Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6[6] May 2017: 73-82
©2017 Academy for Environment and Life Sciences, India
Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95
ORIGINAL ARTICLE **OPEN ACCESS**

Storage Stability and Quality Assessment of Instant Vegetable Soup Mixes prepared by Extrusion Processing

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ABSTRACT
Instant food products are the convenience foods which are known to be hygienic, free from microbial contamination and also convenient to eat. The present investigation was carried out to develop instant vegetable soup mixes using extrusion technology and assess their shelf life. Corn and potato starches were optimized using response surface methodology for preparation of instant vegetable soup mixes. Optimized corn and potato starches were mixed with tomato and mushroom vegetable powder, skimmed milk powder, powdered sugar, salt, black pepper and citric acid to develop instant vegetable soup mixes. Soup mixes were stored in low density poly ethylene and aluminium laminates for six months under ambient conditions. Moisture, water activity, free fatty acid content, colour, and sensory parameters were used to evaluate the shelf life of the products. The products were acceptable for a period of six months. Hence, low cost nutritious instant vegetable soup mixes can be processed with high storage stability using extrusion technology.
Keywords: *Instant vegetable soup mix, Extrusion, Shelf life.*

Received 14.03.2017 Revised 12.04.2017 Accepted 25.04. 2017

INTRODUCTION

The modern food industry has developed and expanded because of its ability to deliver a wide variety of high quality food products to consumers on a nationwide and worldwide basis. This feat has been accomplished by building stability into the products through processing, packaging, and additives that enable foods to remain fresh and wholesome throughout the distribution process. Consumer demands for convenience have fueled new innovations in the food product development, packaging and chemical industries. The very term 'instant food' means simple, fast and convenient food which is easy and fast to prepare besides being hygienic, free from microbial contamination and also convenient to eat [25]. Instant mixes have gained popularity by way they are providing convenience to the consumer [23]). The instant food market is observing a growth rate of around 12-15 per cent globally. A fast-paced urban lifestyle, increasing prevalence of nuclear family structure, rising disposable income, increasingly larger number of globe-trotting consumers with an experimentative palate are all favorable demographic factors spurring the adoption of instant food on a global level.

Soups are usually consumed for health as well as nutritive benefits particularly in patients whose intake of solids is poor due to several obstructive or pathological reasons. Under those circumstances, soups are considered as the best source to supply health protective compounds and to avoid the deficiency of nutrients as these contain vegetables. Tomato and Mushroom are of huge importance in human nutrition as they provide essential vitamins and minerals to the diet, which are required to maintain good health.

Extrusion is a modern high temperature-short time process and is being adopted to replace conventional equipments [19]. Extrusion produces high energy density flour and had the added advantage that the extrudate has a low water activity, and is cheaper to transport, handle and store and is less susceptible to microbial spoilage. Extruded flour only requires reconstitution in warm water before consumption [22], so can be used for preparation of powdered instant soup mix. Corn and potato starches were extruded and blended to prepare instant soup mixes to offer convenience and nutrition.

Instant soup mixes are expected to have a better shelf life. As shelf-life studies can provide important information to food technologists, enabling them to ensure that the consumer will see a high quality product for a significant period of time after production. Total quality is of paramount importance, where how the consumer perceives the product is the ultimate measure of total quality. Therefore, the quality built in during the production process must last through the distribution and consumption stages or all is for naught. Hence, the present study was conducted to assess quality of instant vegetable soup mixes, prepared from corn and potato starches, in terms of stability and acceptability.

MATERIAL AND METHODS

Raw materials used in investigation

Corn starch and Potato starch were purchased from the local market, Ludhiana. Fresh Tomato (commonly cultivated variety) and Mushroom (Oyster) were purchased from the local market, Ludhiana and processed into powder using standard methods (Fig a, b). Skimmed milk powder, powdered sugar, salt, black pepper and citric acid were obtained from the local market.

Fresh Tomatoes

↓

Washing under tap water

↓

Cut into halves

↓

Blanching in hot water (95^0C) for 1min (using muslin cloth)
(tomato: water = 1:4)

↓

Dipping in 6% Potassium metabisulphite solution for 10 mins

↓

Draining and spreading in single layer on trays

↓

Drying at 58±2^0 C in hot air dryer

↓

Mixing and Sieving

Fig. a: Flow chart of drying of tomatoes.

