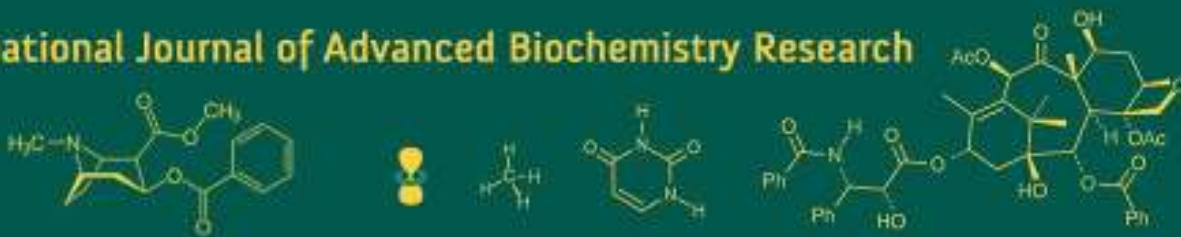


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Effect of natural preservatives on shelf life extension and quality parameters of Peanut butter

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Abstract

Natural food preservatives have distinctive qualities, such as abundant in the nature, ability to be used in large doses, lack of toxicity to humans and lack of side effects. Peanut butter is a culinary ingredient or spread made with roasted peanuts. Peanut butter manufactured by using roasted kernels of peanuts. Peanut butter was prepared by using roasted peanuts, dextrose, sodium chloride, preservatives (chitosan, silicon dioxide and honey at different proportions). Based on sensory evaluation, control (without preservative) sample, peanut butter (Chitosan @ 1%), peanut butter (SiO₂ @ 1%) and peanut butter (Chitosan @ 0.5%) + (SiO₂ @ 0.5%) were selected for observation of oil accumulation on the surface of peanut butter for six months period. After six months the lowest oil accumulation was observed in peanut butter (Chitosan @ 1%) sample. The selected sample i.e peanut butter (Chitosan @ 1%) sample was allowed for shelflife study for six months. During six months storage period, acid value (mg KOH/g) greater than before (from 0.24±0.05 mg KOH/g to 0.84±0.06 mg KOH/g). The protein percentage considerably decreased from 23±0.08% to 20±0.12% during six months storage period. Oil percentage in product was 50±0.15% and fibre was 6±0.23%. During six months storage period, the oil content gradually decreased from 50±0.15% to 34.3±0.62%. During six months storage period, the oil percentage more or less constant but slightly increased from 6±0.23% to 6.2±0.17%. The colour change were quantified by the Hunter L (whiteness/darkness), a (redness/greenness) and b (yellowness/blueness) system.

Keywords: Chitosan, peanut butter, preservation, shelf life and silicon dioxide

Introduction

Natural food preservatives are becoming more and more popular due to their distinctive qualities, including their non-toxicity to humans, ability to be used in large doses, availability in nature, lack of side effects, and environmental friendliness. Peanut is considered earth nut, monkey nut, and ground bean. India is the world's largest producer of peanuts, coming in second only to China. In India, five states, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, and Maharashtra, account for 88 percent of pea nut area and 90 percent of production. Gujarat leads the way in terms of area and production among India's major peanut-producing states, followed by Andhra Pradesh. Major businesses in India create many varieties of peanut butter. Even though the state Andhra Pradesh is the second largest producer of peanuts, the majority of peanut manufacturing enterprises are located in Northern India. A large amount of the peanut crop is used to meet the country's cooking oil requirements. Peanut is a good source of vegetable protein, and it might be used as a food crop as well as an oilseed (Sravani *et al.*, 2020) ^[1].

Peanuts are high in good fats, proteins, and fibre. Potassium, phosphorus, magnesium, and vitamins are all abundant in them. Peanuts are eaten raw at home and are utilized in chikki, salted peanuts, chocolate, and other dishes. Peanuts are used to make nutritional supplements, pea nut butter, confectionary (peanut candy bars, peanut butter cookies, and chocolates), and snack foods (salted peanuts, dry roasted peanuts and boiled pea nuts). Cake or meal is a by-product of the peanut oil milling process. The cake from the oil milling business is used as cattle feed and in low-value products, although it has enormous potential as a nutritional supplement to address human protein deficiencies. As a result, expanding and diversifying pea nut usage will aid in lessening nutrition issues while also assisting farmers in receiving a higher remunerative price (Day 2013) ^[2]. Peanut butter considered as culinary ingredient or spread made with peanuts.

Salt, sweeteners, and emulsifiers are popular additives that alter the product's flavour or texture. Processes that maintain product homogeneity, flavour, and stability are crucial. (Sanders *et al.*, 2014) [3].

Peanut butter is source of protein and contains significant minerals and vitamins like magnesium, potassium, and zinc. It's a nutritious alternative to dairy butter that's widely used in the form of spread in Western countries. Peanut butter can be utilized in variety of ways, including breakfast foods, sauces, and smoothies (Yu *et al.*, 2021). Converting roasted peanuts to peanut butter serves a variety of reasons, including product diversification, protein malnutrition control, convenience, and storage life. The roasting of peanuts is a crucial step in the creation of peanut butter. Temperature, moisture content of kernels upon roasting, and roasting time are all known to affect characteristics of peanut butter. Significant aspect in preventing rancidity in roasted nuts is the time/temperature connection. Peanut butter is normally prepared in two stages of grinding. Initially the peanut kernels are ground into a medium grind and then into a fine, smooth texture in the second (Shi *et al.*, 2018) [5]. Peanut butter's shelf life is depending on storage conditions of raw kernels, quality of peanuts used, and the processing procedures employed in peanut butter manufacturing and storage. Peanut butter is packed in glass or plastic jars to keep the peanut butter fresh for longer. Peanuts having maximum oleic content are best for creating peanut butter (Gong *et al.*, 2018) [6].

