

Physicochemical properties of *Capsicum annuum* (red chilli) and *Capsicum frutescens* (bird's eye chilli) seed powder

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Article history:

Received: 22 June 2023

Received in revised form: 15 November 2023

Accepted: 25 November 2023

Available Online: 29 May 2024

Keywords:

Capsicum annuum seed,
Capsicum frutescens seed,
Functional ingredient

DOI:

[https://doi.org/10.26656/fr.2017.8\(3\).200](https://doi.org/10.26656/fr.2017.8(3).200)

Abstract

Capsicum annuum and *Capsicum frutescens* are the most widely cultivated species in Malaysia. Vegetable processing wastes, such as seeds, have been used as an alternative resource to manage waste and as a food source in the food industry. This research aimed to determine the potential of chilli seed powder as functional ingredient. Following this analysis, the proximate, phytic acid, and mineral were conducted for chemical analysis. Water and oil holding capacity and colour analysis were done for the physical study of chilli seed powder. Results showed that the crude fat, crude fibre, and protein contents were 22.24 ± 0.50 g/100 g, 30.87 ± 1.59 g/100 g and 17.57 ± 0.28 g/100 g for *C. annuum* seed powder and 17.68 ± 0.44 g/100 g, 24.07 ± 1.57 g/100 g, 16.1 ± 0.48 g/100 g for *C. frutescens* seed powder, respectively. Both chilli seed powders displayed low amounts of mineral contents, such as calcium (Ca), sodium (Na), magnesium (Mg) and zinc (Zn). In addition, *C. frutescens* seed powders exhibited phytic acid content (6.03 ± 0.36 g/100 g) and red *C. annuum* seed powder (8.64 ± 1.96 g/100 g). The low amount of phytic acid in both samples may be due to the low amount of minerals. The L^* values of *C. frutescens* seed powder (68.21 ± 0.35) were significantly higher than that of *C. annuum* seed powder (66.17 ± 0.35), indicating the lightness in colour of both samples. As the L^* value increased, the sample became lighter in colour. Positive a^* and b^* values led to a yellowish colour. The water-holding capacity (WHC) and oil-holding capacity (OHC) were 2.25 ± 0.38 and 0.87 ± 0.07 , for *C. annuum* seed powder and 1.40 ± 0.55 and 0.43 ± 0.75 for *C. frutescens* seed powder, respectively. Both powders exhibited low averages of WHC and OHC due to the low amount of protein. Hence, *C. annuum* and *C. frutescens* seed powders may be used to improve colour for the development of food products.

1. Introduction

Chilli is one of the most important commercial spice crops and is widely used as a universal spice. In the Malay community, chilli is known as cili, cabai or lada. These species have been widely cultivated locally around the country, such as in Perak, Johor, and Kelantan (Ramachandran, 2005). The most common types of chilli that can be found in Malaysia are red chilli and bird's eye chilli (Melor, 1990) because their pungent taste was liked by most Malaysians (Chomchalow, 1996). According to the Department of Agriculture Malaysia (2021), Malaysia cultivated 3,257 ha of *C. annuum* in 2021 with 28,740 tonnes of production.

Approximately 60% of the total weight of the dry fruit is from the chilli seeds (Reddy and Sarojini, 1987). Chilli seeds are discarded during the processing of dried chilli (Christinal and Tholkkappian, 2012). Sustained disposal of chilli seeds will cause pollution. In the food industry, the edible parts of chilli fruits are used to make puree, sauces, pickles, and juices (Omobolanle *et al.*, 2014). Fruit seeds are commonly disposed of as wastes and are not utilized for commercial purposes (Ajila *et al.*, 2007; Silva *et al.*, 2013).

To date, many researchers have shown that fruit waste products, such as pumpkin seeds (Elinge *et al.*, 2012), watermelon rinds (Johnson *et al.*, 2012), and

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rambutan seeds, rinds, and pulps (Fila *et al.*, 2012), contain high nutritional values. These waste products display high functional potentials which can be generated into new food products (Omobolanle *et al.*, 2014). Over the years, there have been many research attempts to study the nutritional values of the chilli seeds (El-Adawy and Taha, 2001; Zou *et al.*, 2015). A previous study found that seeds had more capsaicinoids compared to pericarp (Yasin *et al.*, 2023).

