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ARTICLE

Effect of Nanopowdered Peanut Sprouts on Physicochemical and Sensory Properties of Milk

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Abstract

A study was conducted to examine the physicochemical and sensory properties of milk supplemented with nanopowdered peanut sprouts (NPPS) at different concentrations (1, 3, 5, 7, and 9%, w/v) during the storage at 4°C for 16 d. The size of NPPS ranged from 300-350 nm as observed by the particle size analyzer. The pH values of all samples ranged from 6.8 to 6.6 during the storage of 16 d. In color, the L* value of milk samples were not remarkably influenced by NPPS supplementation, whereas the b* and a* values significantly increased with the NPPS supplementation at all concentrations at 0 d storage, due to the original yellow color of NPPS powder ($p<0.05$). DPPH study revealed that higher antioxidant activity of milk supplement with higher concentrations of NPPS. TBARS value found to lower at the lower concentrations (1 and 3%, w/v) of NPPS supplementation. The sensory test revealed that the overall acceptability scores of NPPS supplemented milk samples (1 and 3%, w/v) were quite similar to control throughout the storage period of 16 d. Based on the data obtained from the present study, it was concluded that the concentrations (1 and 3%, w/v) of NPPS could be used to produce NPPS-supplemented milk without significant adverse effects on physicochemical and sensory properties, and enhance functional components from the supplementation.

Key words: milk, nanopowdered peanut sprout, antioxidant activity, sensory properties

Introduction

Polyphenols and its derivative compounds deserve a large interest since it is mainly associated with the prevention of various diseases, such as coronary heart disease and cancer (Servili *et al.,* 2009). Hundreds of polyphenol are occur in edible plants which play a defense role in plants and also serve as antioxidative and anti-inflammatory properties in the dietary. Peanut sprouts are rich in naturally occurring phytoelaxtin, such as resveratrol with an average content of 110.05 μg/g (Kang *et al.,* 2010). Other sources contains resveratrol, but at much lower level such as cranberry juice (0.24 μg/g), strawberry (0.11 μg/g), blueberry (0.02-0.03 μg/g), and peanuts (0.01-1.79 μg/g) (Lyons *et al.*, 2003; Tokusoglu *et al.*, 2005; Wang *et al.*, 2002). As the consequence, this peanut sprout extract represents an alternative source of bioactive compounds used to fortify functional foods and/or beverages. Further it has been shown to prevent various disease, such as Alzheimer's, cancer, and cardiovascular, and proven to extend the life span of various organisms. Recent data also suggested that it has a beneficial role in diabetic prevention and reducing some of its complications. Further it reduced the oxidative stress and renal dysfunction in diabetic rats (Sharma *et al.,* 2006).

Nano sizing is a recent emerging technique which is used in foods to enhance the stability and functional properties of food product (Park *et al.*, 2007). According to Seo *et al.* (2011), ascorbic acid solubilized nano-chitosan supplementation in the milk is an effective way to increase the vitamin C supplement along with chitosan. Similarly, Park *et al.* (2007) also reported that nanocalcium supplementation in the milk may be an effective way to increase the bone calcium metabolism for ovarirectomised rats. Functional milk has huge demand in the market with the enhanced health beneficial properties. Therefore over the years, a huge variety of food ingredients were studied, such as L-ascorbic acid (Lee *et al.*, 2004), isoflavone (Jeon *et al.*, 2005), and fish oil (Fomolla *et al.*, 2009) have been used in milk to improve the functional properties.

Nowadays consumers are more health conscious than ever. To meet the growing demand for the food with

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health promoting functions, functional milk can be developed using the appropriate nutraceutical ingredients, such as nanaopowdered peanut sprout. However, there are no informations on developing the functional milk which incorporates the nanopowdered peanut sprout. Therefore, the objective of the present study was to evaluate the physicochemical and sensory properties of the nanopowdered peanut sprout-supplemented milk during storage.