Fresh Mushrooms

↓

Grading and Washing → Infected/damaged parts removed

↓

Cutting in halves

↓

Place in 2% brine solution for 4-5 mins

↓

Blanching at 80^0 C for 2 mins

↓

Dipping in 0.5% Sodium bisulphate and 0.25% Citric acid solution for 15 mins

↓

Draining

↓

Loading in trays

↓

Drying at 45^0 C for 6 hrs and then at 55^0 C till drying completed (m.c. 9%)

↓

Mixing and Sieving

Fig. b: Flow chart of drying of mushrooms.

Extrusion processing

Corn and Potato starches were extruded to optimize independent variables i.e. moisture content, screw speed and barrel temperature to obtain optimum expansion, density, water absorption index and water solubility index of the product using response surface methodology. The optimized extrusion conditions are depicted in Table no 1. Extrusion of the starches was performed on a co-rotating intermeshing twin screw extruder (Clextral, Firminy, France). The barrel diameter and its length to diameter ratio (L/D) were 2.5 mm and 16:1, respectively. The extruder barrel is divided into four zones. Temperatures of the first, second and third zone was maintained at 40°, 70° and 100°C, respectively, throughout the experiments, while the temperature at the fourth zone was varied according to the experimental design. Screw configuration and screw profile have been illustrated in Table 2.

Preparation of Instant Vegetable Soup Mixes

The optimized corn and potato starch extrudates were ground and blended with vegetable powder (tomato/ mushroom), skimmed milk powder, sugar, salt, black pepper and citric acid. The blending ratios were finalized on the basis of acceptability scores (Table 3). For 1 cup soup, 20 g of powdered Instant Vegetable Soup Mix was added to 200 ml of boiled water, mixed well and serve hot.

Table 1. Optimized extrusion conditions of starches for preparation of Instant Vegetable Soup Mixes

Starch	Feed Moisture (%)	Screw Speed (rpm)	Barrel Temperature (°C)
Corn Starch	16.13-18	400-429	125-137
Potato Starch	18	516-550	125-145

Table 2. Screw configuration in different sections of the extruder (From hopper to die)

Screw section	1	2	3	4	5	6	7	8	9	10
Screw element	BAGUE	C2F	C2F	C2F	C2F	C2F	INO0	C1F	CF1C	C1F
Length (mm)	20	50	50	50	50	50	5	50	25	50
Pitch (mm)	-	50	33.33	25	25	16.66	-	16.66	12.5	12.5

C1F – Conjugated section 1 threads, for transport and compression of the material.
C2F – Conjugated section 2 threads, for supply and transport of the material.
CF1C- Conjugated screw segment section 1 thread, screw segment with groove.
INO0 – Interface rings between C2F and C1F.
CF1C – Conjugated screw segment section 1 thread, screw segment with groove.

Physicochemical composition

Physico-chemical characteristics i.e. moisture, crude protein, crude fat, ash, crude fibre and carbohydrate of raw materials and developed Instant Vegetable Soup Mixes were determined using standard methods [1, 3].

Functional properties

Instant vegetable soup mixes were analyzed for water absorption index (WAI) and water solubility index (WSI) [28]. Colour is measured by color meter, CR-300 (Minolta Camera Co. Ltd., Japan). For overall acceptability scores, sensory analysis was done by semi trained panel of ten judges using nine point hedonic scale [18].

Storage studies

Instant vegetable soup mixes were packed in LDPE and Aluminium Laminate bags (Fig 6). Samples were stored at ambient temperature conditions for shelf life estimation over a period of 6 months and the product was evaluated for moisture content, water activity (a_w), free fatty acids, colour, and overall acceptability, at an interval of one month, during the storage period [3, 17].

Statistical analysis

Data was analyzed statistically using analysis of variance (ANOVA) technique [9].

RESULTS AND DISCUSSION

Proximate composition

The nutritional composition of starches (corn and potato starch), vegetable powders (tomato and mushroom) and milk powder is illustrated in Table 4. Significant difference in all the nutritional parameters of raw materials was observed. Among starches considerable amount of crude protein content was observed in corn starch (0.40%) compared with potato starch (0.13%). The fat content of starches was found out to be very less (< 1%) [11]. Generally cereal starches contain more percentage of fat as compared to tuber starch. The crude fiber content of starches did not vary significantly (2.03% for corn starch and 2.90% for potato starch). Potato starch contains relatively high ash-content (0.39%) because of the presence of phosphate groups. The proximate composition of starches studied was in agreement with the studies of Bello-Perez *et al* [5]. Similar results were documented by Hoover and Manuel [12] for corn starch, Yadav *et al* [27], Wischmann *et al* [26], Hoover [11] for potato starch.

