# Preservation and quality evaluation of ready to cook vegetarian soup incorporated with dehydrated soy bean *(Glycine max)* powder under blast freezing

RMNA Wijewardane[1#], MRF Risna[2], NWIA Jayawardane [2], WMCB Wasala[1] and BMKS Thilakarathne[1]

[1] Institute of Postharvest Technology, Jayanthi Mawatha, Anuradhapura, Sri Lanka
[2]University of Rajarata, Facalty of Agriculture, Puliyankulama, Sri Lanka
[#]corresponding author; nilanthiwijewardana@yahoo.com

***Abstract***— *Formulation and development of nutritious complementary foods from locally and readily available raw materials have received a lot of attentions, recently. The growth of vegetable industry as a commercial proposition is largely depends on allied enterprises like storage, processing and marketing. Food production is increasing, it is essential to sustain increased production besides nutritional standard of the people. The present research work aimed to prepare and preserve a supplement vegetarian soup mix with dehydrated soy bean powder under two different freezing conditions and evaluate its chemical, physical, microbial, sensorial properties during storage.*

*Vegetarian soup mix (VSM) was prepared by using soya powder, carrot, pumpkin, and spinach. The product was frozen under blast freezing (-18℃) and normal freezing (-20ºC) and stored at -20$^0$C. The storage quality was evaluated for 4 months. Total Plate Count (TPC), physico-chemical characteristics such as firmness, colour, total soluble solid (TSS) and sensory properties using 5 point hedonic scale were evaluated. In VSM, firmness of carrot and pumpkin were 30.86±1.67 and 24.03±1.01 respectively at the end of four months of storage. Total plate count and the TSS of VSM were 6.41x10$^2$ CFU/g and 5.52±0.05 respectively under blast freezing. Colour of the VSM was not significantly different ($p<0.05$) among treatments. VSM under blast freezing exhibited excellent sensory quality attributes at the end of storage.*

***Keywords***—vegetable soup, blast freezing, soya bean storage

## I. INTRODUCTION

Vegetables are rich and comparatively cheaper source of vitamins. Consumption of these items provides taste, palatability, increases appetite and provides fiber for digestion and thereby prevents constipation. Supplement of protein requirement with some legumes is vital in vegetarian soups in the nutritional point of view.

Soy bean is highly nutritious pulse. It contains 40% protein, 20% lipid, 35% carbohydrate, minerals and vitamins. Nagarajan (2010) suggested that soy isoflavones may inhibit the effect of endothelial cell activation associated to chronicle diseases such as atherosclerosis by blocking the activation of inflammatory cells and the adhesion to the vascular endothelium. Another mechanism associated with soy iso-flavones regarding cardiovascular health has been demonstrated by the reduction of vascular contraction through inhibition of the RhoA/Rho-kinase signaling pathway, which has a major role in muscle contraction (Seok *et al.,* 2008).

Freezing is one of the oldest and most widely used methods of food preservation, which allows preservation of taste, texture, and nutritional value in foods. The freezing process is a combination of the beneficial effects of low temperatures at which microorganisms cannot grow, chemical reactions are reduced, and cellular metabolic reactions are delayed (Delgado and Sun, 2000). It has capable of retaining valuable sensory attributes and nutritive value of fresh foods (Xu *et al.,* 2015). Most common problem in frozen fruit and vegetables are chemical reactions that cause changes in flavor, color, texture, and nutritional value, and physical damage that causes loss of turgor and texture changes (Otero *et al*., 2000). The formation of ice in frozen foods is influenced by the amount of available water, rate of freezing and storage temperature. When food tissue is frozen slowly, ice crystals grow large and will be randomly distributed. Extra cellular ice crystals grow by drawing water from cells until the water potential of the ice and cell is equal, thus dehydrating cell since water potential of ice decreases as the temperature decreases, cellular dehydration increases as the temperature falls (Cano, 1996).