Materials and Methods

Materials

Commercial peanut sprout was offered from Jangsuche. Co., Ltd. (Korea). Peanut sprouts were ground to nanopowdered peanut sprout (NPPS) by the dry milling method at room temperature in Apexcel Co. (Korea). Market milk (3.8% milk fat) was purchased from Seoul Dairy Co-op. (Korea). 2-thiobarbituric acid (TBA), 2, 2-diphenyl-1-pitryl-hydrazyl were obtained from Sigma Chemical Co. (USA). All chemicals were purchased from Sigma Chemical Co. (USA), and all solvents were of chromatographic grade.

Solubilization of nanopowdered peanut sprouts

To solubilise the NPPS, 0.5% (w/v) NPPS was sonicated in water for 1 h. The NPPS solution was stirred at 800 rpm at room temperature for 2 h and then 10% (w/v) polyglycerol monostearate (PGMS) was added to be 0.2% (v/v) solution. The resulting suspension was placed at room temperature for 24 h, followed by the centrifugation at 3,889 *g* for 5 min using a centrifuge (HMR-220IV, Korea). After centrifuging, the supernatant was collected and neutralized to pH 6.6 with 0.1 M NaOH.

Manufacture of NPPS enriched milk

Different concentrations (1, 3, 5, 7 and 9%, v/v) of the NPPS solution were aseptically added with pasteurized milk and agitated for 2 min. The NPPS supplemented milk pack was then stored at 4°C for 0, 4, 8, 12 and 16 d for various analyses. The samples were made in duplicate.

Particle size analysis and scanning electron microscopy

Scanning electron microscope (SEM, Hitachi S-4700, Japan) was used to analyze the microstructure of the powdered peanut spout and NPPS. The morphology of powdered peanut sprout and NPPS was in the range 50 to 150 μm by SEM and 300 to 350 nm by particle size analyzer (Ahn *et al*., 2012).

pH

The pH values of the NPPS enriched milk samples were measured using a glass electrode pH meter (Orion 900A, USA).

DPPH radical scavenging activity

The free radical scavenging activities of NPPS were measured by the 2,2-diphenyl-1-picryl-hydrazil (DPPH) method proposed by Brand-Williams *et al.* (1995). Briefly, 0.1 mM solution of DPPH in ethanol was prepared and 1.0 mL of this solution was added to 0.5 mL of samples in different concentrations. After 20 min, the absorbance was measured at 525 nm. The DPPH radical scavenging activity was calculated according to the following equation:

$$\text{DPPH radical scavenging activity (\%)} = [(A_0 - A_1)/A_0] \times 100$$

where A_0 was the absorbance of the control and A_1 the absorbance in the presence of the test compound.

Thiobarbituric acid reactive substance (TBARS)

TBARS of NPPS supplemented milk was performed according to the method of Stapelfeldt *et al*. (1997). First of all, TBA solution was made by dissolving 2-thiobarbituric acid (1.4 g) in 95% ethanol to 100 mL. NPPS-supplemented milk (17.6 mL) was taken into a flask fitted with glass stopper, heated to 30°C, added 1mL trichloroacetic acid (TCA) solution containing 1 g/mL, followed by 95% ethanol (2 mL), stopped and shaked for 10 s. After 5 min, the contents were filtered through Whatman No. 42. One mL of the TBA solution was added into 4mL of the clear filtrate. The contents were mixed and placed in the water bath at 60°C for 1 h followed by cooling in an ice bath for 10 min. Absorbance was read at 450 nm with a UV-VIS-NIR scanning spectrophotometer (Beckman coulter, USA). Each sample was measured at least three times.

Color measurement

Color values of milk sample supplemented with NPPS were measured using a colorimeter (CR210, Minolta, Japan) after calibrating its original value with a standard plate (X=97.83, Y=81.58, Z=91.51). Measured L*, a* and b* values were used as indicators of lightness, redness and yellowness, respectively.