The texture quality of peanut butter is affect the composition of peanuts, particularly the oil level (Citerne *et al.*, 2001) [7]. Furthermore, fatty-acid profile of peanut oil is intimately linked to the nutritious value (Tanti *et al.*, 2016) [8]. Peanut butter meal can be added to sweets, sandwiches, nutritious snacks, or simply eaten directly from package. Peanut butter is also fantastic for its shelf life and storage possibilities, in addition to its nutritional content (Gong *et al.*, 2018) [6]. Industrially prepared peanut butter requires no cold temperatures in most cases. An opened jar of prepared peanut butter can be kept in a dark cabinet at room conditions for up to three months (Degen *et al.*, 2021) [9].

Materials and methods

This work performed in laboratory of Post-Harvest Engineering and Technology Centre, Regional Agricultural Research Station, Tirupati during 2020-2022. Seeds of peanut cultivar namely Dharani was selected for peanut butter preparation. Other food grade ingredients used in peanut butter preparation including sodium chloride, dextrose, honey, silicon dioxide and chitosan were collected from local market. Proximate analysis and storage studies performed at Post Harvest Engineering and Technology Centre, Regional Agricultural Research Station, Tirupati. The experimental overview of present work, method of peanut butter preparation and packed samples are presented in Fig. 1, Fig. 2 and Fig. 3 respectively.

Peanut butter preparation

Peanuts (variety Dharani) were shelled and spread on aluminum trays. Peanuts were roasted by using peanut roaster (Make: NANS Tamil Nadu, India) with 10 kg/h roasting capacity, single phase power supply (230 V) and 0.5 HP capacity motor. Peanuts were roasted at 160 °C for 30 min in hot air oven until golden color and desirable flavor was obtained. Peanut seeds were blanched (removal

of skin) manually. Peanuts and remaining ingredients were weighed according to set formulation and then fed into peanut butter making machine to two stage grinding process. Bulk sample of 100 g peanuts were ground in mill for 30 seconds, then dextrose (8% w/w) and salt (1% w/w) then mixture was ground for one minute until smooth paste was obtained. Prepared product stored in cleaned, air tight PET bottles at room temperature to determine shelf life.

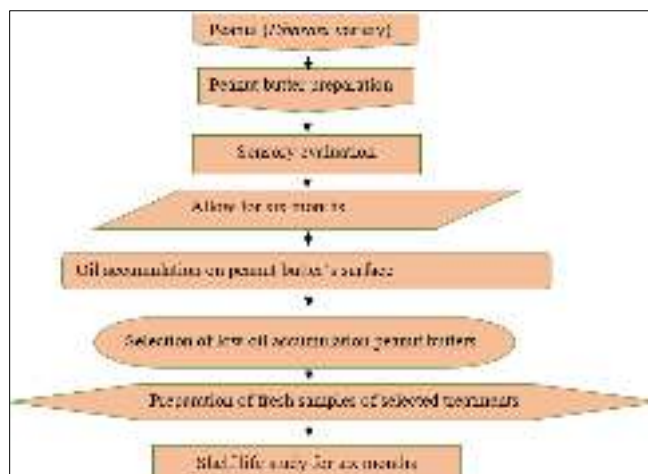


Fig 1: The experimental overview of present investigation.

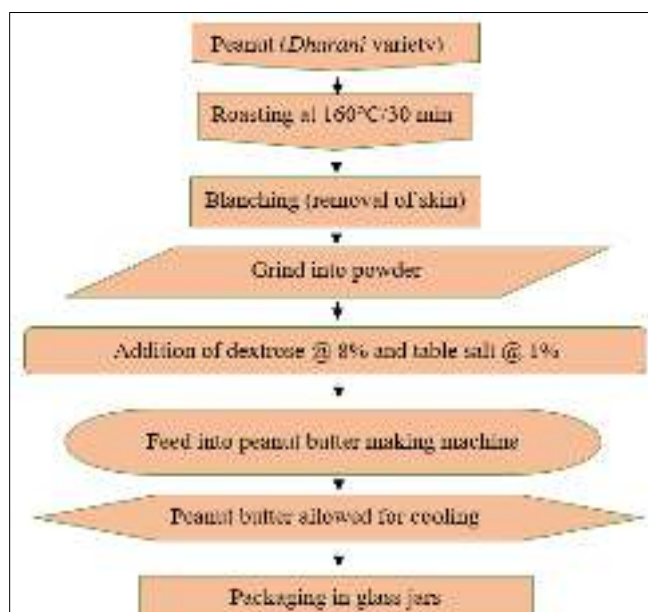


Fig 2: Peanut butter preparation



Fig 3: Peanut butters (T₀ - Peanut butter; T₂ - Peanut butter + Chitosan (1% by wt. of butter); T₆ - Peanut butter + Silicon dioxide (1% by wt. of butter); T₉ - Peanut butter + Chitosan (0.5% by wt. of butter) + Silicon dioxide (0.5% by wt. of butter)).

Proximate analysis

Moisture analysis performed by method no. 44-19 (AACC, 2000) [10] and crude fat with adopting AACC (2000) [10] method no. 30-20 with the help of soxhlet instrument

(FossST243 Soxtec B-811, Denmark) using n-hexane as solvent. Sample's crude protein contents in peanut butter determined following AOAC method no. 950.48 using Foss Auto Kjeldahl (Kjeltec 8100). Crude fibre of samples analyzed as per AOAC (2010) [10] method using Foss FT 122 Fibertec instrument.

