Indian Journal of Traditional Knowledge
Vol 20(2), April 2021, pp 486-491

Studies on development of instant pumpkin soup tablets and evaluation of storage stability

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Received 15 July 2019; revised 24 December 2020

A study was carried out to develop pumpkin soup tablet with enriched β-carotene which can be instantly reconstituted in hot water. Ingredients of pumpkin soup tablet namely pumpkin flour (32.5%), corn flour (19.4%), milk powder (14.5%), onion powder (3.2%), pepper powder (3.2%), coriander (1.3%), garlic (1.3%), saturated fat (6.5%) and salt (13.9%) were optimised. Maltodextrin and xanthan gum were used as emulsifier to prepare two variants of the soup cube formulations. Proximate composition, β-carotene, textural attributes and microbiological quality of the developed product were determined during storage at room temperature. Sensory acceptability of the product was evaluated by reconstituting the soup cube in hot water. The study revealed that the product was acceptable and could be reconstituted instantly in hot water. Soup tablets prepared with xanthan gum as emulsifier were superior in colour, texture and retention of β-carotene. The incorporation of pumpkin flour in soup cube enhanced its nutritional value to an extent of 50% of RDI for β-carotene. The product could be a convenient alternative for preparing an organoleptically acceptable soup instantly and thereby saving packaging cost and space.

Keywords: β-carotene, Organoleptic evaluation, Pumpkin flour, Sorption isotherms, Soup tablets, Storage, Texture

IPC Code: Int Cl.[21]: A21D 2/40, A21D 4/00, A21D 6/00, A21D 13/04, A23L 1/30, A23L 2/02, A23 L 2/52, A23L 33/00

The increasing trend in consumption of ready-to-eat foods can be attributed to higher per capita incomes, increased population in urban areas, poor availability of labour, time and erratic work schedules. Consumers are opting for convenient, economical and nutritious foods with better shelf-stability[1]. Vegetable soup, considered as an appetizer can be fortified with essential nutrients to make it health promoting. Various types of instant soup mixes are available in the market which contain different ingredients, mostly corn starch, spices, salt, flavours and flavour enhancers. Earlier, researchers[2] developed different types of soup powders using hot-air dried ingredients. The soup mixes are mixed with boiling water for varying periods of time before consumption. Ready to use instant soup tablets can become more popular and convenient than soup mixes as they are compressed into tablet form and are easy to reconstitute thereby minimizing the packaging and storage requirements.

Pumpkins are native to tropical and subtropical countries where it has been used as a vegetable. The yellow orange colour of pumpkin is attributed to the presence of β-carotene[3], which is proven to be beneficial in the prevention of skin diseases, eye disorders and cancer[4]. Supplementation of β-carotene rich resources in human diet is considered to be a cost-effective approach to combat vitamin-A deficiency in the developing countries. Pumpkin has been used as a functional food and as a source of valuable phyto-nutrient components. Literature is abundant with reports to confirm the health-promoting properties of pumpkin and its products[6,7]. Pumpkin seeds along with flax seed, oats and peanuts have been used in the preparation of a snack bar to avail the fiber from pumpkin and flax seeds[8]. Processing the pumpkin pulp to produce shelf-stable carotene rich flour can help utilize pumpkins in bakery, extruded and other culinary applications. The pumpkin flour supplemented products could enhance their nutritional quality for the target populations to combat vitamin A deficiency. Vegetable soups with spice ingredients have been used before meals for enhancing appetite. In the Himalayas, fresh bamboo shoots fermented and made into products such as *gundruk*, *sinki* and *inziangsang* with acidic profiles were used as soups and appetizers[9].

Various studies have been reported on the usage of pumpkin flour in bakery products, soups, sauces,

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instant noodles, pasta and flour mixes as a partial supplement to cereals. In the present study, an attempt has been made to develop nutritious ready-to-serve instant soup tablets by incorporating β-carotene rich pumpkin flour and to evaluate the shelf life of the product. The optimized product was tested for stability of colour, β-carotene, microbiological safety, sorption studies and organoleptic acceptability of the reconstituted soup over a storage period of 6 months.

