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FULL PAPER

Comparison of amino acid and chemical composition of jackfruit seed flour treatment

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Abstract

The study was conducted to analyse amino acid and chemical composition of raw jackfruit seed flours, germinated jackfruit seed flour and thermal jackfruit seed flour. The result showed that thermal jackfruit seed flour contained the highest essential amino acid composition followed by germinated jackfruit seed and raw jackfruit seeds. Amino acid leucine was the most abundant amino acid in thermal jackfruit seed flour, while lysine and phenylalanine were the highest compositions found in germinated jackfruit seed flour respectively. Thermal jackfruit seed flour enhanced the amino acid levels of histidine, threonine, valine, isoleucine and leucine. Proximate analysis showed that the ash, crude fat, carbohydrate and total dietary fiber of thermal jackfruit seed flour samples were the lowest among the three samples. The thermal jackfruit seed flour had the highest protein content (24.94%) while germinated jackfruit seed flour had the highest vitamin C content (78.78 mg/100 g). The flour composition of three different treatments showed that the starch content was highest in germinated jackfruit seed flour while energy value significantly highest in thermal jackfruit seed flour. In conclusion, thermal jackfruit seed flour contains vitamin C and also a significant amount of protein and dietary fiber.

1. Introduction

Jackfruit (*Artocarpus heterophyllus Lam.)* is a tropical fruit and widely grown in Malaysia, Indonesia, Thailand and also others neighbouring countries such as Philippines and India. The ripe fruit of jackfruit is consumed fresh or processed into products while the seeds are usually discarded as a waste. The jackfruit seed rich in carbohydrate and protein and about 8-10% of total fruit weight is the yield of seed weight. A study was done by Suresh Kumar *et al.* (1982) on jackfruit seeds; found that it contained lectin, a class of glycoproteins which has been reported to possess antibacterial, antifungal and anticarcinogenic properties. Numerous studies have been conducted to evaluate the functional and nutritional properties of jackfruit seed. A study was done by Shaiful *et al.* (2015) found that jackfruit contains 5.78% protein and 2.49% crude fibre. Madruga *et al.* (2014) analysed the starch composition of jackfruit seed and find out soft and hard jackfruit seed contains 92.8% and 94.5% starch respectively. The method of flour treatment influenced several of nutritional and functional properties of jackfruit seed flour such as fiber, sugars, fat, proteins, pectins, organic acids, antioxidants, phenols, vitamins, minerals, flavors and other bioactive substances (Reis *et al.,* 2012)

Germination techniques in seeds have drawn attention among researchers during recent years due to its unique nutritional value and health benefits. Germination process involved enzymes reaction, for example, proteinases resulted in some amino acids and peptides can be released, and the synthesis or utilization of others, to form new proteins, can occur. Therefore, the nutritional quality of proteins can be enhanced and affects the unique taste and flavour of germinated seed as well.

Thermal treatment in seed was observed some effects in proteins interaction. Heating is responsible for protein denaturation, eventually followed by aggregation of the unfolded molecules, which results in loss of solubility. Thermal denaturation involves an initial stepwise dissociation of subunits and a subsequent reassociation of only partially unfolded molecules with the formation of either soluble or insoluble complexes (Kinsella *et al.,* 1985). Plant protein is gaining a lot of interest in the food industry due to its unique properties. The fundamental property necessary for the utilisation of protein concentrates in food and forage industry is the solubility of the precipitated and dried protein powder, suitable for use from the health point of view and possessing suitable nutritional and biological values

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(Bartova and Barta, 2008).

Thus, the development of jackfruit seed flour into the varied industrial application may be considered as alternative flour and also give extra medicinal health properties benefits. In illustration of the increasing awareness of the risks associated with the consumption of saturated fats and cholesterol and increasing demand for non-animal proteins, the potential of the plant protein products is still more recognized, and it is, therefore, an objective of the invention to develop protein rich flours from germinated jackfruit seed.

2. Materials and methods

Jackfruit seeds were obtained from minimally processed jackfruit industries and some fruits were purchased from Lanchang, Pahang.