In case of vegetable powders, tomato powder was found to contain 12.50% crude protein, 0.34% fat, 16.30% crude fiber, 6.91% ash and carbohydrate 54.07% whereas mushroom powder contained 16.83% crude protein, 2.32% fat, 30.50% crude fiber, 4.11% ash and carbohydrate 37.49 %. Similar results were reported by Idah *et al* [13] for tomato powder and Khan *et al* [15] for mushroom powder. The proximate composition of milk powder revealed 18.70% crude protein, 18.90% crude fat, 0% crude fiber, 4.26% ash and 55.20% carbohydrate.

Data presented in Table 5 represents the proximate composition of Instant vegetable soup mixes. All the soup mixes possessed variation with respect to their chemical constituents (moisture, crude protein, ash, fat, crude fiber and energy).

Functional Properties of Instant vegetable soup mixes

Functional properties of instant mixes are illustrated in Table 6. Water absorption index (WAI) measures the water holding by the starch after swelling in excess water, which corresponds to the weight of the gel formed. Table illustrates the WAI of instant soup mixes which ranged from 1.70-1.94 g/g. Higher values of WAI for instant soup mixes prepared from potato starch indicated that extruded potato starch has more ability to absorb water as compared to extruded corn starch. This increase in water absorption by soup mixes prepared with modified/ extruded starches may be attributed to the increased water binding ability and increased water absorption capacity of the pregelatinized starch.

Water solubility Index (WSI), often used as an indicator of degradation of molecular components, measures the degree of starch conversion during extrusion which is the amount of soluble polysaccharides released from the starch after extrusion [8]. Significant variation with respect to WSI was assessed in samples of tomato and mushroom soup mixes prepared with extruded corn and potato starches. Tomato soup mix prepared from corn starch had maximum WSI (72.25%).

Colour of the instant mixes was measured in terms of L*, a* and b* values. L* represents lightness, a* represent greenness if negative and b* defines yellowness of the product. All the instant soup mixes had L* value near to 80 which means products were not much darker in color. The L* value ranged from 68.95 (III) to 77.39 (II). With respect to a* values, all the values were on positive side which depicted redness in the mixes. Tomato soup mixes were more red in colour (a* values 12.12 and 12.38). A positive b* value depict yellowness. b* value was maximum for instant mix III (33.33) trailed by instant mix I (27.46) and instant mix IV (26.71) where instant mix II (16.32) had minimum value. Acceptability scores based on different attributes (appearance, consistency and mouthfeel) elucidated that all the instant mixes were highly acceptable by the panelists. Butt *et al* [6] observed that antioxidant fortified breakfast cereals are acceptable on the basis of sensory evaluation. Corn soup mixes were observed to have enhanced solubility which results in better consistency. This might be due to the better expansion and less density of the corn starch extrudates. Potato starch results in moderate expansion which represents less cooking and ultimately describes less consistency as compared to the corn starch based soup mixes.

Storage study of Instant Vegetable Soup Mixes

Moisture content

Moisture content of the product is the predominant parameter defining the stability of products during storage. Higher moisture content usually is associated with the detrimental changes in physico-chemical properties of the food product. The effect of storage period and packaging material on the moisture content of stored instant vegetable soup mixes is illustrated in the Table 7. Moisture content (%) of instant vegetable soup mixes did not show much variation. With progressive storage, there was slight increase in the moisture content of instant soup mixes in both packaging materials. The increase in moisture content was within safe limit (< 14%). The mean moisture content of tomato soup mixes prepared from corn and potato starch at 0 month was 8.05 and 8.57 per cent which increased to 9.20 and 8.83 (packed in LDPE and AL); 9.43 and 9.42 (packed in LDPE and AL) for corn and potato starches respectively after 6 months of storage. Increase in moisture was found to be lower in AL packed samples than LDPE. Similarly, the mean moisture content of mushroom soup mixes prepared from corn and potato starch at 0 month was 7.14 and 7.33 per cent which increased to 8.03 and 7.75 (packed in LDPE and AL); 8.17 and 8.09 (packed in LDPE and AL). Butt *et al* [6] stated increase in moisture content during storage period of 45 days was affected due to storage, treatments and packaging conditions which the authors explained was due to hygroscopic properties of the flour. Hence, further storage period do not likely to influence the changes in moisture content of soup mixes, noticeably.