Fatty acid profile

For the determination of fatty acid profile, fatty acid methyl esters were prepared by taking 1-2 drops of extracted fat from flaxseed in a clean screw capped tube and 0.5 N of 5 ml methanolic sodium methoxide was added. Tube was capped and heated in the boiling water bath for 10 minutes. After cooling 0.5 ml of boron trifluoride (14% BF₃) was added, and was again heated in the similar manner for 5 minutes for complete methylation and the tube was allowed to cool at room temperature. Measured fatty acids percentages showed as the percentages out of total fat content.

Acid value (mg KOH/g)

Acid value of treatments and control measured by taking 3g of each sample into 100ml conical flask. Solvent mixture (50ml; neutral 95% ethanol: diethyl ether, v/v) with phenolphthalein to the sample in the flask. After 20 minutes holding with 3 minutes interval shaking free fatty acids in the sample dissolved into the solvent. The supernatant was decanted off and standard sodium hydroxide solution used to the pink end point (the pink color persisting 10 seconds).

$$\text{Acid value} = \frac{56.2 \times N \times V}{M} \quad (1)$$

Where; V is the number of ml of NaOH solution used N is the exact normality, and M is sample's weight.

Peroxide value

According to AOAC (2010) [11] method, one gram of fat extracted from the samples was dissolved into 30 ml of the solvent (3/2 mixture of glacial acetic acid /chloroform) and 0.2 mg of potassium iodide. Obtained mixture was left to stand in the dark for about 1 minute, thereafter 20 ml of distilled water and 2-3 drops starch indicator was added and titrated against with 0.1 N sodium thiosulphate solution. Amount of sodiumthiosulphate used was recorded. Same procedure used for blank.

$$\text{Peroxide value (meq/kg oil)} = \frac{A \times N \times 1000}{W} \quad (2)$$

Where, A = ml of sodium thiosulphate (Test – Blank), N = normality of sodium thiosulphate solution (ml), W = weight of sample.

Colour measurement

Color characteristics studied with color lab (Lovibond RT850i) which records “L*” (lightness), “a*” (-a greenness; +a redness) and “b*” (-b blueness; +b yellowness) with a measuring head hole of 22 mm, illuminance of D65 and 108 standard observer, calibrated to a white plate (X: 79.61, Y: 84.45, Z: 90.64) (Schnell et al, 2005).

Following equations (3, 4, 5, 6) were used to describe the colour characteristics such as chroma, hue-angle, hue-difference and browning index.

$$\text{Chroma (C}_{ab}^*) = (a^{*2} + b^{*2})^{1/2} \quad (3)$$

$$\text{Hue-Angle (h}^\circ) = \tan^{-1} \frac{b^*}{a^*} \quad (4)$$

$$\text{Hue-Difference (}\Delta H_{ab}^*) = [(\Delta E_{ab}^*)^2 - (\Delta L^*)^2 - (\Delta C_{ab}^*)^2]^{1/2} \quad (5)$$

$$\text{Browning Index (B.I)} = \frac{[100(x - 0.31)]}{0.17};$$

$$(\text{Where, } x = \frac{(a^* + 1.75L^*)}{(5.645L^* + a^* - 0.3012b^*)}) \quad (6)$$

Sensory evaluation

Sensory evaluation done by eighteen judges who were presented three tests. The nine point hedonic scale rated peanut butter samples on the basis of color, aroma, taste, flavor, oiliness, spread ability. Plain water and bread to clean their palate alternatingly before testing each sample were supplied.

Texture profile analysis

The hardness of prepared peanut butters analysed by Stable Microsystem Texture Analyzer Model (TA- H di England). The product put and double compression was applied using cylinder probe. The load cell used for the test was 100 kg, the test speed was 2 mm/sec, probe diameter was 5 mm and 1.4 mm and the penetration index of the probe was 50 percent of the sample thickness. The test was performed in five replications. The textural parameters expressed as hardness (peak force of the first compression cycle) were determined and represented in TPA curve.

Storage studies

Storage study was performed for six months during May 2021 to March 2022 when average room temperature and relative humidity was 34 °C and 55% respectively. These quality attributes calculated in storage period with one-month interval.

Statistical analysis

The statistical tool, OPSTAT software a statistical method as described by Sheoran (1998) [12] and it was used to find significance among treatments and chemical constituent's changes in storage of peanut butter.

Results and Discussion

Sensory evaluation

On the first day of preparation of sample sensory evaluation was conducted. The sensory evaluation was conducted on the first day of peanut butter preparation. The data related to sensory evaluation was collected from score cards of eighteen judges thrice and average values taken. All the samples were allowed for six months to observe quantity of oil accumulated on the surface of the peanut butters. The sensorial results of peanut butters and oil accumulation on their surface are shown in Table 1. Based on sensory evaluation and lower oil accumulation characteristics four peanut butter samples namely, T₀ - control (without preservative) sample, T₂ - peanut butter (chitosan @ 1%), T₆ - peanut butter (SiO₂ @ 1%) and T₉ - peanut butter (Chitosan @ 0.5%) + (SiO₂ @ 0.5%) were selected. After six months the lowest oil accumulation was observed in peanut butter (Chitosan @ 1%) sample followed by peanut butter

(Chitosan @ 0.5%) + (SiO₂ @ 0.5%) and peanut butter (SiO₂ @ 1%). The selected peanut butter samples were allowed for six months shelf life.