This research aims to determine the potential of *C. annuum* and *C. frutescens* seed powder as functional ingredients. Following this analysis, the proximate, phytic acid, and mineral were conducted for chemical analysis. Water and oil holding capacity and colour analysis were done for the physical study of chilli seeds powder.

2. Materials and methods

2.1 Sample collection

Fresh *C. annuum* (index 4 mature) and *C. frutescens* (index 4 mature) were obtained from a local market at Sungai Dua, Penang, Malaysia and were identified by Dr. Rahmad Zakaria of the Herbarium Unit, School of Biology, Universiti Sains, Malaysia. The voucher specimen numbers of *C. annuum* and *C. frutescens* were USM Herbarium 11711 and USM Herbarium 11712, respectively and selected according to the maturity of the fruit based on the guidelines of the Federal Agriculture Marketing Malaysia (Nordin, 2015).

2.2 Extraction of chilli seeds

About 1 kg of *C. annuum* and *C. frutescens* were cleaned with running tap water at room temperature (28°C). The chillies were cut in half and the seeds were peeled. The seeds were dried in a hot air dryer at 40°C overnight, blended and sieved to obtain a fine powder. The yield of seed powder of *C. annuum* and *C. frutescens* was 22% and 33%, respectively. The chilli powders were stored in an airtight container prior to analysis.

2.3 Proximate analysis

This analysis was determined according to the guidelines of The Association of Official Analytical Chemists (AOAC, 2020). Moisture content was determined by a moisture analyser (MS-70-Moisture Analyzer, A and D Instruments Ltd, Oxfordshire, UK). Ash was determined gravimetrically in a muffle furnace (Nabertherm, D2804, Lilienthal-Bremen, Germany) by heating at 550°C until constant weight. Protein content was determined according to the Kjeldahl method (nitrogen to protein conversion factor was 6.25). Crude

fiber was determined after digesting the sample refluxing with boiling sulphuric acid and potassium hydroxide. Crude fat was determined by exhaustively extracting a known weight of sample in petroleum ether (boiling point, 60°C) in a Soxhlet extractor and the ether evaporated from the extraction flask. Total carbohydrate content was calculated by subtracting the weight of moisture, ash, protein, fiber and fat from total sample weight.

Carbohydrate (%) = 100% - (ash + protein + fat + fibre) %

2.4 Phytic acid analysis

Phytic acid analysis was conducted using the method by Oluwatoyin (2014) with some modifications. About 8 g of finely ground samples were soaked in 200 mL of 2% HCl and allowed to stand for 3 hrs. Afterwards, the extracts were filtered using a filter paper (Whatman No. 1). Subsequently, 50 mL of the aliquot of the filtrate was pipetted into 100 mL conical flasks and added with 10 mL of ammonium thiocyanate solution (Na₄SCN) as an indicator. Distilled water was added into the conical flask to attain a pH value of 4.5. The solution was titrated with iron chloride (FeCl₃) solution until it turned brown-yellowish. The phytic content was determined and multiplied with the value of phytic-phosphorus (3.55), where 1 mg of iron (Fe) is equivalent to 1.19 mg phytin-phosphorus.

2.5 Mineral determination

The mineral elements were extracted from the chilli seed powder using a microwave digestion method. The contents of the elements (Ca, Na, Zn and Mg) were determined directly by atomic absorption spectroscopy (AAS) (Gul and Safdar, 2009). A series of stock solutions 0, 0.5, 1.0 and 2.0 ppm were prepared, respectively. The method for running each element was created and the three replicates of the standards, samples, and blanks were run. The calibration curve of standards was used to calculate the concentration of elements in the samples.

2.6 Determination of water and oil holding capacity

The water and oil absorption of chilli seed powder was determined by the method of Mirhosseini and Amid (2013) with some modifications during the centrifuging process. About 1 g of chilli seed powder was suspended in 10 mL of distilled water. Subsequently, the solution was vortexed for 2 mins and centrifuged at 2330×g for 30 mins. The free water was decanted and the wet matter was precipitated, weighed, and the water absorption capacity of the starch samples was calculated according to the following equation:

$$\text{WHC or OHC (\%)} = \frac{\text{PSW} - \text{SW}}{\text{SW}} \times 100$$

Where WHC = water holding capacity, OHC = oil holding capacity, PSW = precipitated sample weight and SW = sample weight

2.7 Determination of colour

The colour of chilli seed powder was analyzed using a colourimeter (Minolta Spectrophotometer CM3500d). The colour parameters L^* , a^* and b^* are indices reflecting lightness, redness/greenness yellowness and blueness, respectively. The spectrometer was calibrated with zero calibration and white tile prior to use.