Water activity (a_w)

The water activity (aw) represents the ratio of the water vapour pressure of the food to the water vapour pressure of pure water under the same conditions or 'water activity' (aw) describes the (equilibrium) amount of water available for hydration of materials (i.e. water activity = water availability). When it is all available, aw = 1, and when none is available, aw = 0. Water activity has become one of the most important intrinsic properties used for predicting the survival and growth of microorganisms in food. Data presented in Table. 8 reveals that water activity of different soup mixes increased with progressive storage in both type of packaging materials but the overall increase was small. The increase in water activity was under safe limits (aw = 0.6 for soup mixes) and did not alter the quality of the soup mixes. The slight increase in water activity measured during storage was due to the gain in moisture as the storage period progressed. It was observed from the table that the increase in water activity was constant for both tomato and mushroom soup mixes and the trend of changes in water activity over the entire storage period was almost same for all the samples. Also, it was elucidated that the rate of increase in water activity of LDPE packed samples was more than AL packed samples after six months of storage. Manthey *et al* [20] observed a progressive increase in water activity of breads during storage.

Free fatty acidity

Lipids and lipid-associated components are key factors in the quality of various food products. Under unfavourable storage conditions or in products where heat treatment is insufficient to destroy lipase, lipolytic activity will cause rapid release of free fatty acids (FFA), which may then be oxidized and cause rancidity in food products. Thus, the study of FFA during storage is important. With increase in storage period a slight increase in free fatty acid content of the stored instant vegetable soup mixes was noticed in both type of packaging materials (Table 9). Overall free fatty acids of soup mixes ranged in between 0.45-1.35 per cent during entire storage period. An increase in free fatty acids during storage may be due to hydrolytic lipolysis of the fat present in the soup mixes [16]. However, a non-significant effect on FFA content was observed during first three months of storage.

The FFA content of tomato and mushroom soup mixes after 4 months of storage was more profound. The effect of storage and packaging material on free fatty acid content of soup mixes was comparable irrespective of the initial level. The permissible level for safe storage of cereal flour is 50 mg KOH per 100 g (Codex Standards). The results of this study are in agreement with the observations of Khan *et al* [15] who also reported increase in free fatty acid content in chapattis during storage period of 12 months. Kadam *et al* [14] and Molteberg *et al* [21] also observed similar trend in free fatty acid content during storage period.

Colour

L, a, b value of soup mixes as influenced by storage period and packaging material is illustrated in Fig. 1-3. With progressive storage, slight decrease in L* value was observed in both tomato and mushroom soup mixes, however the decrease was less in case of AL packed product. a* and b* value did not show much variation during the entire storage period. Overall, there was no significant effect on the color of tomato and mushroom soup mixes samples packed in LDPE and AL pouches during storage at ambient conditions. The values were at par from 0 to 6 months of storage and did not alter the visual acceptability of the soup mixes.

Table 3. Proportion of ingredients in final Instant Vegetable Soup Mixes

Type of soup mix	Quantity (g/100g)						
	Extruded starch	Vegetable powder	SMP	Sugar	Salt	Black pepper	Citric acid
Corn starch							
Tomato (I)	50	17.9	10	10	10	2	0.1
Mushroom (II)	50	17.9	10	10	10	2	0.1
Potato starch							
Tomato (III)	50	17.9	10	10	10	2	0.1
Mushroom (IV)	50	17.9	10	10	10	2	0.1

Table 4. Proximate composition of the raw material

Raw materials	Moisture (%)	Crude protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrates (%)	Energy (Kcal/100g)
Corn Starch	8.59	0.40	0.10	2.03	0.18	88.70	357
Potato Starch	7.19	0.13	0.08	2.90	0.39	89.31	358
Tomato powder	9.88	12.50	0.34	16.30	6.91	54.07	269
Mushroom powder	8.75	16.83	2.32	30.50	4.11	37.49	238
Milk powder	3.40	18.70	18.90	0	4.26	55.20	466

Table 5: Proximate composition of Instant vegetable soup mixes.