Proximate analysis

The results pertaining to proximate analysis and characteristics of peanut butters prepared with addition of preservatives at zeroth (0th) day are presented in Table 2. Moisture play major role in properties of food products and their shelf life. All prepared peanut butter samples had safe and lower moisture contents ranging from 2.14±0.16 to 3.28±0.18%. This moisture in peanut butter helps in solubility of solids (dextrose, table salt and other ingredients) and textural characteristics of peanut butter. Peanut butter is rich source of proteins and can provide half of the daily protein requirement to the human body solely. Freshly prepared peanut butter had protein content ranged from 22.18±0.24 to 24.29±0.42%. During storage, the protein may be decreased due to deterioration from putrefaction of protein fraction caused by bacterial spoilage (Shrestha, A., 2018). Protein values obtained in the study are similar (22 to 30%) to results by Boli *et al.*, (2013) [14] and Shakerardekani *et al.*, (2013) [16].

Peanut butter is rich in essential fatty acids and fat soluble vitamins. Fat quality is very important as far as storage of peanut butter is concerned because it affects shelf-life due to oil susceptibility to rancidity. Rancidity is often used as an

indicator of the stability and edibility of oils. Oil percentage in peanut butter was 45.47±1.34%. During storage the fat content may be decreased due to oxidation of lipids (Bendini *et al.*, 2010) [17]. Main fatty acid compounds of peanut butter were oleic acid (58.91±1.3%), linoleic acid (18.42±0.21%) and linolenic acid (0.7±0.16%). Fig. 6 shows the fatty acid profile graph obtained from gas chromatography.

The fibre in foods has hypocholesterolemic effect by binding to cholesterol in the small intestine and prevents cholesterol particles from entering into bloodstream and traveling to remaining of body parts. The fiber content in peanuts butter was ranged from 3.14±0.13 to 4.88±0.02%. The hardness of peanut butter increased when chitosan and silicon dioxide solely or in combination added in peanut butter compared to the control sample. Even though fat accumulation on peanut butter minimized by 1% chitosan addition, solid like character and hardening of the peanut butter appears to be directly related to surface modifications and structural reorganization of the proteins mediated by oxidized lipids (Ibadullah and Zunair 2013). Acceptable characteristics of peanut is soft and high spreadability. Maximum spreadability with lowest hardness (315.25±4.67 g) and smooth texture observed in control sample than other samples. Maximum hardness (365.65±2.47 g) was observed in T₂ (1% chitosan) sample followed by T₂ and T₂ samples.

Table 1: Sensory evaluation of peanut butters and oil accumulation on their surface

Treatment code	Treatments Details	Sensory Rank	Oil accumulation (%)*
T ₀	Peanut butter (Control)	1	7.01
T ₁	Peanut butter (Chitosan @ 0.5%)	7	6.72
T ₂	Peanut butter (Chitosan @ 1%)	2	4.54
T ₃	Peanut butter (Chitosan @ 1.5%)	5	5.93
T ₄	Peanut butter (Chitosan @ 2%)	13	5.75
T ₅	Peanut butter (SiO ₂ @ 0.5%)	15	6.81
T ₆	Peanut butter (SiO ₂ @ 1%)	3	4.93
T ₇	Peanut butter (SiO ₂ @ 1.5%)	14	6.19
T ₈	Peanut butter (SiO ₂ @ 2%)	21	5.94
T ₉	Peanut butter (Chitosan @ 0.5%) + (SiO ₂ @ 0.5%)	4	4.81
T ₁₀	Peanut butter (Chitosan @ 1%) + (SiO ₂ @ 1%)	10	6.25
T ₁₁	Peanut butter (Chitosan @ 1.5%) + (SiO ₂ @ 1.5%)	6	5.73
T ₁₂	Peanut butter (Chitosan @ 2%) + (SiO ₂ @ 2%)	20	5.41
T ₁₃	Peanut butter (Honey @0.5%)	11	6.83
T ₁₄	Peanut butter (Honey @1%)	8	6.63
T ₁₅	Peanut butter (Honey @1.5%)	18	6.17
T ₁₆	Peanut butter (Honey @2%)	16	5.96
T ₁₇	Peanut butter (Chitosan @ 0.5%) + (SiO ₂ @ 0.5%) + (Honey @0.5%)	9	6.34
T ₁₈	Peanut butter (Chitosan @ 1%) + (SiO ₂ @ 1%) + (Honey @1%)	17	6.18
T ₁₉	Peanut butter (Chitosan @ 1.5%) + (SiO ₂ @ 1.5%) + (Honey @1.5%)	12	5.51
T ₂₀	Peanut butter (Chitosan @ 2%) + (SiO ₂ @ 2%) + (Honey @2%)	19	5.34

*Each value is an average of three replications

Table 2: Characteristics of peanut butters prepared with addition of preservatives at zeroth (0th) day

Parameters	T ₀	T ₂	T ₆	T ₉
Moisture (% w.b)	2.6±0.12	3.28±0.18	2.14±0.16	2.95±0.06
Protein%	24.29±0.42	22.18±0.24	24.04±0.25	24.05±0.06
Carbohydrate%	20.68±0.14	24.08±0.32	20.94±0.36	20.95±0.06
Ash%	3.16±0.26	3.88±0.45	4.74±0.12	3.75±0.06
Crude fat%	45.47±1.34	46.98±1.21	45.84±0.91	45.85±1.06
Crude fiber%	3.8±0.15	4.88±0.02	3.14±0.31	4.5±0.06
Free crude fatty acid%	0.69±0.17	0.78±0.01	0.74±0.32	0.75±0.06
Oleic acid%	58.91±1.13	59.98±1.23	58.94±1.52	59.25±1.06
Linoleic acid%	18.42±0.21	19.448±0.42	18.434±0.36	18.735±0.12
Linolenic acid%	0.7±0.16	0.728±0.14	0.714±0.06	0.515±0.02
Hardness (g)	315.25±4.67	365.65±2.47	325.64±1.14	335.17±2.24

Where, T₀= T₂=Peanut butter + (by wt of butter); T₆=Peanut butter + (by wt of butter); T₉=Peanut butter + Chitosan (0.5% by wt of butter) + Silicon dioxide (% by wt of butter).