2.1 Treatment of samples

2.1.1 Raw jackfruit seed flour

The separation of seed from the pulp proceeded manually and the seeds were washed using filtered tap water. After that, the seeds were sliced using a food slicer (Hallde, Sweden) and dried in a forced draft oven (Memmert, Germany) at 60°C. The dried samples were milled into flour using a grinder (Toshiba, Japan).

2.1.2 Germinated jackfruit seeds flour

The seeds were washed with filtered tap water for three times then samples were soaked in filtered tap water and further with the germination process starting from 0 hr (no germination process) until 96 hrs. Next, the seeds were sliced into thin layers (Hallde, Sweden), dried in a forced draft oven (Memmert, Germany) at 60°C. The dried samples were milled into flour using a grinder (Toshiba, Japan) and used for the analysis.

2.1.3 Thermal jackfruit seed flour

About 150 g of jackfruit seed flour were homogenized with water and then heated to 60-80°C for 30 to 60 mins. Then the solution was separated by gravity filtration in a muslin cloth and allowed to settle for 2 hrs, and then dried in oven dryer (Memmert, Germany) at 60ºC. The dried samples were milled into flour using a grinder (Toshiba, Japan) and used for further analysis.

2.2 Essential amino acids analysis

Amino acids were extracted according to the modified method of Abe *et al.* (2000). The identification and quantification of amino acids were determined using the AccQ tag Method (Waters, USA), scanning fluorescence detector. The mobile phase consists of eluent A and eluent B. Eluent A was borate buffer while the Eluent B was 60% acetonitrile (v/v). All separation was carried out on a 4 µm AccQ. Tag C18 column (150 x 3.9 mm) at 36ºC. Analysis of amino acids was done in duplicate.

2.3 Proximate composition

The flours were analyzed, in triplicates, for moisture, crude protein, crude fat, ash using approved methods 925.10, 923.03, 920.85 and 920.87 of the Association of Official Analytical Chemists (AOAC,2000). Carbohydrate was estimated by different. Total dietary fibers were determined using AOAC Official Method of Analysis 985.29 (45.4.07) (AOAC, 2012). Vitamin C and vitamin A were analysed according to AOAC (2000).

2.4 Determination of total starch

Starch was isolated from processed flours by water steeping method and dried using the solvent exchange method as described by Badenheizen (1964) with minor modifications.

3. Results and discussion

3.1 Essential amino acid analysis

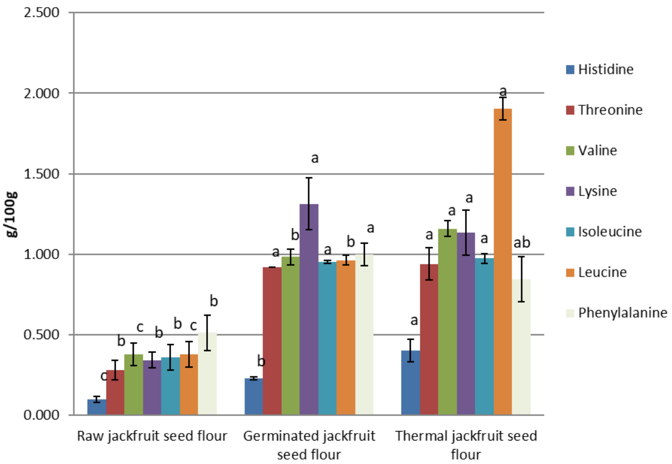

Figure 1. The essential amino acids of raw, germinated and thermal jackfruit seed flours (g/100 g crude protein) dry matter. Different letters within bars indicate significant differences (p<0.05, Tukey's HSD).