Materials and Methods

Pumpkins were purchased from local market in Hyderabad, Telangana, India. Raw materials for the preparation of soup tablet were procured from local super market. Chemicals and solvents of analytical and HPLC grade were procured from SD Fine Chem. Mumbai, India. Standard β-carotene for HPLC was procured from Sigma Aldrich, Bangalore, India.

Preparation of pumpkin flour (PF)

Mature pumpkins were peeled and the fibrous matter and seeds were removed. The pumpkins were sliced to approximately 5 mm thickness using a vegetable slicer. The slices were blanched in hot water for 2 min followed by treatment with 0.2% potassium metabisulphite for 45 min to maintain the natural orange colour and microbial safety during drying. The treated pumpkins were dried in a tray drier at 55±5°C for 16 h and pulverized and sieved through a standard 72 BSS mesh and stored in metallised polyester polyethylene (MPE) pouches for further analysis.

Proximate composition of the pumpkin flour such as moisture, protein, crude fibre, sugars, ash and minerals were determined employing standard methods[10]. Colour of the products was determined using Hunter Ultra scan colorimeter.

Formulation of pumpkin soup tablets

Optimization of major ingredients was conducted by varying pumpkin flour (30-50%), corn flour (15-25%) and salt (12-15%) during preparation of instant soup mix. Other minor ingredients such as milk powder, onion powder, pepper powder, coriander, garlic and saturated fat were used for enhancing the taste. The prepared hot soup was evaluated by a semi-trained panel of 10 members who were requested for scoring on a 9 point Hedonic scale (9: like extremely, 5: neither like nor dislike, 1: dislike extremely).

Preparation of instant pumpkin soup tablets (IPSC)

Two variants of pumpkin soup tablet were prepared using emulsifiers such as maltodextrin (IPSC-M) and xanthan gum (IPSC-X) at 5% for binding of the soup tablet. The flour moisture was adjusted (15-18%) by blending the ingredients with water in a planetary mixer for 15 min and were compressed to tablets of 25 mm dia, 7.5 mm thickness using a continuous rotary punch machine (model no. CMD3-16, Cadmach, Ahmedabad, India) having 16 punch dies. The cubes were dried at 45°C for 4 h to remove the excess moisture. The instant soup tablets were packed in metallized polyester polyethylene pouches (47.5 µ MPE) and stored at RT (27±3°C) for further analysis and storage.

Proximate analysis of pumpkin soup tablets

Pumpkin soup tablets were evaluated for nutritional composition (moisture, ash, crude protein, crude fat, and crude fibre) employing standard methods[8]. Carbohydrate content was calculated by difference. Minerals like Phosphorus and Iron were determined by spectrophotometric assays. The soup tablets were evaluated for microbiological safety by determining total plate count, yeast and mold count employing APHA (1992)[11] methods.

Colour measurement

The colour of pumpkin flour and soup tablets 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. L*, a* & b* values were determined in triplicate and the mean values were reported.

Extraction of β-carotene from pumpkin flour and soup tablets and quantification by high performance liquid chromatography

Standard β-carotene

β-carotene standard (Sigma Aldrich, Bangalore, India) was diluted in hexane (1 mg/mL) and stored in an amber coloured volumetric flask prior to use. The stock solution was further diluted with hexane (0.2 mg/mL). A sample volume of 10 µL (2 µg) was injected. HPLC of standard β-carotene samples were performed using a reverse phase C18 column with gradient elution of acetonitrile and chloroform.

The HPLC system with Shimadzu prominence LC-20AD binary gradient fitted with an Ultra Restek HPLC C18 analytical column (25 cm x 4.6 mm ID)

5 µm particle size. Variable wavelength detector (SPD 20A series) was used at a wavelength of 450 nm for confirming β-carotene. Compounds were quantified using LC solution software. Programming of the mobile phase 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 programme time was 25 min.