Type of soup mix	Moisture (%)	Crude protein (%)	Ash (%)	Fat (%)	Crude fiber (%)	Carbohydrates (%)	Energy (Kcal/g)
Corn starch							
Tomato	8.05	5.80	9.26	2.25	3.81	70.83	3.27
Mushroom	8.57	6.42	7.43	2.27	5.60	69.71	3.25
Potato starch							
Tomato	7.14	6.39	10.16	2.23	4.29	69.79	3.25
Mushroom	7.33	7.26	8.50	2.35	5.89	68.67	3.25

Table 6: Functional properties of instant vegetable soup mixes

Instant Soup Mix	WAI (g/g)	WSI (%)	Color			Acceptability score (Out of 9)
			L*	a*	b*	
Corn Starch						
Tomato	1.74	72.25	71.57	12.12	27.46	8.48
Mushroom	1.49	63.61	77.39	2.34	16.32	8.00
Potato starch						
Tomato	1.97	67.98	68.95	12.38	33.33	8.20
Mushroom	1.70	60.88	72.66	5.44	26.71	7.58

Table 7. Effect of storage period and packaging material on moisture content (%) of Instant vegetable soup mixes

Moisture content (%)								
Month	Tomato soup mix				Mushroom soup mix			
	Corn starch		Potato starch		Corn starch		Potato starch	
	P	Al	P	Al	P	Al	P	Al
0	8.05	8.05	8.57	8.57	7.14	7.14	7.33	7.33
1	8.49	8.37	8.78	8.66	7.29	7.28	7.54	7.43
2	8.56	8.44	8.86	8.79	7.4	7.33	7.6	7.49
3	8.94	8.55	9.09	8.86	7.47	7.41	7.68	7.66
4	9.04	8.62	9.12	9.1	7.65	7.52	8.01	7.93
5	9.12	8.71	9.22	9.26	7.81	7.68	8.08	8.04
6	9.2	8.83	9.43	9.42	8.03	7.75	8.17	8.09

Table 8: Effect of storage period and packaging material on water activity of Instant Vegetable Soup Mixes

Water activity (a_w)								
Month	Tomato soup mix				Mushroom soup mix			
	Corn starch		Potato starch		Corn starch		Potato starch	
	P	Al	P	Al	P	Al	P	Al
0	0.43	0.43	0.48	0.48	0.49	0.49	0.51	0.51
1	0.46	0.46	0.49	0.49	0.5	0.5	0.53	0.52
2	0.49	0.48	0.5	0.5	0.52	0.52	0.54	0.53
3	0.52	0.51	0.52	0.51	0.54	0.54	0.55	0.54
4	0.52	0.52	0.52	0.52	0.55	0.54	0.57	0.55
5	0.53	0.53	0.53	0.53	0.56	0.55	0.57	0.56
6	0.54	0.53	0.54	0.53	0.56	0.55	0.58	0.57

Table 9: Effect of storage period and packaging material on free fatty acid content (percent, oleic acid) of Instant Vegetable Soup Mixes

Free fatty acid (%)								
Month	Tomato soup mix				Mushroom soup mix			
	Corn starch		Potato starch		Corn starch		Potato starch	
	P	Al	P	Al	P	Al	P	Al
0	0.586	0.586	0.451	0.451	0.541	0.541	0.631	0.631
1	0.698	0.631	0.632	0.623	0.722	0.631	0.732	0.692
2	0.812	0.778	0.721	0.63	0.812	0.811	0.857	0.834
3	0.902	0.871	0.901	0.802	1.081	0.981	1.172	1.081
4	0.912	0.901	0.92	0.901	1.194	1.1	1.225	1.198
5	1.261	1.172	1.08	0.973	1.259	1.161	1.262	1.244
6	1.262	1.24	1.172	1.162	1.351	1.254	1.354	1.349