In recent years, due to the changing consumer profile, the demand of frozen food has increased significantly. The major trend in consumer behavior documented over the last half century has been the increase in the number of working women and the decline in the family size. The entry of more women into the workforce also led to improvements in kitchen appliances and increased the variability of ready-to-eat or frozen foods available in the market. Therefore the study was conducted to evaluate the effect of blast freezing on preservation of ready to cook fresh vegetarian soup and its quality evaluation during storage.

## II. MATERIAL AND METHODS

*A. Procedure for preparation of ready to cook vegetarian soup mix for storage*

Dry soya bean was washed and soaked for 24 hours, steamed for 20 minutes and dried at 55$^0$C for 24 hours. It was grinded into powder and it was mixed with 2% of salt + 1% of pepper powder. Pumpkin and carrot were peeled, washed with 5% Hydrogen peroxide and surface water was removed by wiping using paper towel. Carrot and pumpkin were cut into cubes (1cm x1cm x1cm) and steamed for 5 minutes. Spinach was cleaned, washed and steamed for 30 seconds.

*B. Product freezing and storage quality evaluation*

Samples were packaged in PET (Polyethylene Terephthalate) containers; 100 g of carrot, 100 g of pumpkin, 30 g of spinach and 20 g of soya powder (soya powder was mixed with 2% of salt 1% of pepper powder).The blast freezer temperature was set at -40$^0$C and the product was frozen up to the core temperature of vegetable cubes reached to -18$^0$C. After freezing, the product was stored at -20$^0$C under normal freezing condition. Storage quality was evaluated at one-month interval for four month period.

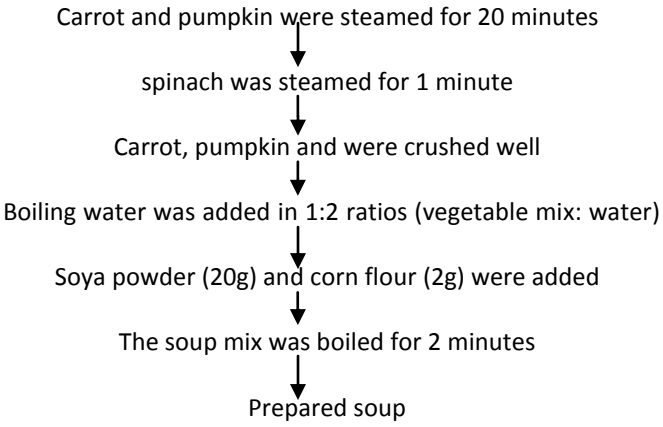


Fig 1: Procedure for preparation of ready to cook vegetarian soup for serving

*C. Physico-chemical analysis and organoleptic properties of vegetable soup mix and prepared soup*

Colour was assessed in carrot, pumpkin, spinach, soya powder using colour difference meter of CIE colour space co-ordinates, L*a*b* values. Lightness value, L*, indicates lightness of the sample is varying from 0-black to 100-white, a* is a measure of greenness/redness (varying from -60 to +60), and b* is the grade of blueness/yellowness (varying from -60 to +60).The colorimeter was calibrated against a standard white reference tile. Samples were placed in a clear glass Petri dish and colour measurements were done in triplicates. Fruit firmness was measured with digital firmness tester (model TR 53205) and the values were expressed as force required (1 kg) to complete penetration (1 cm). Chlorophyll content of spinach was measured after thawing; 5 g of sample were weighed and macerated with mortar and pestle by adding 85% acetone. The acetone extract was decanted. Extraction was repeated with 85% acetone till the residue was colourless. The coloured acetone extract was filtered in to a 250 mL volumetric flask. The filtrate was diluted with 85% acetone and measured the colour at 660 nm and 642.5 nm to detect total chlorophyll content (Ranganna, 1986). Total Soluble Solids (TSS) was determined by direct reading on a refractometer {ATAGO, Model: HR-5 (9-90%), Japan}. Reading was reported as °Brix.