Sensory analysis

The sensory evaluation was performed by 8 trained panelists, who were the graduate students (4 males and 4 females) in the Dairy Products Laboratory (Food Science and Technology Department, Sejong University, Seoul, Korea), aged 25 to 33 yr, and familiar with milk consumption. Panelists were trained in 2 sessions using a 7-point scale, where 1 represented very weak peanut flavor, yellow color, and taste, and 7 represented very strong peanut flavor, yellow color, and taste. Reference samples prepared at the level of 1, 5, and 9% NPPS-enriched milk were kept in a closed cup for 0, 4, 8, 12, and 16 d, representing the score of 1, 4, and 7, respectively. To test the flavor of samples, the panelists were asked to open the closed cup and sniff the headspace above the samples. The samples were then scored.

Statistical analysis

All statistical analyses were performed using SAS version 9.0 (SAS Institute, 2002). An ANOVA was performed using the general linear models procedure to determine significant differences among the samples. Means were compared by using Duncan's multiple range test (p<0.05).

Results and Discussion

pH

The changes in pH values of milk samples supplemented with various concentrations of NPPS and control (without supplement of NPPS) during 16 d of storage at 4°C are shown in Fig. 1. The pH values of the milk samples ranged from 6.5 to 6.7 as a reflective of the fresh state (Seo *et al.,* 2011). It was observed in this study pH values for all the milk samples were nearly constant during 8 d storage. The pH values for the control were slightly higher than those for all the NPPS milks. Initially pH values were proportionally decreased with increasing concentrations (1, 3, 5, 7, and 9%) of the NPPS and this trend kept with final period of storage ranged from 6.70 to 6.42 which are in normal scope of market milk. The decrease in pH values resulted from the adjustment of pH of the NPPS solution with 0.1 M NaOH at the final stage of solubilization. The pH values for all the milk samples were nearly constant during 16 d storage and ranged from 6.5 to 6.7, as a reflective of fresh state (Lee *et al.,* 2006). These results indicated that the various concentrations of NPPS supplement did not provide adverse effect on the pH of the milk during the storage of 16 d.

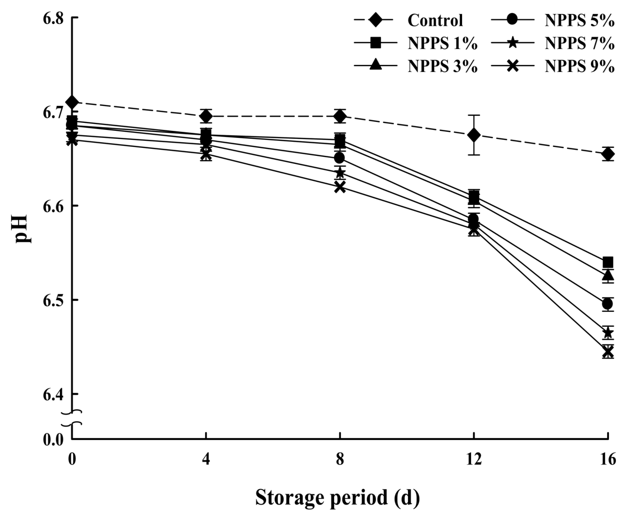

Fig. 1. Changes in pH of dispersable nanopowdered peanut sprout-supplemented milk stored at 4°C for 16 d. NPPS: nanopowdered peanut sprout.

DPPH radical scavenging activity

The DPPH radical scavenging activity of NPPS-supplemented milk during storage at 4°C for 16 d is shown in Fig. 2. The radical scavenging activities were normally used to measure the capacity of antioxidant activity in various plant and animal foods (Kang *et al.*, 2010). DPPH radical scavenging activity was found to be lower in the control (without supplement of NPPS). However, increasing the concentrations of NPPS (1, 3, 5, 7, and 9%) significantly increases the DPPH radical scavenging activity in NPPS-supplemented milk (p<0.05). Higher the concentration of NPPS supplementation in milk (7 and 9%) was found to be higher radical scavenging activity at 0 d to 16 d storage of milk. NPPS are rich in resveratrol and other plant polyphenolics which has greater antioxidant activity (Kang *et al.,* 2010). Further DPPH radical scavenging activity found to be constant upto 4 d and dramat-

