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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 2514-2518

www.thepharmajournal.com
Received: 22-01-2023
Accepted: 26-02-2023

Deepali Mudgal
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Sweta Singh
Assistant Professor, College of Agriculture, Bhusawar, Bharatpur, Rajasthan, India

Puja
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Neelash Chauhan
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Jaivir Singh
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Vivak Kumar
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

BR Singh
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Deepali Mudgal
Department of Agricultural Engineering (Process and Food Engineering), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Study of functional, color attributes and storage effect on physicochemical properties of guava and chia seed flours

Deepali Mudgal, Sweta Singh, Puja, Neelash Chauhan, Jaivir Singh, Vivak Kumar and BR Singh

Abstract
Due to pharmacological properties, guava (*Psidium guajava* L.) is utilised in subtropical regions all over the world as both food and traditional medicine. It contains antioxidant, anti-diabetic, anti-diarrheal, analgesic & anti-inflammatory, anti-cancer, anti-hypertensive, and high nutritional value properties. Likewise chia seeds are highly valued for their medicinal value and nutritional properties. It has vitamins, calcium, and other vital minerals, as well as protein that include all essential amino acids, polyunsaturated fatty acids, and healthy dietary fibre. The aim of this research was to evaluate the physicochemical properties of guava and chia seed flours during storage of 0, 30, 60 and 90 days and the functional and color attributes of flours. Lightness, redness and yellowness of flours in terms of L*, a* and b* values was measured. Moisture content, ash, pH, acidity, protein, fat, fibre and optical density for guava flour was 7.52%, 2.51%, 4.84, 0.102%, 4.56%, 4.22%, 7.09% and 0.43 respectively and for chia flour, it was 1.10%, 4.92%, 7.34, 0.0064, 18.35%, 36.59%, 24.72% and 0.05 respectively. The L*, a* and b* values of the guava flour was L* (37.85), a* (5.07) and b* (15.38) and that of chia seed flour was L* (39.62), a*(2.68) and b* (13.01).

Keywords: Chia seed, guava (*Psidium guajava* L.), omega-3, functional food, polyunsaturated fatty acids, dietary fibre

1. Introduction

Guava (*Psidium guajava* Linn.) is native to tropical America and was launched in India in the early 17th century and now has occupied an area in India of more than 60,000 acres (Sathe, 2015; Pradhan, 2021) [39, 33]. In India, it is found in Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal, Assam, Orissa, Karnataka, Kerala, Rajasthan and many more states. Main Varieties grown in India are Allahabad Safeda, Lucknow 49, *Chittidar*, *Nagapur Seedless*, *Bangalore*, *Dharwar*, *Akra Mridula*, *Arka Amulya*, *Harijha*, *Hafshi*, *Allahabad Surkha CISHG1*, *CISHG2*, *CISHG3* etc (Verma, 2013) [42].

Guavas are often considered as superfruits (Gross, 2009) being rich in vitamin A and C in the pericarp, omega-3 and 6 polyunsaturated fatty acids in the seeds and have high levels of dietary fiber. A single guava fruit weighing 160–170 g can contain over four times more of vitamin C compared to a single orange (220–230 mg/100 g) and also has adequate levels of dietary minerals, potassium, magnesium and an otherwise broad, low-calorie profile of essential nutrients (Mahendran, 2010; Verma, 2013) [25, 42].

Since high perishability of fruit limits commercialization and consumption, guava is categorized as a subutilized crop, and there have been efforts to stimulate the development of new industrial products using this fruit (Williams and Haq, 2002; Castelo-Branco, 2016) [43, 12]. Additionally, guava presents high marketing potential due to its typical and pleasant aroma, and low market prices (Correa *et al*., 2014; Castelo-Branco, 2016) [15, 12].