2.8 Data analysis

Experiments were performed in triplicates for each batch and data was presented as mean value \pm standard deviations (SD) ($n = 3$). Significance among samples was determined by an Independent T-test at the level significance of $p < 0.05$ (IBM SPSS 25.0 software, Chicago, Illinois, USA).

3. Results and discussion

3.1 Proximate analysis

The protein content of *C. annuum* and *C. frutescens* seed powders were significantly different with values of 17.57 ± 0.28 and 16.17 ± 0.48 g/100 g, respectively (Table 1). These values were slightly higher than that of bell pepper seed flour with 14.1 g/100 g (Adeyeye, 2014), but lower than paprika seed flour with 24.23 g/100 g (El-Adawy and Taha, 2001). The fat content of *C. annuum* and *C. frutescens* seed powders were 22.24 ± 0.50 g/100 g and 17.68 ± 0.44 g/100 g, respectively ($p < 0.05$), which were lower than hot pepper seeds (23.65 g/100 g) (Zou et al., 2015) and pumpkin seeds (38.0 g/100 g) (Elinge et al., 2012). The fibre content in *C. annuum* seed powder (30.87 ± 1.59 g/100 g) was significantly ($p < 0.05$) higher than that of *C. frutescens* seed powder (24.07 ± 1.57 g/100 g). The moisture content of *C. annuum* and *C. frutescens* seed powders were 4.04 ± 0.03 and 2.87 ± 0.16 , respectively, which displayed a significant difference ($p < 0.05$). Significant difference ($p < 0.05$) were observed on the ash contents between *C. annuum* and *C. frutescens* seed powders. The ash contents of *C. annuum* and *C. frutescens* seed powders were 2.78 ± 0.08 g/100 g

and 3.73 ± 0.08 g/100 g, respectively. In addition, the carbohydrate contents of *C. annuum* and *C. frutescens* seed powders were significantly different with values of 22.49 ± 2.29 and 35.47 ± 1.14 g/100 g, respectively.

A previous study found that paprika seed powder was a good source of protein with 24.43 g/100 g of crude protein (El-Adawy and Taha, 2001). From this study, both *C. annuum* and *C. frutescens* seed powders were good sources of protein. According to Okpala and Gibson-Umeh (2013), seed powder with low-fat content cannot be considered for commercial edible purposes. Fibre is an important nutrient required for good digestion (Ogungbenle, 2003). This claim was supported by Olorode et al. (2014), who reported food with high fibre content helps in the contraction of the colon to pass by the intestine, thereby making it effective against constipation. The optimized moisture content during powder processing is $< 15\%$ (Gafar et al., 2012). This finding is due to the effect of powder quality during storage. When the moisture exceeds 15%, mould growth, agglomeration and insect infestation occur (Aziah and Komathi, 2009).

Nevertheless, the moisture content of both chilli seed powders is within the suitable range for powder making. Consequently, the shelf life is prolonged. The high percentage of ash indicates the amount of mineral in the samples (Omobolanle et al., 2014). The ash content of *C. frutescens* seed powder is higher than that of *C. annuum* seed powder, indicating a higher concentration of minerals in the former. Both chilli seed powders had significantly lower carbohydrate content ($p < 0.05$) than other seed powders, such as those of ben oil, watermelon, pear, pawpaw, and melon ($37.67\text{--}78.47$ g/100 g) (Omobolanle et al., 2014). Chilli is not considered a good source of carbohydrates compared with conventional sources, such as cereals ($72\text{--}900$ g/100 g) (Adewusi et al., 1995).

3.2 Phytic acid content

The phytic acid content of *C. annuum* seed powder (8.64 g/100 g) was a bit higher than *C. frutescens* seed powder (6.03 g/100 g) (Table 1) but considerably lower than that of pumpkin (35.06 g/100 g) seed flour (Elinge et al., 2012). Phytic acid is associated with the ability to combine with protein and some minerals (Urbano et al.,

Table 1. Proximate composition *C. annuum* and *C. frutescens* seeds powder.