The extraction of β-carotene from soup tablets and PF (1.0 g) was carried out using acetone which was recovered by liquid-liquid extraction into hexane in a separating funnel. The hexane layer was thoroughly washed with distilled water to remove traces of acetone. The solvent was dried over anhydrous sodium sulphate and was made up to a known volume. Ten (10) µL of the sample was injected. The β-carotene in the samples was identified and quantified by comparing retention time (RT) and areas of unknown peak with the reference standard.

Texture analysis of soup tablets

The texture analysis of soup tablets was carried out using a Brookfield texture analyzer (CT3, Middleboro, Massachusetts, USA) fitted with a three point bending assembly. Test probes namely TA-7 and TA-25 were used to determine breaking strength and compression respectively.

Soup tablet was placed on two vertical supporting bars and the third bar attached to the crosshead of the instrument was driven perpendicular to the sample at a speed of 1 mm/sec till it touches and breaks the product. The peak load and the force of deformation were obtained in four replicates and mean values were presented[12].

Moisture sorption studies of soup tablets

The moisture sorption studies were carried out to determine the product deterioration characteristics and to design a suitable and economical packaging material. Accurately weighed tablet samples were placed in glass petri dishes and exposed to different relative humidity (RH) conditions ranging from 11 to 92% maintained in airtight desiccators using appropriate saturated salt solutions[13]. The samples were weighed at regular intervals till they attained constant weight or showed mold growth, lumping, whichever is earlier. The equilibration moisture content (MC) of the product at different RHs was computed using the moisture gain or loss data. The visual sensory remarks on the quality were noted during the study and critical moisture content was computed from the data generated.

Organoleptic evaluation

Sensory evaluation of the reconstituted soup cube variants (each tablet weighing 5 g were dispersed in 100 mL hot water) was carried for colour, texture, taste and overall acceptability by a semi-trained panel of 10 members on a 9 point Hedonic scale with 9 for like extremely, 5 for neither like nor dislike and 1 for dislike extremely[14].

Shelf life studies

During storage, the soup tablets were analyzed for parameters like moisture, texture, colour, ß-carotene and microbial quality at regular intervals of 0, 3 and 6 months. Sensory evaluation was conducted during storage for the reconstituted soup for determining changes in flavour and overall acceptability.

Results and Discussion

Proximate composition of raw pumpkin and pumpkin flour

Dehydration of fresh pumpkin resulted in flour with lower moisture, higher protein, fibre and minerals (Table 1). The higher L*, a* and b* values of pumpkin powder compared to fresh pumpkin slices indicated higher brightness and yellowness due to concentration of carotenoids by moisture removal. The results obtained were similar to earlier studies[15]. The pumpkin flour was found to be a good source of β-carotene. HPLC analysis for ß-carotene elution and resolution in pumpkin flour samples was optimum with the mobile phase used. ß-carotene eluted after 8 min and was identified and quantified using the standard reference. The pumpkin powder had higher β-carotene content (116.75 ± 0.02 mg/100g) than fresh Pumpkin (32 ± 0.00 mg/100g). The blanching and sulphitation treatments of pumpkin slices not only helped in accelerating the dehydration, but also preserved the quality of the product during storage[16]. Processing of vegetables has been found to increase the bio availability of carotenoids[17]. Processing of pumpkin into flour helps in extending its shelf life and also in application into different processed food products to enhance their nutritional quality in terms of protein, fibre, ash and minerals[18,19]. This could lead to efficient and profitable utilization of pumpkin and ensure reduction in post-harvest losses.