Chia (*Salvia hispanica* L.) seed originated from Mexico and belongs to the family *Lamiaceae* (Zettel & Hitzmann, 2018) [45]. Chia seeds are among the nutritionally dense foods which contains superior quality of omega-3 fatty acids, gluten-free protein and high content of anti-oxidants protecting seeds against microbial and chemical degradations (Ullah *et al*., 2016) [41]. Chia seed can be utilized in raw form as well as it can also be incorporated in cereal based foods and beverages (Ali *et al*., 2012; Din *et al*., 2021) [3, 16]. Chia seeds can be either black or white and they are oval shaped with size of approximately 1 mm to around 2 mm (Ali *et al*., 2012; Rana, 2019) [3, 35].

Conventionally, chia seeds have been used as a food, in a wide range of primary cosmetics, traditional medicines and a part of religious rituals in pre-Columbian civilizations (Coates and Ayerza, 2009) [14]. Chia seeds have a lower content of saturated fatty acids (palmitic and stearic acids), adequate concentration of linoleic acid omega 6 (18–20%), and higher content of alpha-linolenic acid omega 3 (55-60%) which makes chia oil as a preferred and appealing choice for healthy food and cosmetic applications (Peiretti and Gai, 2009; Reyes-Caudillo *et al*., 2008; Carrillo *et al*., 2018) [32, 38, 11].

Generally the stability of products during their storage changes as compared to the fresh ones. Nutrient retention is greatly influenced by the environmental conditions during storage. Therefore, present work was undertaken to study the physicochemical, functional and color attributes of the guava and chia flours prepared and effect of storage on them.

2. Materials and Methods

2.1 Procurement of Raw Material

The present research work was conducted in the lab at the Department of Agricultural Engineering, College of Post-Harvest Technology and Food Processing, S.V.P. University of Agriculture & Technology, Meerut. Fresh guava and chia seeds were procured from local market in Meerut.

2.2 Preparation of Flours

Guavas were cleaned under running tap water. Guava with any spot or damage was discarded. After cutting into thin slices by knife, it was blanched in hot water for 2-3 min and then dried in tray dryer at 60 ℃ for 10-12 hours. Dried guava slices including seeds were then ground into fine powder by grinder. Chia seeds after cleaning all the impurities were roasted in a griddle for 5-7 min. The seeds were cooled and then grinded into flour by using electric grinder. Prepared flours were stored in glass jars at room temperature.

2.3. Experimental Analysis

2.3.1 Physico-chemical analysis

Physico-chemical properties of flours were determined at the time of 0 day and during storage of 30, 60 and 90 days. Moisture content of sample was determined by standard air oven method (Ranganna, 2001) [36]. The ash content was estimated by (Ranganna, 2001) [36]. The protein was estimated by micro Kjeldahl Method (AOAC, 1990) [5]. Fat content of flours was determined by (Nagi *et al*., 2007) [27]. Crude fiber was estimated by employing standard method of analysis (AOAC, 1990) [5]. The samples of flours were mixed with equal quantity of distilled water and the pH was determined using digital pH meter after calibration with standard buffers of 4 and 7 (Ranganna, 2010) [37]. The acidity and the optical density in each sample were determined according to standard procedure given in AOAC (2002) [6].

2.3.2 Analysis of Functional properties

In present studies functional properties were also carried out to evaluate *viz*. water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foaming capacity, foam stability and bulk density of flours. The water absorption capacity of the flours was determined by the method of Sosulski *et al*., (1976) [40]. Oil absorption capacity was examined as percent oil bound per gram flour. It was determined by the method of Sosulski *et al*., (1976) [40]. The emulsion activity and stability was described and followed by Yasumatsu *et al*., (1972) [44] as the emulsion (1 g sample, 10 ml distilled water and 10 ml soybean oil) was prepared in calibrated centrifuged tube. The foaming capacity (FC) and foam stability (FS) were determined by Narayana and Narasinga (1982) [28] as described with slight modification. The volume of 100 g of the flour was measured in a measuring cylinder (250 ml). After tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated (Jones *et al*., 2000) [23].

