C_0 = Cookies without (MBC), C_1 = 2% MBC, C_2 = 4% MBC, C_3 = 6% MBC

Table.3 Physical parameters of cookies*

Treat-ments	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio	Spread factor (%)
C_0	9.71	46.37	11.37	4.08	100
C_1	9.72	46.33	11.38	4.07	99.76
C_2	9.72	46.28	11.39	4.06	99.51
C_3	9.71	46.21	11.42	4.05	99.27
SE±	0.004	0.002	0.003	--	--
CD at 5%	0.011	0.007	0.010	--	--

Each value is the average of three observations
*****Cookies (40 % PMF) from *Dhanshakti* variety
C_0 = Cookies without (MBC), C_1 = 2% MBC, C_2 = 4% MBC, C_3 = 6% MBC

Table.4 Colour values of cookies*

Treatments	Colour values				
	L*	***a****	***b****	***C****	***H****
C_0	58.710	3.393	17.708	18.030	79.121
C_1	58.575	3.310	17.973	18.275	79.565
C_2	57.883	3.279	18.326	18.617	79.856
C_3	56.027	3.032	19.351	19.587	81.095
SE±	0.054	0.097	0.033	0.057	0.071
CD at 5%	0.166	0.369	0.103	0.187	0.218

Each value is the average of three observations
*****Cookies (40 % PMF) from *Dhanshakti* variety
C_0 = Cookies without (MBC), C_1 = 2% MBC, C_2 = 4% MBC, C_3 = 6% MBC

Table.5 Textural characteristics of cookies*

Treatments	Hardness (N)	Breaking strength (N)	Cutting strength (N)
C_0	11.58	38.97	40.16
C_1	11.26	38.68	39.82
C_2	10.97	38.33	39.65
C_3	10.64	37.92	39.23
SE±	0.033	0.071	0.054
CD at 5%	0.103	0.218	0.166

Each value is the average of three observations
*****Cookies (40 % PMF) from *Dhanshakti* variety
C_0 = Cookies without (MBC), C_1 = 2% MBC, C_2 = 4% MBC, C_3 = 6% MBC

Textural characteristics of cookies

Textural characteristics of cookies (Table 5) were affected slightly with the increase in the level of MBC. The hardness, breaking strength and cutting strength of β-carotene enriched pearl millet based cookies ranged from 11.58 to 10.64 N, 38.97 to 37.92 N and 40.16 to 39.23 N, respectively. The decrease in hardness, breaking strength and cutting strength might be due to weakened gluten network which reduced the dough cohesiveness and strength due to addition of MBC. Sudha *et al.*, (2007) reported improvement in texture of biscuits containing maltodextrin. Agrahar-Murugkar *et al.*, (2014) reported similar decrease in cutting strength of composite flour biscuits.

In conclusion, the results of this study indicate laboratory prepared microencapsulated β-carotene has the potential for use in cookies enrichment. Microencapsulation protected β-carotene during processing of cookies, thus maintaining its activity.

It was observed that pearl millet based cookies supplemented with MBC improved all the sensory characteristics of cookies. The physical and textural characteristics of cookies were slightly affected by MBC supplementation. The supplementation of MBC (4%) in cookies was considered to be better on the basis of physico-chemical, sensory and textural analysis of cookies.

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