Table 1 — Proximate composition of raw pumpkin, pumpkin flour and instant pumpkin soup cubes

Parameters	Raw Pumpkin	Pumpkin Flour	IPSC-M	IPSC-X
Moisture (%)	87.86±0.02	5.82±0.01	6.99±0.01	8.06±0.02
Colour	L*- 53.17±0.00 a*-16.62±0.01 b*-44.63±0.01	L*- 69.26±0.00 a*-12.38±0.01 b*-49.17±0.01	L*-65.38±0.01 a*-5.90±0.00 b*-36.32±0.01	L*-66.83±0 a*-5.92±0.01 b*-35.92±0.00
Ash (%)	0.59±0.00	4.80±0.02	17.11±0.02	17.93±0.05
Fat (%)	0.59±0.01	3.94±0.01	8.11±0.03	9.15±0.03
Protein (%)	1.80±0.02	10.13±0.02	8.20±0.05	8.20±0.05
Crude Fibre (%)	0.62±0.01	7.92±0.01	2.28±0.00	2.64±0.01
Carbohydrate (%)	8.54±0.01	67.39±0.02	57.31±0.01	54.02±0.02
β-carotene (mg/100 g)	32±0.00	116.75±0.02	28.36±0.00	32.79±0.03
Starch Content (%)	-	30.51±0.02	31.18±0.01	31.32±0.02
Iron (mg/100 g)	3.027±0.01	18.6±0.02	10.62±0.02	13.19±0.01
Phosphorous (mg/100 g)	48.90±0.06	318.27±0.02	153.81±0.02	244.84±0.02
Texture: Hardness (Peak Load, g)	-	-	6817.5±31.81	3665±21.21

Values are means ± standard deviations of triplicate determinations

Proximate analysis of pumpkin soup tablets

The optimized composition of pumpkin soup tablets consisted of pumpkin flour (32.5%), corn flour (19.5%), salt (13.0%), milk powder (14.5%) and saturated fat (6.5%). Other minor ingredients used were spices (onion 3.2%, pepper, 3.2%, coriander 1.3% and garlic 1.3%). Maltodextrin or xanthan gum (5%) was used as a binding agent. The proximate composition of the two variants of pumpkin soup tablet is presented in Table 1. Both the variants were similar in proximate composition, colour and could be instantly reconstituted in hot water (100 mL). However, higher retention of β-carotene (Fig. 1a and 1b) was observed in IPSC-X based soup cube (32.79 mg/100 g) than IPSC-M (28.36 mg/100 g).

Texture analysis of soup tablets

The peak load is the maximum force required in Newton for the tablet to break up. This is a measure of sample hardness or firmness of the tablet. The area under the graph from the start of the test till the tablet snaps is a measure of work done (Table 1). Higher breaking strength was noticed for IPSC-M (6817.5 ± 31.81 N) when compared to IPSC-X (3665 ± 21.21 N).

Moisture sorption studies of soup tablets

The moisture sorption isotherms presented in Figure 2a and 2b reveal that both formulations are similar and sigmoid. The rising slope of the curve above 56% RH indicates the deterioration of the product due to higher moisture absorption. The products with an initial moisture content of 6.42 and 8.24% equilibrate to 39 and 47% RH respectively for IPSC-M and IPSC-X. The product with 44% equilibrium RH at moisture range of 7.22-7.26% was free of lumps and stable. Both products had a tendency for softening when equilibrated to 56% RH and the corresponding moisture contents were 10.29 to 10.41%, respectively. The tablet products IPSC-M and IPSC-X with equilibrium moisture contents of 47.82 and 47.63% respectively developed stickiness when equilibrated to 75% RH. At higher RH (86 and 92%), mold growth was observed within 2 weeks of exposure. Based on the data, the moisture content corresponding to 56% RH was critical for both the products. The moisture tolerances of IPSC-M and IPSC-X are 3.87% and 2.17%. Hence, high moisture barrier packaging materials are recommended for both products for a projected shelf life of one year.

Sensory evaluation

Sensory evaluation is the most important tool in determining the food acceptability. Sensory assessment of food products can be successfully adopted in new product development, product improvement and also quality control[20,21]. Soup should possess desired quality, representing the dominant flavour and aroma of the ingredients used. It is desirable that the product be free from off flavour, off taste, unacceptable aroma and faulty texture[22]. Sensory evaluation of the soup tablets reconstituted in hot water (5 g/100 mL) revealed IPSC-X was most preferred in terms of colour, flavour, taste and overall acceptability (Fig. 3).