2.4 Statistical analysis

All the experimental analysis was carried out in triplicates. Data were reported as mean and standard deviation. One way ANOVA by Duncan's Multiple Range Test (DMRT) test at 0.05% significant level was carried out to analyze any significant difference during storage. Data analysis was done using SPSS version 20.0.

3. Results and Discussion

3.1 Physico-chemical Properties of Flours

The effect of storage on physico-chemical properties (moisture content, ash, protein, fat, crude fiber, pH, acidity and optical density) of guava flour and chia seed flour was analyzed at 30 days interval till 90 days and presented in Table 1 and 2. The moisture content for guava and chia flour at 0 day was observed as 7.52% and 1.10% respectively. The moisture content for guava flour varied from 7.52% to 8.07% and for chia flour it varied from 1.10% to 1.31% during storage. The moisture contents of both the flours increased with storage period. The moisture content should be below 9% as per Indian Standards (IS: 7836AND 7837 1975). Accordingly flours can be stored for more than 90 days of storage. The increases in moisture content during storage correlate the findings of Agrahar-Murugkar and Jha, 2011 [2]. The increase in moisture might be caused by absorption from the environment and aerobic respiration of the microorganisms which normally leads to the release of water and carbon dioxide.

The ash content for guava and chia flour at 0 day was observed as 2.51% and 4.92% respectively. The ash content for guava flour varied from 2.51% to 2.37% and for chia flour it varied from 4.92% to 4.78% during storage. The ash content of both the flours decreased with storage period. Ash content of the flours is also affected due to inorganic mineral content, atmospheric condition and moisture of the flour. Gupta and Shukla, 2017 [20] also showed the decreasing trend of ash content of dehydrated carrot and onion slices during storage.

The protein content for guava and chia flour at 0 day was observed as 4.56% and 18.35% respectively. The protein content for guava flour varied from 4.56% to 4.27% and for chia flour it varied from 18.35% to 18.02% during storage. The protein content was decreased with storage period. This may be due to the moisture present in the flour which favors proteolytic activity (Nasir *et al*., 2003) [29]. Similar findings were observed by Amadi and Adebola, 2008 [4] in which protein content decreased with increasing storage which might be as a result of the breaking down of protein by the microorganisms in the food.

The fat content for guava and chia flour at 0 day was observed as 4.22% and 36.59% respectively. The fat content for guava flour varied from 4.22% to 4.08% and for chia flour it varied from 36.59% to 36.44% during storage. The fat content of both the flours was found decreasing with storage period. Due to the oxidation of unsaturated fatty acids with atmospheric oxygen and moisture absorption, fat content decreases during storage. Thus, an oxidation process will result. It's also likely that the proteolytic and lipolytic activities of the respective enzymes contributed to the decrease in fat content, which in turn caused the nutrients to be lost (Agrahar and Jha, 2011) [2]. Similar findings have been reported on cassava flour (Chukwu and Abdullahi, 2015) [13].

The crude fibre content for guava and chia flour at 0 day was observed as 7.09% and 24.72% respectively. The crude fibre content for guava flour varied from 7.09% to 6.76% and for chia flour it varied from 24.72% to 24.53% during storage. The crude fibre content of both the flours decreased with storage period. This may be mainly due to the losses of insoluble fibre polymers which are susceptible to heat treatment and microbial degradation (Nyman *et al*., 1991; Nynian and Nilsson, 1994) [30, 31].

The pH for guava and chia flour at 0 day was observed as 4.84 and 7.34 respectively. The pH for guava flour varied from 4.84 to 4.17 and for chia flour it varied from 7.34 to 6.81 during storage. The pH of both the flours decreased with storage period. During increasing storage period, the pH may have been reduced due to a number of factors, one of which may be the enzymatic action that led to the formation of acidic chemical components. Similar findings were observed by Goyal *et al*., 2017 [17] who reported gradual decrease in pH of different flours after 30 days of storage.