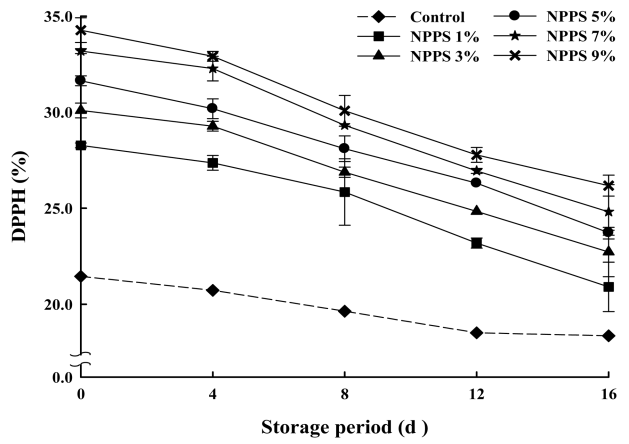

Fig. 2. Changes in DPPH of dispersable nanopowdered peanut sprout-supplemented milk stored at 4°C for 16 d. NPPS: nanopowdered peanut sprout.

ically decreased during 8 d to 16 d storage (Kang *et al.,* 2010). However, the antioxidant activity was found to be greater in NPPS supplemented milks irrespective of its concentrations supplemented in milk. These results confirmed that NPPS provides greater antioxidant activity with increasing NPPS supplementation in milk.

Changes in TBARS

The changes in TBARS of NPPS-supplemented milk during storage at 4°C for 16 d are shown in Fig. 3. TBARS absorbance values of all samples ranged below 0.2 showed mostly lower oxidation in the milk. Increasing the concentrations of NPPS (1, 3, 5, 7, and 9%) significantly increased the TBARS values of NPPS-supplemented milk ($p<0.05$). This was most likely due to the higher fat content in the nanopeanut sprouts which was readily prone to oxidation during the increase storage period of 16 d. However, it did not exceed 0.2 until 16 d storage and were maintained the lower value of 0.15 and 0.17 up to 16 d. Ahn *et al*. (2010) were also reported that milk supplemented with *I. obliquus* extract powder had lower TBARS value of 0.13. At higher concentration of NPPS supplementation (7 and 9%), the TBARS value exceed to 0.16 during 16 d storage period. It was most likely due to the higher nanopeanut sprout fat oxidation during the storage period of 16 d. However, TBARS values were maintained within 0.16 during for 7 and 9% NPPS-supplement milk during the storage of 8 d of the normal shelf life of market milk. Therefore, the results indicated that there was no considerable chemical oxidation in the NPPS-supplemented milk samples at various concentrations during the 16 d storage.

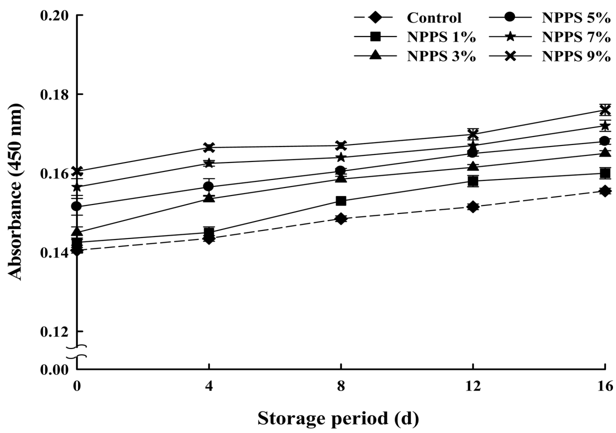

Fig. 3. Changes in thiobarbituric aicd (TBARS) values of dispersable nanopowdered peanut sprout-supplemented milk stored at 4°C for 16 d. NPPS: nanopowdered peanut sprout.