Colour, TSS and TPC were assessed in prepared soup (Fig. 1) during storage .The total plate count was determined according to AOAC (2005). Sensory evaluation was done to find out the acceptable dilution and effect of blast freezing on sensory attributes of prepared soup. Preliminary trial was conducted to evaluate the acceptable dilution. The processing parameters were successfully established in this study to minimize changes in quality attributes. Thus, Prepared soup T1 (1:2 ratio) T2 (1:3 ratio) as preliminary trial and 2$^{nd}$ was to evaluate the freezing conditions. The prepared soup was served for 30 semi trained panellist and evaluate the sensory stimuli namely appearance, colour, aroma, taste, texture and overall acceptability using 5 point hedonic scale (5-like extremely, 4-like moderately, 3-neither like nor dislike, 2-dislike moderately, 1-dislike extremely).

D. *Data Analysis*

Parametric data obtained from the study pertaining to the completely randomized design were analysed using ANOVA by SAS statistical package. Mean separation was done by using Least Significant Difference (LSD) at α= 0.05. The results with respect to sensory evaluation were analysed

using Friedman test of Minitab statistical package and treatment means were compared at *p<0.05* using multiple comparison procedure.

## III. RESULTS AND DISCUSSION

Physico- chemical analysis of vegetables and other ingredients containing carrot, pumpkin, and spinach and soya powder were given in Table 1. Most fruits and vegetables are over 90 percent water of total weight. The water and dissolved solutes inside the rigid plant cell walls give support to the plant structure, and texture to the fruit or vegetable tissue. In the process of freezing, when water in the cells freezes, an expansion occurs and ice crystals cause the cell walls to rupture (Gusthavo *et al*., 2005). Firmness is a critical quality characteristic in the consumer acceptability. In this experiment, after 4 month of storage, blast frozen and normal frozen carrots were loosed it firmness 34.90%, 27.18% respectively from its initial value. Blast frozen and normal frozen pumpkin were loosed it firmness 46.19%, 39.29% respectively (Table 1). The two freezing conditions significantly (*P*<0.05) affect for the firmness of carrot and pumpkin. This observation might be due to the fact that lower freezing rate caused severe changes in product micro structure (Xu *et al.,* 2015). Blast freezing retained more firmness than normal freezing. Respect to colour of carrot, L* value (lightness) was decreased 70.27% and 71.22% in blast freezing and normal freezing respectively and of pumpkin, decreased its firmness by 64.03% and 64.49% in blast freezing and normal freezing respectively. Also, L* value of spinach were decreased in both freezing conditions. It is significantly different among treatments (*P*<0.05). That might be due to bigger crystal formation, more disrupted cell walls and drip loss during normal freezing and thawing process. b* (blueness-yellowness) value of blast frozen and normal frozen spinach were not given significant difference among treatments (*P*>0.05).

Table 1: Physico-chemical properties of vegetables and other ingredients during storage