Textural property i.e., hardness of selected peanut butter was 365.65 g, which is far greater than the hardness (220.29 g) reported for fat spread by Mijeni, (2017) ^[15], but does not had adverse consequences on the spread ability of the optimized peanut butter. A lot of scope for further improvement in spread ability of the product by decreasing the hardness, using industrial scale grinding process.

Acid value (mg KOH/g)

Acid value is the one of the indicator of rancidity, low acid value of food samples indicates low rancidity with higher shelf life. During six months storage period, the acid value was increased from 0.25±0.03 mg KOH/g to 0.40±0.02 mg KOH/g. According to World Health Organization (WHO) guidelines an acceptable maximum acid value level in peanut butter is 0.6 mg KOH/g whereas 0.5 mg KOH/g by Food Safety and Standards Authority of India (FSSAI). Best before date of usage was selected as six months since acid value below acceptable acid value was observed at six month storage in this study. Acid value in six month of storage increased significantly. Upon storage conditions, fatty acids in peanut butter forms hydroperoxides and peroxides which in turn forms acids (Karavalakis *et al.*, 2011) ^[13].

Peroxide value

The results related to peroxide value of selected peanut butter treatments are shown in Table 4. The peroxide value (PV) indicates that, initial stage of fat deterioration and is a very important indicator used in food quality control and safety. A general rule is that PV should not be above 10–20 meq/kg fat to avoid rancidity flavor (Connell, 1975). During six months storage period, the value was amplified from 1.13±0.05 mg KOH/g to 3.45±0.02 mg KOH/g. On six months storage the lowest peroxide value (2.1±0.11 meq/kg) for peanut butter (Chitosan @ 1%) followed by Peanut butter (Chitosan @ 0.5%) + (SiO₂ @ 0.5%). According to WHO guidelines an acceptable maximum peroxide value level in peanut butter is 10 meq/kg. Best before date of usage was selected as six months since peroxide value below acceptable determined peroxide value perceived at sixth month storage in this study. Peroxide value in sixth month of storage increased significantly. Upon storage conditions, fatty acids in peanut butter forms hydroperoxides and peroxides (Karavalakis *et al.*, 2011) ^[13]. Chitosan, as a polycationic biopolymer, may act as an emulsifier and emulsion stabilizer through adsorption of the protective layer at oil-water interfaces, viscosity enhancement, and interaction with surface-active agents there by lowering the oxidation of oils present in peanut butters. Representations of acid value and peroxide value of peanut butter are given in Table 3. and Fig. 4.

Table 3: Acid value (mg KOH/g) and Peroxide value (meq O₂/kg) of selected peanut butter treatments

Treatments	Storage days						
	0 day	30 days	60 days	90 days	120 days	150 days	180 days
Acid value (mg KOH/g)							
T ₀	0.25±0.09	0.30±0.02	0.31±0.04	0.35±0.06	0.38±0.04	0.39±0.05	0.40±0.02
T ₂	0.25±0.06	0.26±0.04	0.28±0.02	0.29±0.02	0.30±0.05	0.31±0.02	0.32±0.04
T ₆	0.25±0.04	0.27±0.06	0.29±0.01	0.30±0.08	0.32±0.02	0.34±0.02	0.36±0.07
T ₉	0.25±0.03	0.27±0.06	0.28±0.05	0.3±0.02	0.31±0.04	0.33±0.07	0.35±0.09
Peroxide value (meq O ₂ /kg)							
T ₀	1.13±0.05	1.29±0.15	1.85±0.18	2.08±0.18	2.14±0.04	2.82±0.01	3.45±0.02
T ₂	1.14±0.02	1.22±0.04	1.48±0.02	1.69±0.22	1.72±0.01	1.81±0.02	2.11±0.11
T ₆	1.15±0.19	1.29±0.15	1.49±0.09	1.89±0.06	2.28±0.02	2.45±0.01	2.91±0.07
T ₉	1.19±0.16	1.25±0.06	1.55±0.02	2.67±0.02	2.75±0.15	2.80±0.07	2.84±0.15

Where, T₀= Peanut butter; T₂=Peanut butter + Chitosan (1% by wt of butter); T₆=Peanut butter + Silicon dioxide (1% by wt of butter); T₉=Peanut butter + Chitosan (0.5% by wt of butter) + Silicon dioxide (0.5% by wt of butter).