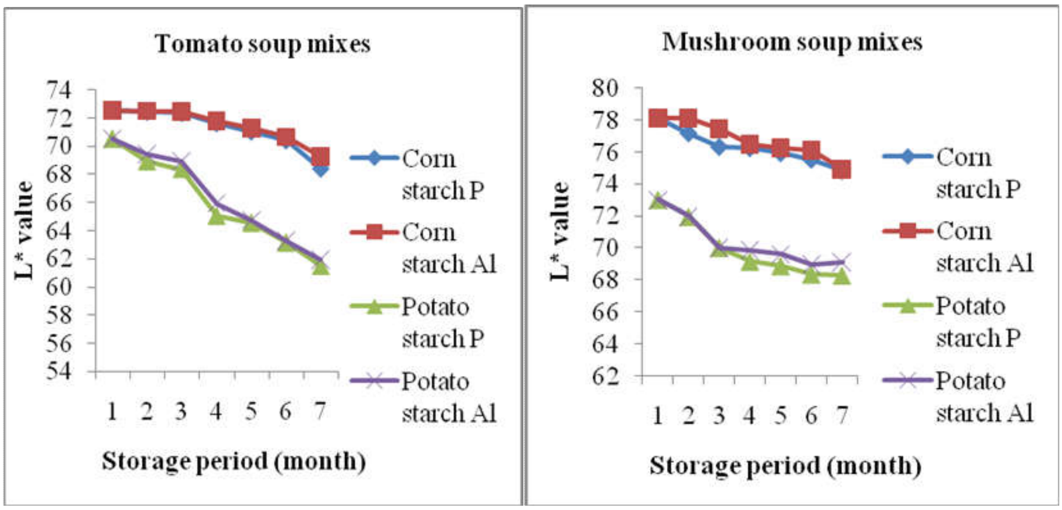

Fig.1: Effect of storage period and packaging material on L* value of (a) Instant Tomato Soup Mixes and (b) Instant Mushroom Soup Mixes

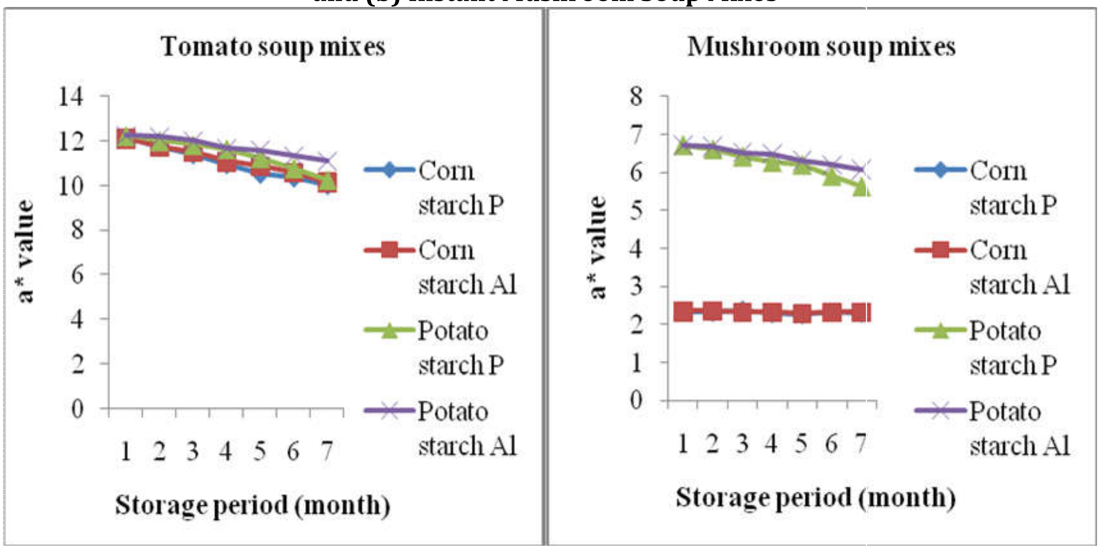

Fig.2: Effect of storage period and packaging material on a* value of (a) Instant Tomato Soup Mixes and (b) Instant Mushroom Soup Mixes

