Evaluation of sensory acceptability and storage stability of frozen carrot based dessert

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Abstract In the present study a recipe for frozen carrot based dessert (carrot *halwa*) was standardized on the basis of sensory characteristics such as appearance, odor, texture, taste and overall acceptability (OAA). The product was developed without addition of pure *ghee* to improve the storage stability under frozen conditions (-20°C). Sensory properties of the developed product (OAA score=8.60) were found to be equally good as compared to the conventional carrot *halwa* (OAA score=8.75) which was prepared using pure *ghee*. From the physico-chemical analysis the developed product was found to have lower amount of fat (ca. 12%) than the conventional one. During the frozen storage, microbial growth in the product was found to be non-significant ($P>0.05$). The free fatty acid content, peroxide value and thiobarbituric acid content increased during frozen storage of 15 months. But the increase was insignificant. Loss in total carotenoids content of the product was found to be 60.5% from initial value at the end of 15 months frozen storage.

Keywords Freezing · Carrot *halwa* · Sensory acceptability · Storage stability · Total carotenoids

Introduction

Use of frozen food products is increasing among the consumers due to the increased desire for convenience in terms of time and energy required for the final food preparation.

Frozen ready-to-eat foods require minimal processing in the form of thawing and warming for consumption (Rahman 1999). Besides this, restricted family size, increased levels of disposable income, wider travel abroad and adaptability of consumers towards of different cuisines are some of the contributing factors for popularization of frozen ready-to-eat foods (Maity et al. 2011a, b).

Freezing preservation is one of the best methods of food preservation as it delivers food product with best sensory, physico-chemical and microbiological attributes as compared to thermal processing (Al-Bulushi et al. 2011). Under sub zero conditions of frozen storage, damage to food nutrients is very less and most of the deteriorative biochemical reactions stand arrested. Freezing process consist of reduction of temperature, generally below -18°C , crystallization of part of the free water and concentration of some of the solutes. However, most of the spoilage causing microorganisms remain dormant in frozen state, but are not able to grow or multiply to cause spoilage and pathogenicity. Flavor retention is the best outcome in frozen foods as compared to other methods of food preservation (Alonso et al. 1997). The quality and safety of frozen food products depends on various factors such as size and shape of ice crystals formed during the freezing process, maintenance of desired sub-zero temperature during subsequent storage of frozen food products, type of packaging material used as well as physiological and bio-chemical nature of the material being frozen. All such factors have a profound effect on the overall acceptability in terms of its flavor, texture, aroma, color, visual appearance besides microbiological safety and nutritional quality (Torres and Canet 2001). Though the quality retention in frozen foods is high but quality deterioration continue to occur during frozen storage at a slower rate.

Indian traditional foods delivered a wealth of cultural heritage and are gaining popularity in the whole world.

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The demands for ready-to-eat Indian ethnic foods are increasing in the retail sector day-by-day. Carrot *halwa* is one of the popular desiccated Indian sweet meat products which are calorie dense and rich in nutritional value. It is widely used in festivals, marriages, feasts, religious functions as well as in daily menus. The basic preparation of carrot *halwa* involves cooking of grated carrots with sugar and oil (Sampathu et al. 1981). But its preparation takes hours together depending on the quantity of raw materials and the whole process is laborious and cumbersome. In the present study a recipe for ready-to-eat carrot *halwa* was standardized which was prepared without addition of pure ghee for longer term frozen storage. The product was also evaluated for the storage stability ($-20\text{ }^{\circ}\text{C}$) in terms of change in rancidity parameters (free fatty acid content, peroxide value and thiobarbituric acid value) and microbial safety for a period of 15 months.

Materials and methods

Raw materials

Carrots (*Ooty* variety) devoid of microbial infections and physical injuries were procured from the local market, Mysore. Milk (toned; fat: 3%, SNF: 8.5%), *khoa* (pindi variety; fat: 25.7%, protein: 19%) and pure *ghee* were purchased from *Nandini* Milk Dairy plant, Mysore. Sugar and dry fruits (cashew nut, pistachio, almonds) of good quality were purchased from local supermarket. All the chemicals used in present investigation were of AR grade and procured from S.D. Fine chemicals Ltd., Mumbai, India.

