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Baking and Storage Stability of Retinyl Acetate (Vitamin A) Fortified Cookies

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Abstract: Cookies were prepared from commercially available straight grade flour using Retinyl acetate (RA) as fortificant @ 30, 40 and 50% of Recommended Daily Allowance (RDA). The product was packed in Bioriented poly propylene (BOPP) and analyzed on monthly basis for physico-chemical and sensory attributes including baking and storage stability of the fortificant up to three month. The results revealed the non-significant influence of fortification on physico-chemical composition and sensory characteristics and the cookies containing 50% of RDA; Retinyl acetate were found the best in overall acceptability. Baking loss of Retinyl acetate was 9.30% while 8.33% loss was observed during storage.

Key words: Fortification, Retinyl acetate, cookies, baking stability and storage stability

Introduction

Vitamin A deficiency (VAD) is a global nutritional problem particularly in the developing world that afflicts severely health of pregnant and lactating women, infants and children. In Pakistan about 60% of the males, 71% of the non-pregnant and lactating females and 79% of pregnant women consume less than 70% of the RDA of vitamin A (GOP, 1970).

Based on the above mentioned facts, it is highly probable that Pakistani females and children both in rural and urban areas are at significant risk of vitamin A deficiency. Enhancing vitamin A supplement can help to reduce child mortality by 25% (Sher, 2004).

There are three major strategies to combat Vitamin A deficiency, which are as food fortification, supplementation with vitamin A and food diversification (Bloem *et al.*, 1998; Chakarvarty, 2000; Filteau and Tomikins, 1999). Food fortification can be an economical, flexible and socially acceptable way to improve the nutrient intake of groups at risk in order to ensure nutritionally adequacy of the diet (Hoffpauer and Wright, 1994). It is an option where people have access to milled or processed food (Mason *et al.*, 2001). Fortification can also reinstate the natural vitamin A content of a foodstuff if it has been lost during processing. Vitamin A fortification requires special attention in regard that vitamin A is fat-soluble and proven vehicles for vitamin A fortification include sugar, oils and fats and cereals flours (Arroyave *et al.*, 1979; Dary *et al.*, 1996; Lotfi *et al.*, 1996). Bauernfeind and De Ritter (1991) described cereals as best for fortification because in developing countries 95% of the population consumes cereals as dietary staple and according to Ranum (2002) as staples, milled cereals are relatively inexpensive, they are grown and consumed worldwide by all economic classes, versatile in preparation and use, generally processed in large centralized plant and milled cereals are better for fortification. In poor households, the overwhelming part of the diet might consist of staple grains and vegetables (Graebner *et al.*, 2004).

There are three biologically active forms of vitamin A, i.e., Retinol, Retinal, and Retinoic acid. Retinol is the true form of vitamin A, found in the foods of animal origin, readily used by the human body. Retinyl esters are found in animal foods such as liver, eggs and whole milk (Trumbo *et al.*, 2001).

The most important commercial forms of vitamin A are Retinyl acetate and Retinyl palmitate. These pure chemicals have mainly been added to foods as food improvers and colorants, but foods can also carry them to increase vitamin A intake of the populations consuming these foods (Lotfi *et al.*, 1996).

Regarding the stability of vitamin A in cookies the previous studies of Rice *et al.* (1941) revealed that in baked products such as bread, biscuits and cake, which are baked under moderate conditions, it appears that 80 to 100 per cent of the vitamin A survives the baking process.

Vitamin A is sensitive to heat and light and higher storage temperature increases the oxidation of vitamin A and results in loss of Retinyl acetate's ability of binding with lipids and also lowers its absorption capacities (Butt *et al.*, 2007).

The present study was designed to prepare vitamin A fortified cookies containing Retinyl acetate and to evaluate its stability during baking and storage.

Materials and Methods

Procurement of raw materials: Commercial straight grade flour was purchased from local market and the fortificant (Retinyl acetate) was purchased from Sigma Chemicals, Switzerland.

Table 1: Different treatments used to prepare fortified cookies

Treatments	Retinyl acetate % RDA
T_1	(Control)
T_2	30
T_3	40
T_4	50

Table 2: Effect of fortificant on physical parameters of fortified cookies

Treatments	T_1	T_2	T_3	T_4
Width (cm)	2.37	2.38	2.34	2.33
Thickness (cm)	0.52	0.52	0.53	0.53
Spread Factor (cm)	0.45	0.46	0.46	0.45

Preparation of fortified cookies: Fortified cookies were prepared having fortificant at different proportions by some modifications in the method described in AACC (2000) and stored at room temperature in Bioriented poly propylene (BOPP). The detail of treatments used for preparing fortified cookies is given in Table 1.