Germination and thermal treatment have significant (p<0.05) effect on the amino acid composition of jackfruit seed flour. Aspartic acid and glutamic acid were the most abundant amino acid in thermal jackfruit seed flour. According to Figure 1, the essential amino acids showed significantly increased after jackfruit seeds treated with germination and thermal process. According to previous studies on groundnut from Nigeria, United States and India (Busson *et al.,* 1968; Altschul, 1968) the amino acids which were glutamic and aspartic were the most concentrated compounds in the nuts. Germination of jackfruit seed significantly increased the amino acid

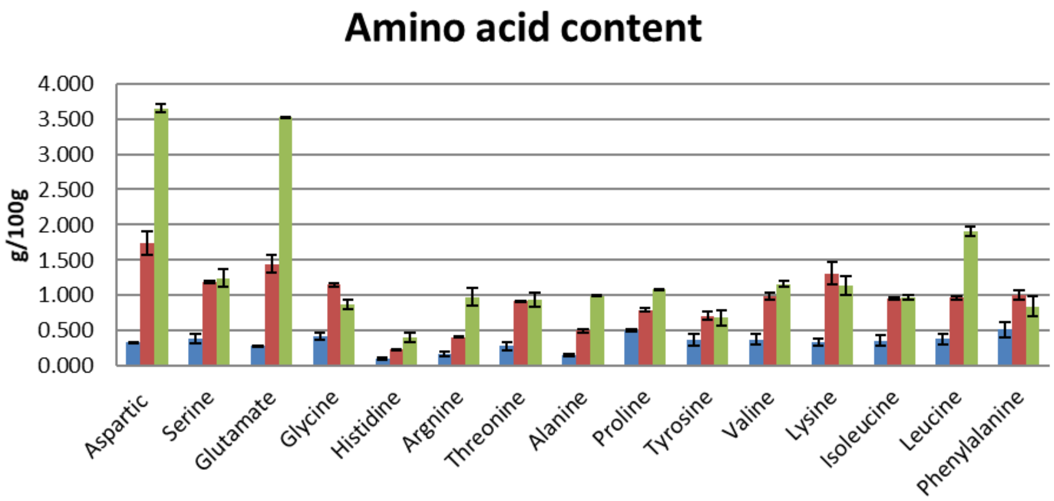

Figure 2. Amino acid profiles of raw, germinated and thermal jackfruit seed flours (g/100 g crude protein) dry matter. Blue columns indicate raw jackfruit seed flour, red columns indicate germinated jackfruit flour and green columns indicate thermal jackfruit seed flour.

lysine, which content was folded four times compared to the sample without treatment (raw jackfruit seed). For essential amino acids, histidine, valine and leucine the pattern of amino acids content in regard to concentration was thermal > germination > raw. Thermal jackfruit seed flour possessed higher amino acid content than the raw jackfruit seed flour regarding the content of aspartic, serine, glutamic, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, lysine, isoleucine, leucine and phenylalanine. The most amino acids affected by thermal processing method compared to germinated seeds were lysine and phenylalanine, which was reduced to 15%, 27%, 14% and 20%, respectively (Figure 2). Thermal treatment affected the nutritional composition of most food products, and little damage was said to be done during Maillard reactions. The profile of amino acids in groundnuts seeds has been found reduced by heat treatment, especially roasting, which reduced the amino acids namely Lysine, Arginine, Cysteine and Histidine content from 16 to 28% (Adeyeye, 2010). However, the thermal process applied in this study was thermal coagulation and defined by Hermansson (1979) as the random interaction of protein molecules, leading to the formation of aggregates that could be either soluble or insoluble (precipitates). According to Roy Chowdhury *et al.* (2017), isolation of protein from jackfruit seed have been found to increase protein quality, for example, increase amount of essential amino acids will lead to the better quality of food. Another study by Bártová and Bárta (2008) also found that protein recovery from industrial potato fruit juice had been achieved through heat coagulation, by exposing the protein isolate to the temperatures ranging from 25°C to 70°C.

Seed germination or sprouting process involves the action of endo and exoproteinases, small peptides and amino acids generated by cleavage of the storage proteins (Callis, 1995). Germination process affects amino acids composition in jackfruit seeds, as shown in Figure 2, the amino acids content increased significantly ($p<0.05$) after the germination process. All amino acids increased by germination process between 47% to 80%. Chavan and Kadam, (1989) found that unique and complex changes were reported to occur during soaking and sprouting of seeds. Kuo *et al.* (2004) found that an increase of the amino acid Lysine content happens during sprouting. An increase in proteolytic activity during sprouting is desirable for nutritional improvement of cereals because it leads to hydrolysis of prolamins and the liberated amino acids such as glutamic and proline are converted to limiting amino acids such as lysine.