Preparation of carrot halwa

Carrots after surface sanitization with chlorinated water (100 ppm) were peeled and grated manually. Grated carrots were blanched in boiling water for 2 min. The recipe for carrot *halwa* was standardized according to the taste preference through preliminary sensory trials. The recipe of the standardized product consisted grated carrots (1 Kg), milk (1 Kg), *khoa* (200 g), sugar (400 g), cardamom powder (10 g) as flavor, and dry fruits such as cashew, almond, and pistachio in the ratio of 1:1:1 (60 g). Grated carrot was cooked at low flame for 15 min in an open pan (*kadai*). After the raw smell of carrot moved out, milk was added to the carrot. Cooking at moderate flame was continued with constant stirring until milk is imbibed into the carrot matrix. Then sugar was added to the carrot. The mixture was cooked for 30–40 min to remove free moisture. At the end of the cooking *khoa* and pre-fried dry fruits were added. All the ingredients were mixed to uniformly distribute the dry fruits in *halwa*. Carrot *halwa* prepared with pure ghee (20% of the

grated carrot) served as the control for the sensory evaluation.

Freezing and thawing

Carrot *halwa* (100 g) packed in polyethylene pouches (100 μm ; $10\times 10\text{ cm}$) was frozen at $-40\text{ }^{\circ}\text{C}$ for 90 min at a blast velocity of 8 ms^{-1} in a blast freezer (Model, SZC-V-425-3, Cryoscientific, Chennai) equipped with freezing rate controller. The frozen samples were stored in deep freezer at $-20\text{ }^{\circ}\text{C}$. Thawing of the samples was done for 1 h at room temperature ($28\pm 2\text{ }^{\circ}\text{C}$) before analysis.

Physico-chemical analysis

The a_w of the samples was determined using dew point equipment (Aqua Laboratory, Decagon CX-2, Decagon Devices Inc., Pullman, Washington, USA) at $25\text{ }^{\circ}\text{C}$ while moisture, fat and protein contents of the samples were determined by standard procedures as described in AOAC (1990). The pH was estimated with a digital pH meter (Cyberscan, Eutech instruments, Singapore). All the estimations were replicated four times and reported the mean values.

Sensory analysis

Frozen-thawed samples were served to a twenty semi-trained member panel for sensory evaluation in terms of overall acceptability using a nine point hedonic scale (Larmond 1977). Panelists were scientific staffs of the laboratory who were trained in the use of attributing rating scale for the characteristics examined. The scores were assigned from extremely liked (9) to disliked extremely (1). The samples were served to the panelists after coding with three digits randomly selected numbers in a sensory lab illuminated with white light and maintained at $20\text{ }^{\circ}\text{C}$.

Storage studies

During storage, the quality of the developed Ready-to-eat frozen carrot *halwa* was monitored by studying the changes in peroxide value (PV), free fatty acids (FFA) as per AOAC (1990) while thiobarbituric acid (TBA) value was determined using the method reported by Tarladgis et al. (1960). The total carotenoids contents were estimated by according to procedure of Kuti (2004). All the estimations were replicated four times and mean values were reported.

Microbiological analysis

The microbiological analyses in terms of standard plate count, yeasts and molds count, psychotropic counts and

coliforms count were carried out using standard methodology (APHA 1992) at zero time and then at a regular interval of 3 months. The counts were expressed as log CFU g⁻¹ of sample. All analyses were performed in duplicate and reported the average results.

Statistical analysis

Statistical analysis was performed by analysis of variance (ANOVA) and means were compared using the least significant difference (LSD, 95%) by Duncan's multiple range tests using Statistics 7 software (StatSoft, Tulsa, Oklahoma, USA).