Baking stability of fortified cookies: Retinyl acetate (vitamin A) contents of cookies were determined through spectrophotometer according to the method of AOAC (1990) before and after baking. Vitamin A losses were computed in percentage to estimate baking losses.

Storage studies: The fortified cookies were evaluated for physical (Width, thickness and spread factor) and chemical (Moisture, crude proteins, crude fat, crude fibre and ash contents) composition at 0, 30, 60 and 90 days of storage according to the methods described in AACC (2000). The Retinyl acetate (vitamin A) contents of cookies were determined through spectrophotometer according to the method of AOAC (1990) at the same intervals. The cookies were analyzed by a panel of judges for color, tastes, flavor, texture and overall acceptability by following the procedures of Larmond (1977).

Results and Discussion

Physical analysis: Fortification showed non-significant effect on width, thickness and spread factor of cookies. The highest width (2.37 cm) was found in T_1 (Control) while the lowest (2.33 cm) in T_4 (50 % of RDA; RA). Regarding thickness, addition of Retinyl acetate slightly increased the value from 0.50 cm to 0.53 cm. However, no trend was observed in change of spread factor due to addition of the fortificant (Table 2).

Present studies reveal that fortification had no adverse effects on physical parameters of cookies. Storage of 90 days also had the significant influence on physical parameters. Only width of cookies slightly but non-significantly decreased from 2.38 cm (at 0 day) to 2.32 cm after 90 days (Table 3).

However, no obvious change was recorded in thickness and spread factor of fortified cookies during storage.

Table 3: Effect of storage on physical parameters of fortified cookies

Storage days	0	30	60	90
Width (cm)	2.38	2.35	2.37	2.32
Thickness (cm)	0.52	0.53	0.52	0.53
Spread Factor (cm)	0.46	0.45	0.46	0.45

Table 4: Effect of fortificant on chemical compositions (%) of fortified cookies

Treatments	T_1	T_2	T_3	T_4
Moisture	2.76	2.72	2.69	2.70
Ash	0.56	0.57	0.57	0.57
Protein	6.56	6.57	6.57	6.56
Fat	22.54	22.43	22.56	22.49
Fiber	0.26	0.25	0.26	0.26
NFE	67.27	67.41	67.34	67.36

Table 5: Effect of storage on chemical compositions (%) of fortified cookies

Storage days	0	30	60	90
Moisture	2.53^c	2.71^b	2.74^b	2.88^a
Ash	0.54	0.55	0.59	0.60
Protein	6.57	6.55	6.55	6.55
Fat	22.41	22.48	22.57	22.55
Fiber	0.25	0.26	0.26	0.26
NFE	67.70^a	67.43^b	67.29^c	67.04^d

Spread factor and size of the cookies depends on particle size and moisture content of flour (Gaines and Donelson, 1985).

Chemical composition: Regarding chemical composition, non - significant effect of fortification was found on all the parameter like moisture, ash, protein, fat, fiber and NFE (Table 4). Addition of Retinyl acetate slightly decreased the moisture level as control treatment had 2.76% moisture content while moisture was found 2.70 % in cookies containing 50% of RDA of Retinyl acetate.

However, no gradual change was observed in other chemical parameters on addition of the fortificant. The mean composition of cookies recorded in present study is in accordance with Butt *et al.* (2007) who found the similar composition in cookies.

The effect of storage was found significant on moisture and NFE content of fortified cookies while non-significant changes were observed in other parameters during 3 months. The moisture level increased from 2.53% (at 0 day) to 2.88% after 90 days and mean NFE content significantly decreased from 67.70% to 67.04% (Table 5).

Although some biochemical changes occurred during storage but do not affect the crude proximate composition. The increase in moisture may be due to moisture in air that affects the cookies even in packaging. Butt *et al.* (2007) also determined the significant increase in moisture content of vitamin A fortified cookies during storage.