From the previous study (Zuwariah *et al.,* 2017) the amino acids profile in jackfruit seeds were reduced during the first twelve hours of germination. However, in the eighteen hours, the amino acid content was started to increase and reached the optimum germination period at 24 hrs. The studied also showed that the last two period (72 hrs and 96 hrs), the amino acids profile were started to decrease (Figure 3). This is due to hydrolysis of protein at certain stages of seed germination and the amino acids produced by hydrolysis of the protein reserves are not used solely in synthesizing new components but may also be used as an energy source (Chen *et al.,* 1975).

The current findings of amino acid compositional changes fit with the previous study that found in sprouted lentil (Rozan *et al.,* 2000), coffee (Shimizu and Mazzafera, 2000) and broccoli plants (Tarasevičienė *et al.,* 2009). The variation and fluctuation in amino acids concentration within sprouting or germination process can be influenced by the second cycle of metabolism activation required for roots and shoots formation. The process involved hydrolysis of storage protein (Khan *et*

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al., 2010), mobilization of the protein from cotyledons to newly emerged shoots and roots (Rodriguez *et al.,* 2008) and metabolism activation of amino acids biosynthesis (Ruuska *et al.,* 2002)

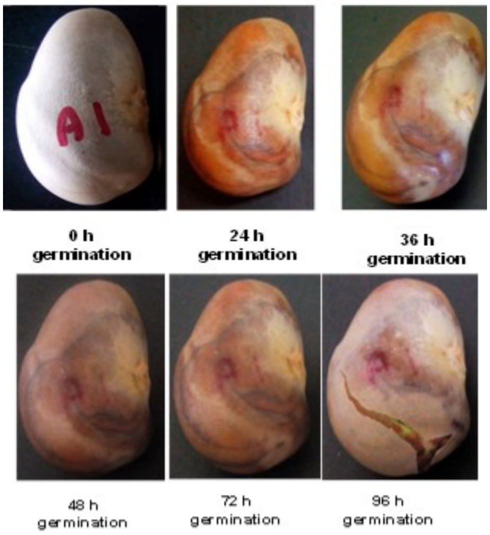

Figure 3. Jackfruit seeds germination from 0 hrs to 96 hrs.

3.2 Chemical composition

Processing treatment also affects the chemical composition of jackfruit seeds flour. The protein content of thermal jackfruit seed flour had the most significant increase (61%) compared to that in the raw jackfruit seeds flour. The increase in the protein content of thermal treatment of jackfruit seeds may be a result of protein denaturation, eventually followed by aggregation of protein, either soluble or insoluble complexes protein. The process of extracting protein from plants basically consists of an extraction step and precipitation of proteins which can be obtained by thermocoagulation (temperature action), autocoagulation (fermentation), flocculation, ultrafiltration and extraction with organic solvents (Coldebella *et al.,* 2013). However, germination treatment has no effect in protein content compared to raw jackfruit seed flour. In contrasts, Dagnia *et al.* (1992), found that germination for 6 days of *L. angustifolius* increased the protein content by about 10%. The increase in protein content after germination was also found in other legumes such as soybean, mungbean and fenugreek (Mostafa and Rahma, 1987; Sangronis and Machado, 2007). This is due to hydrolysis of protein at certain stages of seed germination and the amino acids produced by hydrolysis of the protein reserves are not used solely in synthesizing new components but may also be used as an energy source (Chen *et al.,* 1975).

Another component affects by processing treatment is dietary fiber. As shown in Table 2, a significant decline (44% decreased) in dietary fiber after the thermal process of jackfruit seeds. Azizah and Zainon (1997) also found that insoluble dietary fiber of wheat, barley and mung beans reduce significantly ($p<0.05$) while that of soya beans were increased significantly ($p<0.05$). The reduction in the insoluble dietary fiber of cereals and legumes after heat treatments were also observed by other researchers (Chang and Morris, 1990; Vidal-Valverde and Frias, 1991). On the contrary, Thed and Phillips (1995) noted an increase in insoluble dietary fiber of boiled and microwaved potatoes. They attributed this phenomenon to the formation of lignin-like substances or to chemically modified indigestible starch (resistant starch). The different results may be due to the different temperatures used by Thed and Phillips (1995). The reduction of dietary fiber in thermal jackfruit seed flour in this study was due to filtration steps of insoluble dietary fiber, to concentrate the protein content. However, the germination process did not affect the dietary fiber content compared to raw jackfruit seeds.