| Vegetable | Parameter | Initial value | 1st month | 2nd month | 3rd month | 4th month |
|---|---|---|---|---|---|---|
| Carrot | Firmness | 88.41±0.08 | | | | |
| | 1. T1 (B) | | 56.54±2.31 | 46.66±1.65 | 42.23±0.07 | 30.86±1.67 |
| | 2. T2 (N) | | 50.32±0.66 | 40.07±0.23 | 35.03±0.67 | 24.03±1.03 |
| | Colour | | | | | |
| | 1. T1 (B) | | | | | |
| | L* | 59.88±2.03 | 47.05±0.06 | 45.8±0.11 | 44.62±0.28 | 42.08±0.30 |
| | a* | 23.45±0.53 | 18.5±0.38 | 15.25±0.21 | 13.68±0.24 | 12.47±0.16 |
| | b* | 53.72±0.57 | 43.42±0.03 | 35.47±0.01 | 30.52±0.26 | 26.83±0.12 |
| | 2. T2 (N) | | | | | |
| | L* | | 60.30±0.06 | 45.48±0.25 | 43.62±0.37 | 42.65±0.18 |
| | a* | | 17.76±0.01 | 14.54±0.39 | 13.63±0.21 | 12.55±0.36 |
| | b* | | 40.15±0.05 | 32.37±0.06 | 27.44±0.02 | 23.46±0.02 |
| Carrot | Firmness | 88.41±0.08 | | | | |
| | 3. T1 (B) | | 56.54±2.31 | 46.66±1.65 | 42.23±0.07 | 30.86±1.67 |
| | 4. T2 (N) | | 50.32±0.66 | 40.07±0.23 | 35.03±0.67 | 24.03±1.03 |
| Pumpkin | Colour | | | | | |
| | 1. T1 (B) | | | | | |
| | L* | 75.98±0.9 | 52.98±0.69 | 52.56±0.18 | 50.18±1.10 | 48.63±0.32 |
| | a* | 0.79±0.56 | -0.65±0.04 | -0.35±0.04 | -0.25±0.01 | -0.17±0.01 |
| | b* | 52.48±1.59 | 39.54±0.53 | 34.79±0.16 | 30.40±0.33 | 28.43±0.55 |
| | 2. T2 (N) | | | | | |
| | L* | | 53.5±0.48 | 52.48±0.16 | 50.21±0.18 | 49.00±0.82 |
| | a* | | 0.67±0.02 | -0.35±0.03 | -0.24±0.01 | -0.18±0.01 |
| | b* | | 35.53±0.22 | 32.41±0.27 | 28.81±0.15 | 25.88±0.01 |
| | Firmness | 65.66±0.11 | | | | |
| | 1. T1 (B) | | 39.96±0.43 | 36.77±0.30 | 33.81±0.06 | 30.33±0.06 |
| | 2. T2 (N) | | 36.66±0.28 | 32.59±0.30 | 28.36±0.28 | 25.8±0.11 |
| Spinach | Chlorophyll (mg/100 g) | 370 ±2 | | | | |
| | 1. T1 (B) | | 355±1.8 | 339±0.4 | 336±0.2 | 329±2.1 |
| | 2. T2 (N) | | 347±0.6 | 328±2.4 | 313±1.3 | 299±2.2 |
| | Colour | | | | | |
| | 1. T1 (B) | | | | | |
| | L* | 46.2±0.55 | 29.77±0.58 | 24.95±0.79 | 22.9±0.12 | 20.28±0.65 |
| | a* | -15.74±0.21 | -11.14±0.1 | -9.54±0.20 | -7.96±0.06 | -7.29±0.23 |
| | b* | 21.04±2.65 | 13.53±0.55 | 9.63±0.06 | 7.1±0.21 | 6.1±0.28 |
| | 2. T2 (N) | | | | | |
| | L* | | 30.18±0.09 | 24.38±0.80 | 22.82±0.17 | 20.65±0.30 |
| | a* | | -9.45±0.07 | -7.70±0.16 | -6.48±0.12 | -5.87±0.11 |
| | b* | | 13.7±0.16 | 9.33±0.40 | 7.68±0.43 | 5.82±0.13 |
| Soya powder | Colour | | | | | |
| | 1. T1 (B) | | 82.35±0.46 | 81.95±0.07 | 80.54±0.36 | 79.10±0.38 |
| | L* | 82.35±0.98, | -3.29±0.05 | -1.4±0.07 | 0.28±0.01 | 0.34±0.02 |
| | a* | -4.41±0.03 | 17.58±0.38 | 17.46±0.25 | 17.02±0.03 | 16.43±0.23 |
| | b* | 18.35±0.08 | | | | |
| | 2. T2 (N) | | | | | |
| | L* | | 82.03±0.84 | 81.73±0.21 | 80.54±0.34 | 78.54±0.38 |
| | a* | | -3.15±0.04 | -1.3±0.08 | 0.22±0.02 | 0.36±0.03 |
| | b* | | 17.38±0.04 | 17.05±0.09 | 16.98±0.01 | 16.36±0.20 |

Standard deviation for three replicate (*n*=3) determinations.

Physico- chemical analysis of prepared soup was given in Table 2. The L* value of prepared soup were decreased during storage but no any significant difference among treatments ($P$>0.05). Total plate counts of prepared soups were $6.41x10^2$cfu/g and $7.63x10^2$cfu/g at the end of storage and it is within the acceptable limit.