Results and discussion

Physico-chemical characteristics of the product

The standardized recipe of carrot *halwa* without addition of pure *ghee* as well as with *ghee* (control) was subjected to various physico-chemical analyses. The physico-chemical characteristics of both the desserts are presented in Table 1. The product was formulated with natural ingredients without using any preservative or additive. The acidity of the product was found to be very low. The fat content of carrot *halwa* was 11.8% which is much lesser than the conventional pure *ghee* carrot *halwa* (fat ~20%). The water activity (a_w) of the product was 0.928.

Sensory acceptability

Sensory evaluation of the frozen thawed product in terms of appearance, odor, texture, taste and overall acceptability (OAA) are presented in Table 2. The OAA scores of both the formulations of carrot *halwa* viz. without as well as with pure *ghee* were found to be very high. Although the difference in OAA score between the two formulations was significant ($P<0.05$), the OAA of without *ghee* formulation

Table 1 Physico-chemical characteristics of the developed carrot *halwa* ($n=4$)

Parameters	Without <i>ghee</i>	With <i>ghee</i>
Moisture (%)	38.87±0.02	38.12±0.02
Protein (%)	8.63±0.03	8.68±0.03
Crude fat (%)	11.8±0.04	19.6±0.02
Total ash (%)	1.90±0.01	1.73±0.02
Carbohydrates (%; by difference)	38.90±0.02	31.79±0.01
Titration acidity (% citric acid)	0.12±0.004	0.12±0.003
pH	6.11±0.01	6.12±0.02
a_w	0.928±0.001	0.913±0.001

Table 2 Sensory acceptability of carrot *halwa* after freezing (at -40 °C) and thawing ($n=20$)

	Carrot <i>halwa</i>	
	Without <i>ghee</i>	With <i>ghee</i>
Appearance	8.5±0.01 ^a	8.5±0.01 ^a
Odour	8.8±0.03 ^a	8.8±0.02 ^a
Texture	8.3±0.02 ^b	8.4±0.01 ^a
Taste	8.3±0.03 ^b	8.7±0.02 ^a
OAA	8.6±0.02 ^b	8.7±0.01 ^a

Values with different superscripts in same row differ significantly ($P\leq 0.05$)

was 8.6, which was considered nearly 'extremely liked' score. The difference in appearance, odor and texture of carrot *halwa* without addition of pure *ghee* was statistically insignificant ($P>0.05$) from the pure *ghee* carrot *halwa* preparation. This might be due to the fact that both the formulations were comprised of *khoa* which made the products more palatable (Bajwa and Gupta 2007). Preparation with the addition of pure *ghee* was found to be superior than the without *ghee* carrot *halwa* in terms of taste. This could be due to the lubricating effect of fat which contributed to the higher OAA scores of the conventional carrot *halwa*.

Storage stability

The rancidity parameters indicated the oxidation of fat such as FFA, TBA and PV resulting in off flavor. The rancidity parameters increased during frozen storage (Table 3). The changes in FFA, PV and TBA were at a slower pace during the initial period of storage. The increase in these parameters was recorded to be faster during the end of frozen storage (12 to 15 months). An increase of 2.33% was recorded in FFA value at the end of the storage period of 15 months. PV increased from an initial value of 0.77 to 0.85 meq.O₂/Kg fat and it was found to be more pronounced after 12th months of storage. The initial TBA value of the sample was found to be 0.0214 mg Mal/kg sample. The increase in TBA value was slow and gradual up to 9 months of storage which was insignificant ($P>0.05$) and only after 9 months, it increased significantly ($P<0.05$) up to end of storage period. Increase in TBA value during frozen storage has been reported by several researchers in fat rich products such as ground beef patties (Brewer et al. 1992), soy enriched beef patties (Berry 1990). Several researchers have reported degradation in quality of frozen food products during frozen storage such as in frozen mashed potatoes (Redmond et al. 2003), frozen meat products (Pie et al. 1991) and frozen ready-to-eat meals (Jin et al. 1997). The quality deterioration in these products may be due to the fact that though freezing is one of the best methods of food