The acidity for guava and chia flour at 0 day was observed as 0.102% and 0.0064% respectively. The acidity for guava flour varied from 0.102% to 0.355% and for chia flour it varied from 0.0064% to 0.0111% during storage. The acidity of both the flours increased gradually with storage period which is evident from Table 1 and 2. Increasing acidity during storage may be due to the formation of acidic chemical components because of the enzymatic actions in the flour. The increase in acidity of guava flour during storage correlates the findings of Verma *et al*., 2013 [42]. Similar trends have also been observed in dehydrated aonla fruits (Pragati *et al*., 2003) [34].

The optical density for guava and chia flour at 0 day was observed as 0.43 and 0.05 respectively. The optical density for guava flour varied from 0.43 to 0.45 and for chia flour it varied from 0.05 to 0.07 during storage. The optical density of both the flours increased with storage period.

As analyzed by DMRT test, all values of physicochemical properties of guava and chia flours were found to be significant at $p<0.01$ during storage of 90 days.

Table 1: Effect of Storage on different Physicochemical Properties of Guava Flour

Parameters	Storage (Mean ± SEm)					F value
	0 day N=3	30 days N=3	60 days N=3	90 days N=3	Overall N=12	
Moisture	7.52^{a}±0.006	7.65^{a}±0.009	7.89^{b}±0.012	8.07^{c}±0.088	7.78±0.066	29.567**
Ash	2.51^{d}±0.009	2.47^{c}±0.009	2.43^{b}±0.013	2.37^{a}±0.010	2.45±0.017	35.171**
Ph	4.84^{d}±0.012	4.66^{c}±0.007	4.41^{b}±0.015	4.17^{a}±0.007	4.52±0.076	781.838**
Acidity	0.102^{a}±0.0003	0.199^{b}±0.0009	0.288^{c}±0.0007	0.355^{d}±0.0018	0.2360±0.0287	10851.133**
Optical Density	0.43^{a}±0.000	0.43^{a}±0.006	0.44^{ab}±0.006	0.45^{b}±0.000	0.44±0.003	5.500**
Protein	4.56^{d}±0.009	4.45^{c}±0.006	4.36^{b}±0.010	4.27^{a}±0.007	4.41±0.033	240.754**
Fat	4.22^{d}±0.012	4.17^{c}±0.012	4.14^{b}±0.007	4.08^{a}±0.006	4.15±0.016	40.129**
Fibre	7.09^{d}±0.006	6.92^{c}±0.003	6.81^{b}±0.006	6.76^{a}±0.012	6.90±0.038	405.947**

*Significant ($p\leq0.05$), **Highly significant ($p<0.01$), Treatment along the columns with different superscripts (a - f) differed significantly at ($p\leq0.05$)

Table 2: Effect of Storage on different Physicochemical Properties of Chia Flour

Parameters	Storage (Mean ± SEm)					F value
	0 day N=3	30 days N=3	60 days N=3	90 days N=3	Overall N=12	
Moisture	1.10^{a}±0.009	1.18^{b}±0.003	1.24^{c}±0.003	1.31^{d}±0.006	1.21±0.023	232.00**
Ash	4.92^{d}±0.003	4.87^{c}±0.012	4.83^{b}±0.003	4.78^{a}±0.003	4.85±0.015	78.644**
Ph	7.34^{d}±0.003	7.15^{c}±0.015	6.99^{b}±0.006	6.81^{a}±0.012	7.07±0.059	491.351**
Acidity	0.0064^{a}±0.0001	0.0086^{b}±0.00	0.0098^{c}±0.00	0.0111^{d}±0.0001	0.0090±0.0005	1187.889**
Optical Density	0.05^{a}±0.006	0.06^{ab}±0.003	0.06^{ab}±0.003	0.07^{b}±0.009	0.06±0.004	2.750**
Protein	18.35^{d}±0.015	18.24^{c}±0.003	18.13^{b}±0.007	18.02^{a}±0.009	18.19±0.037	213.444**
Fat	36.59^{d}±0.006	36.53^{c}±0.006	36.49^{b}±0.003	36.44^{a}±0.006	36.51±0.017	146.800**
Fibre	24.72^{d}±0.006	24.66^{c}±0.003	24.61^{b}±0.006	24.53^{a}±0.003	24.63±0.021	278.333**