Color

The changes in color of NPPS-supplemented milk samples stored at 4°C for 16 d are presented in Table 1. The L* values of the milk supplemented with different concentrations of NPPS were not significantly differ at

Table 1. Changes in color of dispersable nanopowdered peanut sprout-supplemented milk stored at 4°C for 16 d

Color	Conc. (%)	Storage period (d)				
		0	4	8	12	16
L* (lightness)	Control	89.01±0.24$^{1)aA2)}$	89.03±0.25^{aA}	89.11±0.24^{aA}	89.08±0.32^{aA}	89.01±0.07^{aA}
	1	89.03±0.25^{aA}	89.02±0.22^{aA}	89.07±0.20^{aA}	89.06±0.20^{aA}	89.10±0.08^{aA}
	3	89.14±0.12^{aA}	89.09±0.42^{aA}	88.98±0.17^{aA}	89.02±0.23^{aA}	89.04±0.23^{aA}
	5	89.11±0.20^{aA}	89.04±0.21^{aA}	89.04±0.21^{aA}	89.06±0.16^{aA}	89.04±0.15^{aA}
	7	89.07±0.11^{aA}	88.94±0.22^{aA}	89.06±0.16^{aA}	88.95±0.13^{aA}	88.97±0.19^{aA}
	9	89.14±0.11^{aA}	88.97±0.12^{aB}	89.03±0.09^{aB}	89.00±0.10^{aB}	89.07±0.12^{aAB}
a* (redness)	Control	2.72±0.09^{cB}	2.65±0.16^{bB}	2.61±0.11^{bB}	2.75±0.28^{bB}	2.96±0.04^{cA}
	1	2.77±0.06^{bcC}	2.65±0.12^{bD}	2.61±0.11^{bD}	2.86±0.09^{abB}	2.97±0.05^{cA}
	3	2.83±0.06^{abBC}	2.77±0.16^{aC}	2.91±0.09^{aB}	2.84±0.17^{abBC}	3.04±0.09^{bA}
	5	2.84±0.09^{abBC}	2.78±0.10^{aC}	2.87±0.10^{aB}	2.85±0.07^{abBC}	3.07±0.06^{bA}
	7	2.87±0.07^{aB}	2.79±0.10^{aB}	2.86±0.16^{aB}	2.90±0.11^{aB}	3.04±0.07^{bA}
	9	2.89±0.14^{aC}	2.82±0.11^{aC}	2.90±0.05^{aBC}	2.97±0.06^{aB}	3.14±0.04^{sA}
b* (yellowness)	Control	2.76±0.22^{dC}	2.86±0.25^{bC}	3.14±0.26^{cB}	3.89±0.44^{abcA}	3.80±0.08^{cA}
	1	3.25±0.21^{cB}	3.31±0.29^{aB}	3.21±0.31^{cB}	3.89±0.22^{abcA}	4.07±0.16^{bA}
	3	3.63±0.16^{bBC}	3.40±0.46^{aC}	3.85±0.23^{bAB}	3.84±0.44^{bcAB}	4.14±0.27^{bA}
	5	3.62±0.31^{bC}	3.52±0.27^{aC}	3.93±0.27^{bB}	3.63±0.24^{cC}	4.25±0.21^{bA}
	7	3.73±0.18^{abB}	3.32±0.25^{aC}	4.16±0.26^{aA}	3.98±0.24^{abA}	4.15±0.28^{bA}
	9	3.87±0.16^{aC}	3.59±0.23^{aD}	4.16±0.14^{aB}	4.15±0.15^{aB}	4.48±0.15^{aA}

$^{1)}$Mean±SD (n=10)

$^{2)}$Values with different superscript in a same row (A-D) and in a same column (a-c) are significant at $p<0.05$ by Duncan's multiple range test