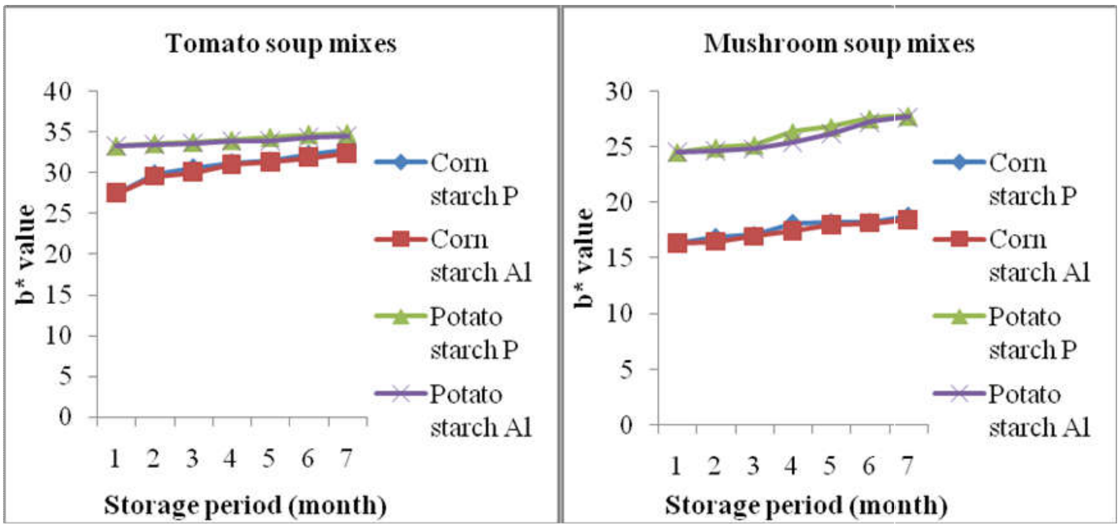

Fig.3: Effect of storage period and packaging material on b* value of (a) Instant Tomato Soup Mixes and (b) Instant Mushroom Soup Mixes

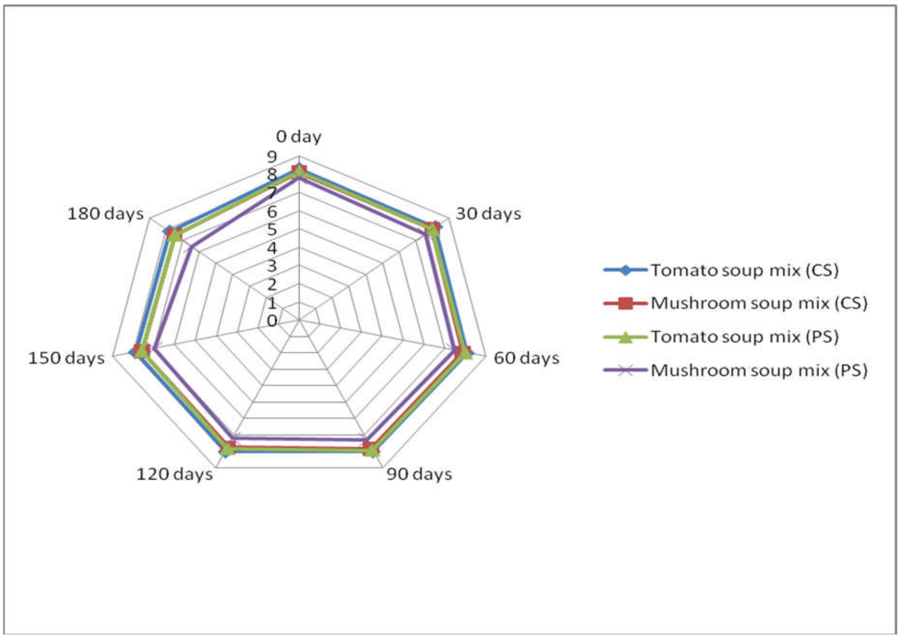

Fig 4: Effect of storage period on overall acceptability scores of Instant Vegetable Soup Mixes

Corn starch extrudates Instant tomato soup mix Instant mushroom soup mix

Potato starch extrudates Instant tomato soup mix Instant mushroom soup mix

Fig.5 Instant vegetable soup mixes.

Fig. 6: Instant Vegetable Soup Mixes stored in Aluminium laminates and LDPE

Overall acceptability

The mean sensory scores (based on appearance, consistency and flavour) for tomato and mushroom soup mixes during storage for six months are given in Fig 4. Storage slightly affected the overall acceptability of instant soup mixes. During the entire 6 months of storage, overall acceptability of instant vegetable soup mixes was within acceptable range. Similarly, Butt *et al* [6] observed that sensory properties were almost same throughout six months storage and there was a non-significant difference in various treatments. Mushroom soup mix prepared using potato starch scored less flavour score than others. The overall acceptability scores of tomato soup mixes from corn starch was awarded maximum scores. During the first month of storage tomato soup mix prepared from corn starch have overall acceptability of 8.3 which decreased to 7.8 at the end of 6 months storage.

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CITATION OF THIS ARTICLE
Neeraj Gandhi, Baljit Singh and Savita Sharma. Storage Stability and Quality Assessment of Instant Vegetable Soup Mixes prepared by Extrusion Processing. Bull. Env. Pharmacol. Life Sci., Vol 6[6] May 2017: 73-82