Table 4: Colour values of selected peanut butter treatments

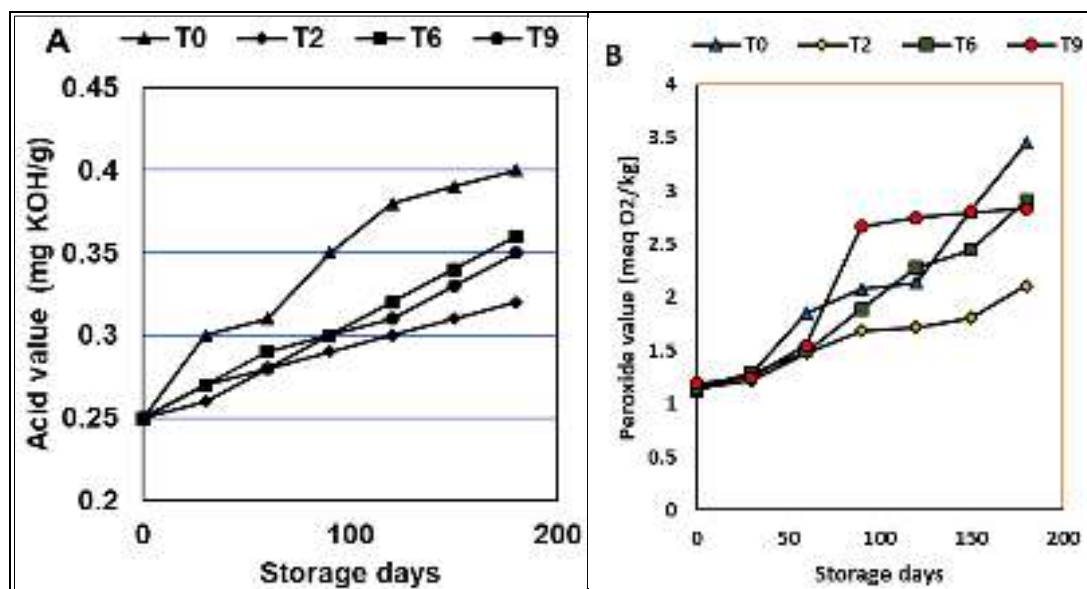
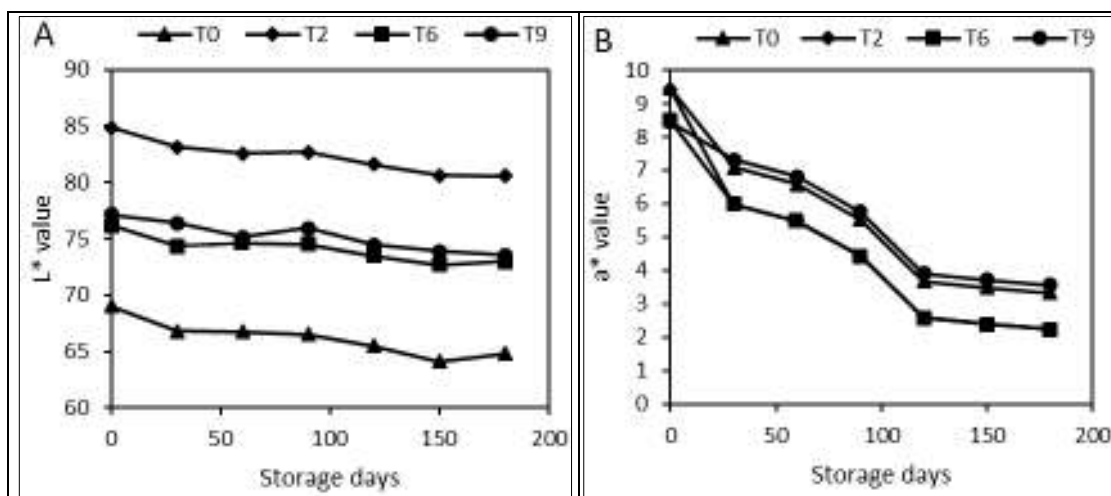
Sample	0 day	30 days	60 days	90 days	120 days	150 days	180 days
L* value							
T ₀	69.04	66.80	66.73	66.52	65.49	64.14	64.84
T ₂	84.82	83.14	82.57	82.65	81.57	80.64	80.57
T ₆	76.17	74.36	74.64	74.54	73.51	72.69	72.96
T ₉	77.15	76.41	75.14	75.92	74.48	73.89	73.54
a* value							
T ₀	9.45	7.08	6.58	5.52	3.67	3.48	3.33
T ₂	9.42	5.98	5.48	4.42	2.57	2.38	2.23
T ₆	8.48	5.98	5.48	4.42	2.57	2.38	2.23
T ₉	8.45	7.31	6.81	5.75	3.90	3.71	3.56
b* value							
T ₀	27.15	28.45	29.05	29.14	29.16	28.998	31.27
T ₂	27.18	28.68	29.08	29.17	29.19	29.028	29.10
T ₆	29.41	30.81	31.31	31.40	31.42	31.258	32.02
T ₉	27.50	29.01	29.40	29.49	29.51	29.348	32.2

Where, T₀= Peanut butter; T₂=Peanut butter + Chitosan (1% by wt of butter); T₆=Peanut butter + Silicon dioxide (1% by wt of butter); T₉=Peanut butter + Chitosan (0.5% by wt of butter) + Silicon dioxide (0.5% by wt of butter).

Table 5: Effect of storage on colour characteristics peanut butter

Character	Sample	Storage days						
		0 day	30 days	60 days	90 days	120 days	150 days	180 days
ΔE (Colour difference)	T ₀	0	3.51	4.15	5.07	7.07	7.94	8.49
	T ₂	0	4.11	4.92	5.8	7.84	8.39	8.57
	T ₆	0	3.39	3.87	4.81	6.79	7.26	7.50
	T ₉	0	2.03	3.22	3.57	5.65	6.04	7.68
Chroma	T ₀	28.75	29.51	29.78	29.65	29.39	29.20	29.53
	T ₂	28.77	29.29	29.59	29.50	29.30	29.47	30.32
	T ₆	30.61	31.48	31.78	31.70	31.52	31.34	31.42
	T ₉	28.77	29.90	30.17	30.04	29.76	29.58	30.31
browning index	T ₀	59.07	61.98	62.98	62.22	61.31	57.19	67.33
	T ₂	46.15	46.74	47.39	46.50	45.52	41.43	45.72
	T ₆	56.01	58.12	58.41	57.59	56.68	52.43	58.22
	T ₉	51.32	53.81	55.23	53.64	53.04	49.71	59.47
Hue angle	T ₀	1.24	1.33	1.35	1.38	1.45	1.45	1.46
	T ₂	1.24	1.37	1.38	1.42	1.48	1.49	1.49
	T ₆	1.29	1.38	1.40	1.43	1.49	1.49	1.50
	T ₉	1.27	1.32	1.34	1.38	1.44	1.45	1.46