$^{3)}$NPPS: nanopowdered peanut sprouts increasing storage of 16 d (*p*>0.05). According to Philips *et al.* (1995), the L* value of milk has been demonstrated to have the most positive impact on consumer appeal. Therefore, in this study, it is speculated that the supplementation of the NPPS in milk samples would not influence the consumer appeal over the extended storage of 16 d. Increasing the concentrations of NPPS-supplementation in milk at 0 d markedly increase the b* values, most likely due to the light yellow color of NPPS. Similarly Seo *et al*. (2011) also reported that the addition of nanopowdered chitosan in milk greatly increases the b* values during the increase storage period due to the light yellow color of the nanochitosan. Increasing the storage period to 16 d greatly increased the a* and b* values irrespective of treatments (Table 1). However, a* value was found to be not significantly different at 1% NPPS supplementation during the storage period from 0 to 16 d of storage (*p*>0.05). Therefore, the results indicated that there were no considerable changes in L* values of the NPPS-supplemented milk samples at various concentrations during the 16 d storage.

Table 2. Sensory characteristics of dispersable nanopowdered peanut sprout-supplemented milk stored at 4°C for 16 d

Concentration of sample (%, w/v)	Appearance	Flavor			Taste			Overall acceptability
	Color	Peanut	Beany	Cooked	Astringency	Bitterness	Sweetness	
				0 d				
Control	1.00±0.00[1)]^{aA}[2)]	1.00±0.00^{bA}	1.00±0.00^{dA}	4.00±0.00^{aA}	1.00±0.00^{aA}	1.00±0.00^{aA}	4.00±0.00^{abA}	4.40±0.97^{bA}
1	1.10±0.32^{Aa}	1.70±0.67^{bA}	1.70±0.67^{cAB}	4.10±0.32^{aA}	1.10±0.32^{aB}	1.00±0.00^{aA}	3.90±0.32^{abA}	5.30±0.82^{aA}
3	1.10±0.32^{aA}	2.70±0.95^{aA}	2.00±0.67^{bcA}	3.70±0.67^{aC}	1.10±0.32^{aB}	1.00±0.00^{aB}	4.10±0.074^{aA}	5.40±0.52^{aA}
5	1.10±0.32^{aA}	3.20±1.14^{aA}	2.10±0.88^{bcB}	3.60±0.70^{aAB}	1.10±0.32^{aB}	1.00±0.00^{aB}	4.10±0.74^{aA}	4.80±0.42^{abA}
7	1.10±0.32^{aA}	3.00±1.15^{aA}	2.50±0.97^{bB}	3.80±1.03^{aA}	1.10±0.32^{aB}	1.10±0.32^{aB}	4.00±0.47^{abA}	4.70±0.82^{abA}
9	1.10±0.32^{aA}	3.60±1.43^{aA}	3.20±0.92^{aA}	3.40±1.43^{aAB}	1.30±0.67^{aB}	1.10±0.32^{aC}	3.50±0.71^{bA}	3.70±0.95^{cA}
				4 d				
Control	1.00±0.00^{aA}	1.00±0.00^{bA}	1.00±0.00^{cA}	4.00±0.00^{aA}	1.00±0.00^{bA}	1.00±0.00^{bA}	4.00±0.00^{abA}	4.70±0.95^{abA}
1	1.00±0.00^{aA}	1.80±0.42^{bA}	1.10±0.32^{cB}	4.10±0.32^{aA}	1.00±0.00^{bB}	1.00±0.00^{bA}	4.00±0.00^{abA}	5.40±0.84^{aA}
3	1.00±0.00^{aA}	3.20±0.92^{aA}	1.80±0.92^{bcA}	4.00±0.82^{aABC}	1.00±0.00^{bB}	1.00±0.00^{bB}	4.10±0.57^{aA}	5.20±0.92^{aA}