*Significant ($p\leq0.05$), **Highly significant ($p<0.01$), Treatment along the columns with different superscripts (a - f) differed significantly at ($p\leq0.05$)

3.2 Functional properties of flours

Table 3 shows the values of various functional properties of guava and chia flours. Water absorption capacity is useful in determining the capacity of flour to take up water and swell to improve uniformity in food. The water absorption capacity for guava and chia flour was observed as 195% and 294% respectively. Water absorption is important in food compositions, notably those involving the formation of dough. It is based on how well the protein in flours can chemically bind to water (Ikpeme-Emmanuel *et al*., 2010) [22].

The oil absorption capacity for guava and chia flour was observed as 90% and 107% respectively. Oil absorption capacity is a crucial element in the formulation of foods since fats enhance the mouthfeel of meals while preserving flavour (Adebowale *et al*., 2004) [1].

Protein, which is one of the surface-active substances, can generate and stabilise an emulsion by causing electrostatic repulsion on the surface of the oil droplets (Kaushal *et al*.,

2012) [24]. The Emulsion Activity (EA) and Emulsion Stability (ES) of flours are shown in Table 3. The emulsion activity for guava and chia flour was observed as 25.75% and 21.73% respectively. The emulsion stability for guava and chia flour was observed as 26.20% and 20.19% respectively. Emulsion stability can be greatly enhanced by the production of very cohesive films from the absorption of stiff globular protein molecules that are more resistant to mechanical deformation (Graham and Phillips, 1980) [18].

The foaming capacity and foam stability for guava flour was not determined. The foaming capacity and foam stability for chia flour was observed as 10.58% and 7.56% respectively.

The bulk density (g/cc) of flour is the density measured without the influence of any compression. The bulk density for guava and chia flour was observed as 0.94 g/cc and 0.63 g/cc respectively. The bulk density of flours is important in determining packaging and material handling requirements. Low bulk density flour blends are recommended because they help reduce dietary bulk and make packaging and transit easier.

3.3 Color Values of Flours

The L*, a* and b* values of the guava flour was L* (37.85), a* (5.07) and b* (15.38) and that of chia flour was L* (39.62), a*(2.68) and b* (13.01).

Table 3: Functional properties of Guava and Chia Flours

Sample	WAC (%)	OAC (%)	EA (%)	ES (%)	FC (%)	FS (%)	BD (g/cc)	*Color*		
								L* (lightness)	a* (redness)	b* (yellowness)
Guava Flour	195±0.577	90±1.154	25.75±0.01	26.20±0.067	N.D	N.D	0.94±0.014	37.85±0.13	5.07±0.10	15.38±0.02
Chia Seed Flour	294±1.154	107±1.527	21.73±0.005	20.19±0.012	10.58±0.012	7.56±0.006	0.63±0.21	39.62±0.007	2.68±0.15	13.01±0.10

4. Conclusion

The preparation of various food products depends on different properties of ingredient flours like physicochemical, functional and color attributes. When designing equipment for various processes, physical properties are significant. The physical properties are used in packaging and transportation of food products. Various nutrient-rich food products are prepared using chemical properties, which are significant. This study demonstrates the high nutritional content of guava and chia seeds, which makes them potentially beneficial in food preparation and value addition. They can be added to a variety of foods, including bread, cookies, soup and so forth, to increase their nutritional value and make them healthier options.

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