Table 6: Effect of fortificant on sensory characteristics (scores) of fortified cookies

Treatments	T_1	T_2	T_3	T_4
Color	7.09^{a}	6.90^{b}	6.81^{c}	6.48^{d}
Flavor	7.00	6.90	6.95	6.67
Taste	6.86	6.90	6.95	7.14
Crispiness	7.00	7.05	7.09	7.24
Texture	7.05^{bc}	7.00^{c}	7.14^{b}	7.43^{a}
Overall acceptability	7.19	7.09	7.14	7.24

Table 7: Effect of storage on sensory characteristics (scores) of fortified cookies

Storage days	0	30	60	90
Color	7.25^{a}	7.17^{b}	6.67^{c}	6.00^{d}
Flavor	7.42^{a}	7.25^{b}	6.75^{c}	6.00^{d}
Taste	7.42^{a}	7.24^{b}	6.75^{c}	6.33^{d}
Crispiness	8.00^{a}	7.25^{b}	6.84^{c}	6.17^{d}
Texture	8.00^{a}	7.42^{b}	7.00^{c}	6.25^{d}
Overall acceptability	7.75^{a}	7.33^{b}	7.16^{c}	6.16^{d}

Sensory evaluation: Fortified cookies were evaluated for organoleptic characteristics after one month intervals. The fortification significantly influenced the color and texture of cookies. Fortified cookies were awarded slightly lower scores for color and flavor as compared to un-fortified cookies. However, taste, crispiness and texture were improved on addition of Retinyl acetate. The lowest scores (6.86, 7.00, 7.05) were awarded by T_1 (control treat) while the highest scores (7.14, 7.24, 7.43) were gained by T_4 (50% of RDA; RA) for taste, crispiness and texture respectively. Overall, the cookies containing 50% of RDA of Retinyl acetate (T_4) was liked the most (Table 6).The adverse effect of fortification on color and flavor of cookies was due to Millard's, reaction (Bender, 1996). However, these changes were under acceptable limits.

During storage, significant decrease was observed in scores awarded to fortified cookies for all the characteristics, however, after 3 months of storage the overall acceptability was under acceptable limits. The mean scores awarded for overall acceptability at 0 days were 7.75 that significantly decreased to 6.16 after 90 days (Table 7).

The decrease in sensory scores as function of storage might be due to oxidation of fats and Millard's reaction. Similar, findings were described by Bender, 1996; Elahi, 2006 and Wada, 1998 who also reported the same decreasing trend in color, flavor, taste, texture, crispiness and overall acceptability with storage. During storage absorption of moisture by cookies results in deterioration of color, flavor, crispiness and texture (Wada, 1998).The same reason may be linked with present findings as the moisture level of cookies significantly increased during 90 days of storage.

Effect of baking on Retinyl acetate: The results regarding vitamin A contents prior and after baking of fortified cookies as presented in Table. Results showed minor loss (9.3%) during baking (Table 8). The mean Retinyl acetate contents before baking were 10.99 which reduced to 9.96 µg after baking. The baking loss of vitamin A is similar to the findings of Emodi and Scialei (1980) who reported 7-10% and Butt *et al*. (2007) who investigated 8.69-11.11% loss during baking.

Table 8: Baking stability of Retinyl acetate (µg) in fortified cookies

Treatments	Before baking	After Baking
T_1	0.19	0.16
T_2	10.98	9.93
T_3	14.59	13.43
T_4	18.18	16.33
Means	10.99^{a}	9.96^{b}

Table 9: Storage stability of Retinyl acetate (µg) fortified cookies

Treatments	0	30	60	90	Means
T_1	0.16	0.15	0.13	0.11	0.14
T_2	9.93	9.62	9.33	9.03	9.48
T_3	13.43	13.08	12.74	12.35	12.88
T_4	16.33	15.92	15.48	15.02	15.69
Means	9.96^{a}	9.69^{b}	9.42^{c}	9.13^{d}	

Storage stability: Storage of cookies for 90 days at ambient temperature high significantly reduced the Retinyl acetate content (Table 9).

At start of study mean vitamin A contents were 9.96 µg which decreased to 9.13 µg after 90 days. The percent loss recorded during storage was 8.33%. As the storage period increased, the higher percent loss was recorded. Butt *et al*. (2007) recorded 10.8% loss in vitamin A content of cookies during one month of storage. Bauernfeind and Ritter (1991) also found slight loss in Vitamin A after six months storage.

At higher storage temperature, due to oxidation Retinyl acetate lose its ability of binding with lipids and also lowers absorption capacities (Butt *et al*., 2007).

Conclusion: Fortification is considered the most effective strategy in combating vitamin A deficiency. The present study revealed that fortification of vitamin A did not influence the physico-chemical properties and sensory characteristics of cookies. During baking 9.3% and during storage 8.33% loss in RA was recorded. Hence, it was concluded that cookies fortified with RA @ 50% of RDA can be prepared and provided to the people to combat VAD.

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