5	1.10±0.32^{aA}	3.90±1.45^{aA}	2.50±1.27^{bB}	3.70±0.95^{abAB}	1.50±0.53^{abAB}	1.00±0.00^{bB}	3.60±0.52^{abA}	4.50±0.71^{abA}
7	1.10±0.32^{aA}	4.00±1.41^{aA}	2.60±1.26^{bB}	3.40±0.70^{abA}	1.60±0.97^{abB}	1.40±0.84^{abB}	3.50±0.71^{bA}	3.90±1.10^{bcAB}
9	1.10±0.32^{aA}	4.30±1.83^{aA}	3.90±1.91^{aA}	3.20±1.14^{bAB}	2.00±1.15^{aAB}	1.80±0.79^{aAB}	3.60±0.84^{abA}	3.30±1.06^{cA}
				8 d				
Control	1.00±0.00^{aA}	1.00±0.00^{dA}	1.00±0.00^{dA}	4.00±0.00^{aA}	1.00±0.00^{aA}	1.00±0.00^{aA}	4.00±0.00^{aA}	4.90±0.88^{abA}
1	1.00±0.00^{aA}	1.70±0.67^{cdA}	1.30±0.48^{cdB}	4.10±0.32^{aA}	1.10±0.32^{aB}	1.00±0.00^{aA}	4.10±0.32^{aA}	5.30±0.82^{aA}
3	1.00±0.00^{aA}	2.60±0.84^{bcA}	2.10±0.74^{bcA}	4.20±0.42^{aAB}	1.10±0.32^{aB}	1.10±0.32^{aB}	4.10±0.32^{aA}	5.10±0.57^{aA}
5	1.10±0.32^{aA}	3.40±0.84^{abA}	2.80±1.23^{bAB}	3.70±0.67^{aAB}	1.30±0.67^{aB}	1.00±0.00^{aB}	3.80±0.42^{abA}	4.40±0.52^{bA}
7	1.10±0.32^{aA}	3.60±1.35^{abA}	4.00±1.15^{aA}	3.70±0.67^{aA}	1.20±0.63^{aB}	1.20±0.42^{aB}	3.90±0.74^{abA}	3.60±0.52^{cB}
9	1.10±0.32^{aA}	3.80±1.75^{aA}	4.20±1.14^{aA}	3.70±0.67^{aAB}	1.40±0.70^{aB}	1.20±0.42^{aBC}	3.50±0.71^{bA}	3.40±0.52^{cA}
				12 d				
Control	1.00±0.00^{aA}	1.00±0.00^{cA}	1.00±0.00^{cA}	4.00±0.00^{aA}	1.00±0.00^{bA}	1.00±0.00^{aA}	4.00±0.00^{aA}	4.80±0.92^{aA}
1	1.00±0.0^{aA}	2.10±1.37^{bcA}	1.80±0.79^{bcAB}	4.40±0.52^{aA}	1.20±0.63^{abAB}	1.20±0.42^{aA}	4.00±0.00^{aA}	4.70±1.37^{aA}
3	1.00±0.00^{aA}	3.30±1.83^{abA}	2.50±1.27^{abA}	4.40±0.52^{aA}	1.30±0.48^{abB}	1.20±0.42^{aAB}	3.90±0.32^{aAB}	4.20±1.14^{abB}
5	1.00±0.00^{aA}	3.60±1.43^{aA}	2.50±1.18^{abB}	4.20±0.42^{aA}	1.70±0.67^{aAB}	1.20±0.42^{aB}	4.10±0.57^{aA}	3.50±0.97^{bB}
7	1.00±0.00^{aA}	3.40±0.71^{abA}	2.60±1.17^{abB}	3.90±0.74^{aA}	1.40±0.52^{abB}	1.00±0.00^{aB}	3.80±0.42^{aA}	3.70±1.16^{bB}
9	1.10±0.32^{aA}	4.10±1.45^{aA}	3.40±1.17^{aA}	4.00±0.67^{aA}	1.40±0.52^{abB}	1.20±0.42^{aBC}	3.90±0.74^{aA}	3.50±1.18^{bA}
				16 d				
Control	1.00±0.00^{aA}	1.00±0.00^{dA}	1.00±0.00^{cA}	4.00±0.00^{aA}	1.00±0.00^{bA}	1.00±0.00^{bA}	4.00±0.00^{aA}	5.10±0.99^{aA}
1	1.00±0.00^{aA}	2.00±1.15^{cdA}	2.40±2.01^{bcA}	3.40±0.97^{abB}	1.70±1.06^{abA}	1.30±0.67^{abA}	3.50±0.85^{aB}	3.30±1.70^{bB}
3	1.00±0.00^{aA}	2.90±1.10^{bcA}	3.10±2.38^{abA}	3.40±0.97^{abC}	2.10±1.37^{abA}	1.50±0.71^{abA}	3.50±0.85^{aB}	3.00±1.41^{bcC}
5	1.00±0.00^{aA}	3.00±0.94^{bcA}	3.90±1.85^{abA}	3.30±0.95^{abB}	2.10±1.20^{abA}	1.60±0.70^{abA}	3.60±0.84^{aA}	2.60±0.97^{bcC}
7	1.00±0.00^{aA}	3.40±1.51^{abA}	4.10±2.18^{abA}	3.10±1.45^{abA}	2.60±1.71^{aA}	2.10±1.37^{aA}	3.50±1.35^{aA}	2.30±0.82^{bcC}
9	1.00±0.00^{aA}	4.40±1.51^{aA}	4.50±2.12^{aA}	2.80±1.32^{bB}	2.70±1.57^{aA}	2.10±1.10^{aA}	3.30±1.25^{aA}	2.00±0.47^{cB}