Table 3 Changes in rancidity parameters of carrot *halwa* (without *ghee*) stored at -20°C ($n=4$)

Parameters	Storage period (months)					
	0	3	6	9	12	15
FFA (% oleic acid)	1.72 ± 0.02^a	1.73 ± 0.02^a	1.74 ± 0.01^a	1.74 ± 0.01^a	1.75 ± 0.03^b	1.76 ± 0.03^b
Peroxide value (Meq. O_2/Kg fat)	0.77 ± 0.03^a	0.78 ± 0.02^a	0.81 ± 0.02^b	0.83 ± 0.01^c	0.84 ± 0.02^c	0.85 ± 0.01^d
TBA (mg Mal/Kg sample)	0.0214 ± 0.008^a	0.0214 ± 0.005^a	0.0216 ± 0.003^a	0.0218 ± 0.002^b	0.0222 ± 0.003^{bc}	0.0225 ± 0.003^c

Values with different superscript letters in same row differ significantly ($P\leq0.05$)

preservation but deterioration of food quality continues to occur during frozen storage if the food is not blanched before freezing. Most of the physical and chemical reactions are slowed with decrease in temperature during freezing or frozen storage, but they do not stop completely (Maity et al. 2011a, b).

Degradation of total carotenoids of the product during frozen storage

One of the quality characteristics of carrot is its color which is due to the presence of carotenoids. Thus, it was found important to investigate the degradation of carotenoids during frozen storage. During the processing of carrot *halwa* the carotenoids were degraded which continued to degrade during frozen storage as depicted in Fig. 1. At the end of the storage period the total carotenoids content decreased from 2.13 mg/100 g to 0.84 mg/100 g. Most of the degradation took place from 9 months of storage to 12 months. Similar degradation of carotenoids was also reported in tomatoes (Urbanyi and Horti 1989) and in papaya (Cano et al. 1996) during frozen storage. Degradation of certain nutrients in

frozen foods is affected by the fluctuations in storage temperature during frozen storage. The molecular mobility of the unfrozen phase greatly influences the chemical and physical stability of frozen foods, which could be quantified as a function of glass transition temperature. As the storage temperature is increased above the glass transition temperature, the amount of unfrozen water mobilizing solutes in the viscous matrix increases. Hence, the increase in mobility of solutes permits enzymic and oxidation reactions to continue, which increases degradation in the product during frozen storage (Lim et al. 2006).

Microbiological quality

Standard plate counts, coliforms counts and Yeast and mold counts in the product were not prominent over the entire period of frozen storage (data not reported). The lower values of the microbiological counts (<1) indicated the microbial safety of the product even after a storage period of 15 months. However at the end of the storage psychrophiles count was found to increase which was not consequential. The developed dessert was microbiologically safe for a storage period of 15 months because the safety of ready-to-eat frozen food for consumption depends on the safety of the raw material used and of the various stages in manufacture to make the product (Cordoba 1998).

Conclusions

Carrot *halwa* is considered as one of the highly acceptable dessert product in the Indian food dietary. The basic ingredients of *halwa* include grated carrots, milk, pure *ghee*, dry fruits, sugar and *khoa*. Although freezing is considered as one of the best method of preservation, still fat oxidation continues to occur in the frozen products at sub-zero storage temperatures rendering the product unacceptable for consumption. In the present study, a recipe for carrot *halwa* was standardized to develop a nutritious calorie dense frozen product without the use of pure *ghee* to stabilize the product during frozen storage which has all the in-built conveniences necessitating merely thawing before serving. The changes in

Fig. 1 Degradation of total carotenoids content in carrot *halwa* (without *ghee*) during frozen storage ($n=4$)

sensory, rancidity as well as microbiological parameters were found to be inconsequential during the storage period of 15 months. The stability of the carrot *halwa* during frozen storage is an indication that it could be used for longer periods as a dessert with Indian dietary staple at homes, restaurants, catering industries and for Services.

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