Type of species	Composition (g/100 g)						
	Moisture	Fat	Fibre	Protein	Ash	Carbohydrates	Phytic Acid
<i>C. annuum</i>	4.04 ± 0.03^a	22.24 ± 0.50^a	30.87 ± 1.59^a	17.57 ± 0.28^a	2.78 ± 0.08^a	22.49 ± 2.29^a	8.64 ± 1.95^a
<i>C. frutescens</i>	2.87 ± 0.16^b	17.68 ± 0.44^b	24.07 ± 1.57^b	16.17 ± 0.48^b	3.73 ± 0.08^b	35.47 ± 1.14^b	6.03 ± 0.35^a

Values are presented as mean \pm SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p < 0.05$).

2000). In the formation of the protein–phytate complex, the functional properties of the protein will be affected by gelation, viscosity, emulsifier ability and other factors (Urbano *et al.*, 2000). According to Elinge *et al.* (2012), a low phytate content is harmless because it can act as an anticarcinogen and antioxidant (Harland and Morris, 1995). Phytate can be removed or reduced by soaking and fermentation (Harland and Morris, 1995; Urbano *et al.*, 2000).

3.3 Mineral content

Table 2 shows the Mg contents of chilli seeds in *C. annuum* and *C. frutescens* chilli seeds powder 1.89 mg/100 g and 1.87 mg/100 g, respectively. A previous study showed magnesium content in red hot pepper seeds was 4.17±2.57 mg/100 g (Simonovska *et al.*, 2016). The average values of sodium concentration in *C. annuum* and *C. frutescens* seeds powder were 1.24 mg/100 g and 1.59 mg/100 g, respectively. However, the average of orange seed flour reported by Akpata and Akubor (1999) was 6.50 mg/100 g higher compared to both chilli seed powders. There is a significant difference ($p < 0.05$) between both chilli seed powders.

Table 2. Composition of zinc (Zn), calcium (Ca), sodium (Na), magnesium (Mg), and potassium (K) of *C. annuum* and *C. frutescens* seeds powder.

Type of species	Composition (%)			
	Zn	Ca	Na	Mg
<i>C. annuum</i>	0.37±0.00 ^a	0.155±0.00 ^a	1.24±0.00 ^a	1.89±0.00 ^a
<i>C. frutescens</i>	0.25±0.00 ^b	0.109±0.00 ^b	1.59±0.01 ^b	1.87±0.00 ^a

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p < 0.05$).

In concentration of zinc, *C. annuum* seed powder had 0.37±0.00 mg/100 g whereas *C. frutescens* seed powder was 0.24±0.00 mg/100 g. There is a significant difference ($p < 0.05$) between both chilli seed powders. Calcium was found to be the least among all the minerals analysed in both of the chilli seeds powder which was 0.155±0.00 mg/100 g of *C. annuum* seeds powder and 0.109±0.00 mg/100 g of *C. frutescens* seeds powder. Both have lower values compared to red hot pepper seeds which were 0.483±1.17 mg/100 g (Simonovska *et al.*, 2016). A significant difference ($p < 0.05$) was observed between both chilli seed powders.

Minerals are important nutritional factors in many crops and have many biological activities in the human body (Zou *et al.*, 2015). Mineral contents of plants are affected by their growth conditions such as the uses of fertilisers and the state of the plant maturity during harvest (Albuquerque *et al.*, 2013). Zinc plays a role in growth and development, immune response, neurological

function and reproduction (Roohani *et al.*, 2013). The low zinc concentration in plants is due to the relatively high content of phytic acid, which inhibits zinc absorption (Gupta *et al.*, 2015).

3.4 Water and oil holding capacity

A significant difference ($p < 0.05$) was observed between the WHC of seed powders (Table 3). The average WHC and OHC of *C. annuum* seed powder were 2.25 and 0.43 g/100 g and those of *C. frutescens* seed powder were 1.40 and 0.87 g/100 g, respectively. The mean OHC values of *C. annuum* (0.43±0.08) and *C. frutescens* (0.87±0.07) chilli seed powder were lower than those in peeled (1.07±0.01) pumpkin pulp flour and unpeeled (1.36±0.05) pumpkin pulp flour (Aziah and Komathi, 2009).