Table 2: Physico-chemical properties of soup during storage

| Parameter | 1st month | 2nd month | 3rd month | 4th month |
|---|---|---|---|---|
| Colour | | | | |
| 1. T1 (B) | | | | |
| L* | 50.78±0.65 | 49.31±0.44 | 47.65±0.36 | 46.39±1.00 |
| a* | 2.3±0.16 | 2.1±0.05 | 1.93±0.05 | 1.44±0.12 |
| b* | 29.04±0.64 | 27.96±0.17 | 27.11±0.05 | 26.66±0.32 |
| 2. T2 (N) | | | | |
| L* | 50.37±0.27 | 49.3±0.65 | 47.64±0.38 | 46.79±0.17 |
| a* | 2.35±0.15 | 2.03±0.01 | 1.94±0.02 | 1.36±0.07 |
| b* | 27.88±0.01 | 26.52±0.37 | 25.42±0.48 | 24.49±0.26 |
| TSS | | | | |
| 1. T1 (B) | 6.5±0.1 | 6.34±0.04 | 5.86±0.05 | 5.52±0.02 |
| 2. T2 (N) | 6.33±0.05 | 5.93±0.15 | 5.53±0.05 | 5.06±5.05 |
| TPC cfu/g | | | | |
| 1. T1 (B) | $3.11x10^2$ | $4.71x10^2$ | $5.61x10^2$ | $6.41x10^2$ |
| 2. T2 (N) | $3.47x10^2$ | $5.33x10^2$ | $6.67x10^2$ | $7.63x10^2$ |

Standard deviation for three replicate ($n$=3) determinations.

Acceptability of the prepared soup

According to the findings from preliminary experiments, 1: 2 ratio (soup mix: water) was identified as most acceptable ratio of dilution (figure 2).

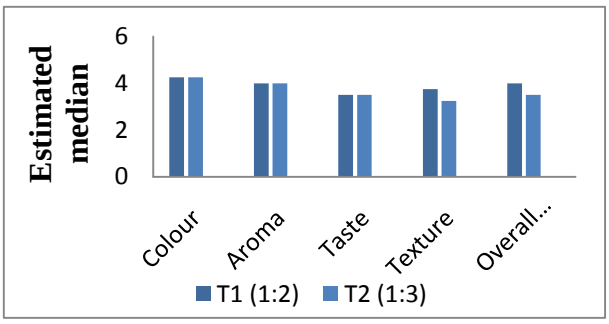


Figure 2: Estimated median for sensory quality attributes of prepared soup in different dilutions

The estimated medians for appearance, colour, texture, and overall acceptability was above the point "like extremely" which corresponds to number of the 5 point Hedonic scale. Estimated median of colour, aroma, and texture were in equal level in prepared soup. But taste and overall acceptability were high in blast frozen soup significantly ($P$<0.05) (Fig 3).

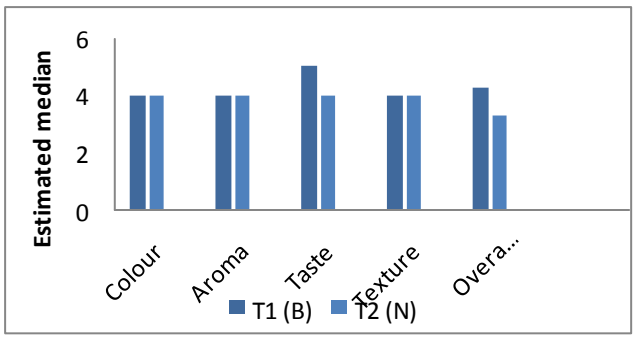


Figure 3: Sensory evaluations of blast frozen) vs. normal frozen VSM

## IV. CONCLUSIONS

Blast freezing can be recommended as a preferable preservation method to protect physico-chemical characteristics of fresh vegetables. Prepared soup from frozen vegetable soup mix has given excellent sensory, physico-chemical properties and microbial quality (TPC) up to 4 months period.

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