Where, T₀ = Peanut butter; T₂ = Peanut butter + Chitosan (1% by wt of butter); T₆ = Peanut butter + Silicon dioxide (1% by wt of butter); T₉ = Peanut butter + Chitosan (0.5% by wt of butter) + Silicon dioxide (0.5% by wt of butter).

**Fig 4:** (A) Acid value and (B) Peroxide value of peanut butter

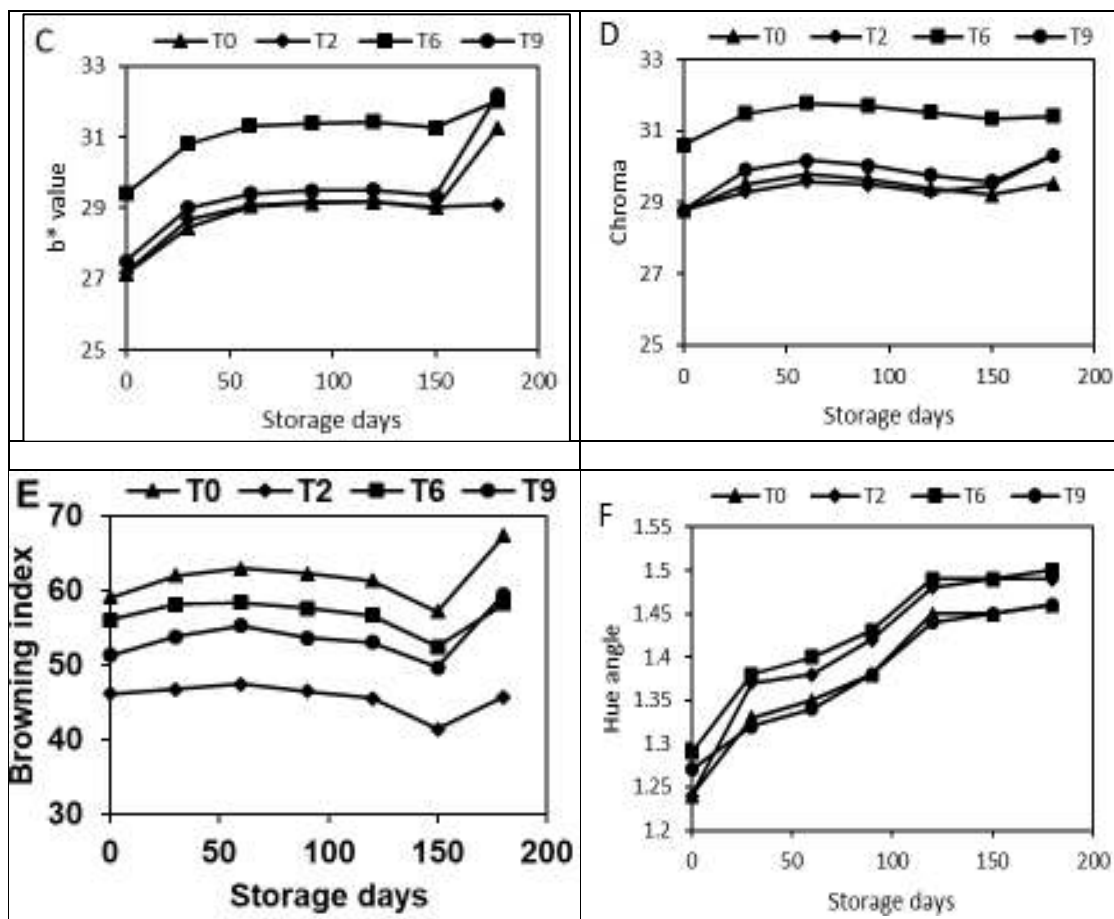


Fig 5: Effect of storage on colour characteristics of peanut butter. (A) L* value; (B) a* value; (C) b* value; (D) Chroma; (E) Browning index; (F) Hue angle;