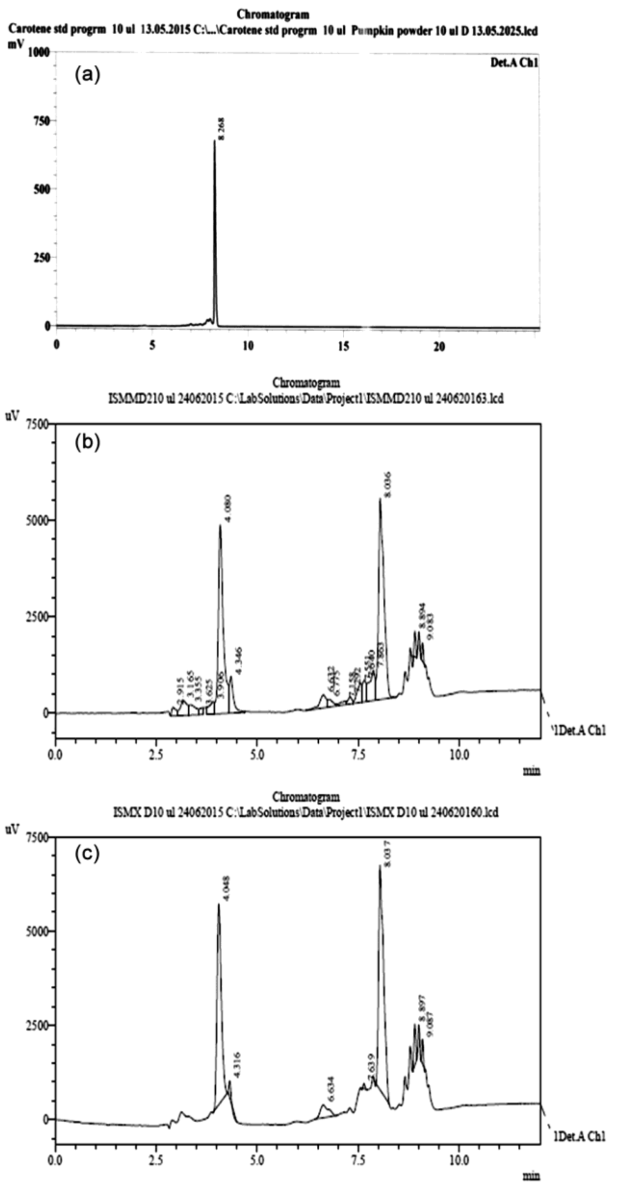

Fig. 1 — HPLC Chromatograms of a. Standard β-carotene b. IPSC-M c. IPSC-X

Shelf life studies of soup tablets

The results of proximate analysis carried out on the two variants of instant soup tablet during a storage period of six months at RT are presented in Table 2. The data shows that the product did not undergo any major deterioration during the six