Table 3. Water and oil holding capacity of *C. annuum* and *C. frutescens* seeds powder.

Type of species	Composition (%)	
	Water holding capacity	Oil holding capacity
<i>C. annuum</i>	2.25±0.38 ^a	0.43±0.08 ^a
<i>C. frutescens</i>	1.40±0.05 ^b	0.87±0.07 ^b

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p < 0.05$).

The WHC of chilli seed powders was influenced by the protein structure of the powder and the hydrophilicity of the carbohydrate (Maninder *et al.*, 2007). According to Olorode *et al.* (2014), high WHC may be due to the high protein concentrations, which reflect the ability of the protein to interact with water (Obatolu and Cole, 2000). The high hydrophilicity of the powder also increases the amount of water absorbed. However, *C. annuum* and *C. frutescens* seed powders had low WHC, indicating poor protein interaction with water. Kinsella and Melachouris (1976) and Obatolu and Cole (2000) revealed that OHC indicates the functionality of the physical entrapment of oil and the number of nonpolar side chains of proteins to bind to the hydrocarbon chains of the fatty acids. The trace amount of nonpolar side (Mirhosseini and Amid, 2013) present in *C. annuum* and *C. frutescens* seed powders could influence oil absorption.

3.5 Color content

The L* values of *C. frutescens* seed powder (68.21±0.35) were higher than those of *C. annuum* seed powder (66.17±0.35) (Table 4). However, both of these chilli seed powders displayed lower L* values than that of wheat flour (95.02±0.01). We compared these results with wheat flour to check if it is suitable to use as flour. *C. annuum* and *C. frutescens* seed powders showed a

positive a^* value or appeared reddish. The b^* values were also observed on the positive side of the scale. Therefore, *C. annuum* and *C. frutescens* seed powders appeared yellowish in colour.

Table 4. Colour composition of *C. annuum* and *C. frutescens* seeds powder

Type of species	Composition		
	L*	a*	b*
<i>C. annuum</i>	66.17±0.35 ^a	9.64±0.90 ^a	36.57±0.25 ^a
<i>C. frutescens</i>	68.21±0.35 ^b	10.03±0.18 ^b	43.43±0.18 ^b

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p < 0.05$).

Scanlon *et al.* (1993) indicated that the colour of flour depends on the extraction process, and the ideal colour is pure white. Wheat flour is white because of bran removal and the milling process (Maeda *et al.*, 2004). Dark colouration of chilli seed powder may occur during drying (Rabeta *et al.*, 2016). The high temperature during processing may cause the slight brown colour of the seed powder. The yellowish colour of the sample is caused by carotenoids (Aziah and Komathi, 2009). Gómez-García and Ochoa-Alejo (2013) demonstrated that capsanthin is responsible for the red colouration of the chilli fruit, and the yellow-orange colour is due to α - and β -carotene, zeaxanthin, lutein, and β -cryptoxanthin. Nevertheless, the drying process can cause the yellow-orange or reddish colour of the seed powder (Rabeta *et al.*, 2016). The considerable redness and yellowness values of *C. annuum* and *C. frutescens* seed powders can contribute to a more attractive powder colour than wheat flour.

4. Conclusion

Proximate analysis results showed that *C. annuum* seed flour had higher protein content, fat content, fibre content, moisture content, and only ash content which was lower than *C. frutescens*. The results of the analysis of phytic acid levels, mineral levels, zinc concentrations, and calcium levels showed that *C. annuum* seed flour had higher but lower sodium content than *C. frutescens*. The WHC and OHC values of *C. annuum* seed flour were higher than those of *C. frutescens*. The L* value of *C. annuum* seed flour was lower than that of *C. frutescens*. *Capsicum annuum* and *C. frutescens* seed flour were both positive on a^* and b^* values, however, *C. annuum* and *C. frutescens* seed flour gave a yellowish colour. These results indicate that both chilli seed flours being a good source of nutrients, are underutilized as a functional food compound.

Conflict of interest

The authors declare that they have no competing interests.

Acknowledgements

We are thankful to the Food Technology Division, School of Industrial Technology, Universiti Sains Malaysia for the support towards the research.

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