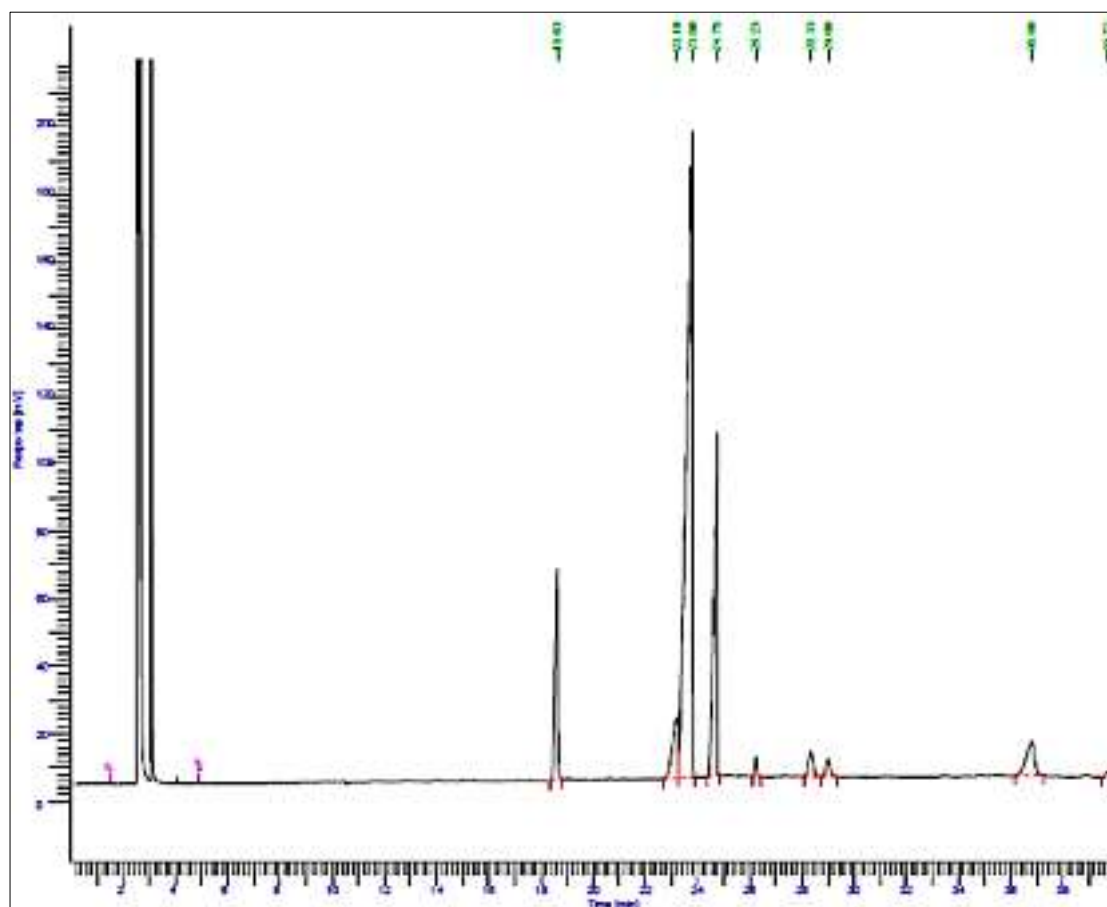


Fig 6: Fatty acid profile of peanut butter (prepared with 1% chitosan)

The colour change in peanut butter during storage was observed. The results related to effect of storage days on colour parameters of peanut butters (Figure 5) such as colour values, ΔE (Colour difference), ΔC (Chroma change), browning index and hue angle are presented in Table 5. There was a decrease in luminosity (L^* -values) of the fresh and samples with six months storage which ranged from 69.04 to 84.82 which occurred for 0 month of storage to six months storage. This represents the transition from fresh to stored samples. For the 0 and 6 months, there was a gradual change in the color parameters. The L^* values decreased gradually. T_2 (1% chitosan) sample showed maximum lightness (L^* 84.82) and control sample showed lowest lightness (L^* 69.04). The color value, a^* with positive value indicates redness. Control sample had maximum a^* value (9.45), this redness may be due to natural color of roasted peanuts compared to other samples in which redness was masked by added preservatives (SiO_2 and chitosan). The color value, b^* with positive value indicates yellowness. Maximum b^* value (29.41) was found in T_6 sample (1% SiO_2), remaining three samples showed similar yellowness values. The interaction of storage temperatures, relative humidity and sugars, amino acids present in peanut butter might be the cause to decrease in lightness (L^* value) and caused browning of peanut butter. Color parameter for samples on zero (0) day showed that whiteness (L^* -value) between 69.04 – 84.82, while a -value (red/green) and b -values (yellow/blue) ranged 8.45- 9.45 and 27.15 - 29.41 respectively. Similarity in color parameter of samples prepared by chitosan ingredients was observed. After six (6) months of storage, there was a general decrease in luminosity (L^* -values), which ranged between 64.84 – 80.57 but showed no significant difference ($P>0.05$). The red/green (a^* -values) were decreased. Less or no colour change gives maximum acceptability of peanut butter. Lowermost color change observed in T_6 (peanut butter + 1% silicon dioxide) sample followed by T_2 (Peanut butter + 1% Chitosan) sample. Whereas high color change was observed in T_9 (Peanut butter + 0.5 Chitosan + 0.5% Silicon dioxide). Less concentration of silicon dioxide (0.5%) might be the reason for higher color change in T_9 sample.

Conclusion

During six months storage of peanut butter prepared with 1% chitosan, the acid value was amplified from 0.24 ± 0.05 mg KOH/g to 0.84 ± 0.06 mg KOH/g. The protein content diminished from $23 \pm 0.08\%$ to $20 \pm 0.12\%$ during six months storage period. Fat content in peanut butter was $50 \pm 0.15\%$. During six months storage period, the fat content was gradually decreased from $50 \pm 0.15\%$ to $34.3 \pm 0.62\%$. Fiber content in peanut butter was $6 \pm 0.23\%$. During six months storage period, the fat percentage not changed but slightly increased from $6 \pm 0.23\%$ to $6.2 \pm 0.17\%$. Even though fat accumulation on peanut butter minimized by 1% chitosan addition, solid like character and hardening observed. Further studies are needed to improve product textural properties, include ease of spreadability, during maintaining the criterion of this product characteristics is justified.

Ethical approval and consent to participate

The study was approved by Ethics committees of Regional Agricultural Research Station, Acharya NG Ranga Agricultural University (Project Code number: P1-2020/1-

AAI-F60/0332). Written informed consent was obtained from the participants before enrolling them in the study.

Conflict of interest

Authors declare no competing interests.

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