1) Mean±SD (n=10)

2) Values with different superscript in a same row (A-D) and in a same column (a-c) are different significantly at *p*<0.05.

3) NPPS: nanopowdered peanut sprout

Sensory evaluation

The sensory properties of NPPS-supplemented milk stored at 4°C for 16 d are shown in Table 2. Appearance, flavor, and taste properties were analyzed with increasing concentrations (1, 3, 5, 7, and 9%) of NPPS supplementation and storage period of 16 d. The appearance scores for the NPPS-supplemented milk at different concentrations and for the control were not significantly different by the prolonged storage period of 16 d or the supplementation of NPPS (p>0.05). Peanut, beany, and cooked flavor significantly increased with increased supplementation of NPPS in milk at 0 d (p<0.05). Further increasing the storage period from 0 to 16 d significantly increases the flavor properties (p<0.05). However at the lower concentrations (1, 3, and 5%) of NPPS-supplementaion, peanut, beany, and cooked flavor were quite similar to control upto 8 d storage. In the taste test, astringency and bitterness were found to be lower without much difference during 0 d. Increasing the storage period of 16 d greatly increased the astringent and bitterness score irrespective of the concentrations of NPPS-supplemented to the milk. It was correlated to the TBARS value which undergoes greater oxidation during the increase storage period of 16 d. Seo *et al*. (2011) are also reported that addition of nanochitosan in milk greatly increase the astringent score in milk during the storage periods. Sweetness scores found to be decreased with increasing supplementation of NPPS in milk at 0 d. Increasing the storage period to 16 d greatly reduced the sweetness score of NPPS-supplement milk most likely due to the greater oxidation of milk. Finally, NPPS supplemented into the milk samples at lower concentrations (1 and 3%) did not significantly influence the overall acceptability at 0, 4, and 8 d of storage (p>0.05). Based on all the sensory data obtained from the current study, it is suggested that NPPS concentrations (1 and 3%) could be used for the supplementation in milk without affecting the sensory properties.

This study was designed to develop the NPPS milk and to evaluate the effect of supplementing NPPS on the physicochemical and sensory properties of the products during storage. The data on pH, color, and sensory analysis indicated that the lower concentrations (1 and 3%) of NPPS could be applicable in the development of functional milk. The production of the milk which incorporates the NPPS can broaden the utilization of nanopeanut sprout extract, and the products can be regarded as possible health-promoting nutraceutical foods.

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