The amounts of starch were observed different significantly ($p<0.05$) among the three samples. Thermal treatment samples involved solubility of jackfruit seeds powder, which then turned into water thus gelatinization process indicates that it has been processed to remove the starch. When the starch granule is submitted to heat and moisture a phenomenon known as starch gelatinization may occur. Gelatinization is an irreversible process: water diffuses into the starch granule, hydrogen bonds are disrupted, the granule swells and loses shape, and amylose begins to leach (Moritz *et al.*, 2005; Coral *et al.*, 2009).

The others nutritional value affects after processing treatment was vitamin C content. The highest amount of vitamin C was found in germinated jackfruit seed flour (78.78 mg/100 g), followed by raw jackfruit seed flour (31.98 mg/100 g) and thermal jackfruit seed flour (21.71 mg/100 g). A study was done by Devi *et al.* (2015) on cowpea seeds, discovered vitamin C were also increased 37.87 times after sprouting for 24 hrs. This study was supported by another researcher such as Uppal and Bains (2012) which reported 9.4 times increase in vitamin C content after 24 hrs of sprouting. Both studies reported that by extending the sprouting period, ascorbic acid content was significantly enhanced in chickpea, cowpea and mungbean. As a result of the reactivation of vitamin C biosynthesis that undergone in the seeds (Xu *et al.,* 2005), it was observed that vitamin C is synthesized during the germination process (Bibi *et al.,* 2008). The effect of germination and thermal process on the chemical composition of jackfruit seeds flour were observed in Table 2. Thermal jackfruit seeds flour showed significantly contain higher moisture and energy value, while raw jackfruit seeds flour showed the highest value in ash, fat, and carbohydrates. The jackfruit flour composition studied by Chowdhury *et al.* (2012) reveals that the similar result variation of ash content and

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Table 2. The chemical composition of raw, germinated and thermal jackfruit seed flours (g/100 g crude protein) dry matter.

Samples	Raw jackfruit seed flour	Germinated jackfruit seed flour	Thermal jackfruit seed flour
Moisture, g/100g	3.215±0.16[b]	2.925±0.02[b]	5.985±0.11[a]
Ash, g/100g	2.75±0.04[a]	2.56±0.04[a]	2.43±0.04[a]
Protein, g/100g	9.78±0.0[b]	10.41±0.0[b]	24.94±0.08[a]
Fat, g/100g	0.56±0.01[a]	0.48±0.03[b]	0.22±0.03[c]
Dietary fiber, g/100g	25.43±0.54[a]	24.48±0.10[a]	14.33±0.04[b]
Carbohydrate, g/100g	83.68±0.13[a]	83.63±0.08[a]	76.03±0.42[b]
Starch, g/100g	55.90±0.22[b]	64.98±1.01[a]	50.97±0.29[c]
Vitamin C(mg/100g)	31.98±0.44[b]	78.78±0.18[a]	21.71±1.31[c]
Energy value, kcal/100g	429.5±0.71[b]	429.5±0.70[b]	434.5±1.84[a]

*Values followed by the same letter within the same row are not significantly different from each other ($p>0.05$).

carbohydrate except in moisture and fat content. The method used in producing jackfruit seeds flour can affects the chemical composition of flours.

4. Conclusion

In conclusion, this study indicated that there was variation in all the jackfruit seed treatments, in terms of amino acids and chemical composition of jackfruit seed flour. Thermal jackfruit seed flour gave the best results based on protein content, essential amino acids, dietary fiber and also contains vitamin C. Plant-based protein flour with essential amino acid is a fundamental factor with regard to the end use properties of the functional ingredient. Further research on the toxicology and anti-nutritional compound in jackfruit seeds are needed, in order to optimize its health benefits, for future purposes.

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