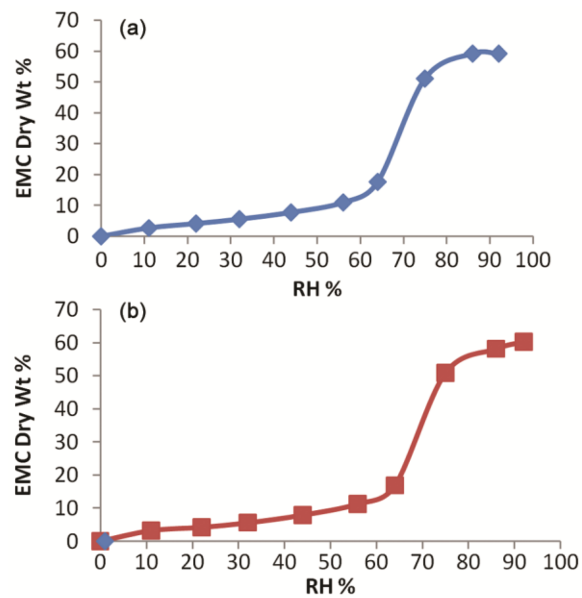

Fig. 2 — Moisture sorption isotherm of (a). IPSC-M at 27°C (b). IPSC-M at 27°C

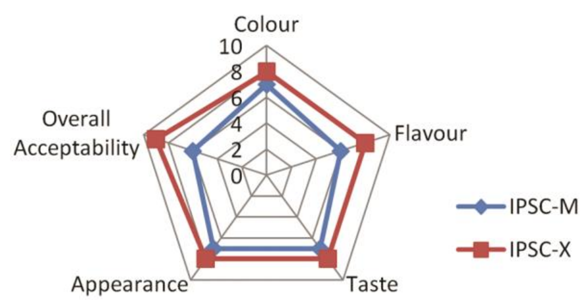

Fig. 3 — Organoleptic evaluation of IPSC-M and IPSC-X

Table 2 — Shelf-life studies of soup tablets

Parameters	IPSC-M			IPSC-X		
	0	**3**	**6**	**0**	**3**	**6**
Colour	L*-65.38 ± 1.30 a* -5.90 ± 0.10 b* -36.32 ± 0.37	L*-59.42 ± 0.71 a* -5.17 ± 0.09 b* -29.80 ± 0.46	L*-68.97 ± 0.50 a*-6.18 ± 0.18 b*-37.10 ± 0.25	L*-66.83 ± 0.84 a*-5.92 ± 0.10 b*-35.92 ± 0.45	L*-64.27 ± 1.03 a*-5.68 ± 0.12 b*-30.92 ± 0.60	L*-70.78 ± 0.78 a*-5.99 ± 0.51 b*-33.21 ± 0.36
Moisture (%)	6.99 ± 0.15	6.38 ± 0.15	5.62 ± 0.13	8.06 ± 0.08	7.75 ± 0.07	7.01 ± 0.08
β-Carotene (mg/100 g)	28.36 ± 0.08	23.90 ± 0.18	16.37 ± 0.07	32.79 ± 0.08	27.36 ± 0.08	17.99 ± 0.05
Non enzymatic browning (NEB)	2.348 ± 0.09	1.381 ± 0.06	3.27 ± 0.14	2.615 ± 0.28	1.517 0.02	3.36 ± 0.19
Microbial count	TPC- 0 Y&M- 0	TPC - 2 x10^5 Y&M- 0	TPC- 0 Y&M- 1	TPC- 0 Y&M- 0	TPC- 1x10^5 Y&M- 0	TPC- 0 Y&M- 1

Values are means ± standard deviations of triplicate determinations months storage period. However, higher β-carotene retention was observed in IPSC-X. These findings are further corroborated by the organoleptic evaluation of the reconstituted soup. Also, the loss of β-carotenes during storage was more pronounced in IPSC-M. In general, IPSC-X had better acceptability and higher β-carotene retention during storage.

Conclusion

Incorporation of pumpkin flour yielded a soup cube rich in β-carotene. The carotene rich soup can be a better intervention to help the target population suffering from Vitamin A deficiency. The physico-chemical analysis and the organoleptic properties showed that the soup tablets prepared with xanthan gum as emulsifier had a superior quality and acceptability.

The tablet products were found to be microbiologically safe and stable for six months at room temperature when packed in metallized polyester polyethylene pouches.

Acknowledgement

Authors thank the Director, CSIR-CFTRI, Mysuru, India for the facilities provided. The financial support from MFPI, New Delhi is gratefully acknowledged.

Conflict of interest

Authors declare that we do not have any conflict of interest.

Author(s) contribution statement

A E K carried out the analytical work, sensory analysis and collection of data. P G P R was involved in the formulation and development of soup tablet product. A N was involved in the operation tableting machine, optimal dehydration and preparation of soup tablets. K S was involved in the sorption studies of the products and K S M for planning and coordination of the project work and drafting the manuscript.

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