Biochemical Content of Two Sweet Potatoes (*Ipomoea batatas*) Cultivars Under Dry Heat and Moist Heat Treatment

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ABSTRACT

Sweet potatoes (*Ipomoea batatas*) is one of the important nutritious crops in Malaysia classified as high-energy and capable to sustain populations for multiple generations. The aim is to analyse and compare the composition of biochemical compounds in two cultivars of sweet potatoes under different treatments. All the readings except pH were expressed as sampled percentage and on dry mater basis. The moisture content of moist sweet potatoes ranged from 71.43 to 74.63%, whilst dry heat at 64.11-72.59%. The pH of moist heat sweet potatoes is approaching alkaline values (6.20-6.32), whilst dry heat samples are acidic (5.68 to 6.20). The crude ash (2.34 to 2.67%), crude fiber (3.25 to 3.91%), crude protein (3.51 to 3.40%), digestible protein (2.44 to 2.72), non-digestible protein (0.79-2.09) and total carbohydrates (26.57 to 16.52) content were significantly higher dry heat sweet potatoes compared to moist heat sweet potatoes. Digestible protein is significantly higher in dry heat treatment than in moist heat sample and the reverse was true for non-digestible protein. Dry heat sweet potatoes were found to be more nutritious, compared to the moist heat sweet potatoes and findings are discussed. Orange fleshed sweet potato cultivar is more nutritious compared to Purple fleshed cultivar, under dry heat treatment and also under moist heat treatment; albeit at some lower degree. The amount of biochemical compositions in sweet potatoes is seen to be influenced by cultivars, heat treatment, geographical location, climate, weather and terrestrial factors when compared with data elsewhere.

KEYWORDS: Sweet potatoes; Biochemical compounds; Heat and moist dry

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INTRODUCTION

Sweet potato (*Ipomoea batatas*) or locally known as *Ubi Keledek* is an extremely important crop in many parts of the world which can sustain the growing population for many generations. It is being cultivated in more than 100 countries including Malaysia (Loebenstein, 2009), for its cheap source of carbohydrate, protein and minerals and considered as one of the most nutritious vegetables in the world. They are grown commercially and consumed widely in Malaysia as part of the main ingredient for making cakes, puddings and traditional Malay cakes and sweets. It is a native American root vegetable, a warm-weathered vegetable that requires a long frost free season, easy to cultivate and more nutritious than the native yam of Africa and Asia (Campbell, 2014). The potato skin texture can be smooth or rough; whilst the colour can be yellow, orange, dark red, brown, purple and beige. The flesh ranges from beige to white, to red, to pink, to violet, to yellow, to orange and purple (Abidin, 2004). Interestingly, some cultivars are also grown as ornamental plants (James, 2014).

This plant reproduces in tree ways; which are from seed, actual storage root or from the plain vine and can even be vegetative propagated. The crop can be harvested in 3-4 months, in the form of mature large useful tuber. The edible tuberous root is long and tapered with some varieties being wide and tapered.

The most common way to cook this tuber is boiling it in hot water, steaming, frying in hot oil or baking in oven or microwave. Sweet potato has been found to be rich in carbohydrate and beta carotene (Fresco & Boudion, 2002). In addition, Vitamin C, Vitamin B complex, Vitamin E, and also minerals such as Fe, Ca and K were reported by Mateljan Foundation, (2014) and rich in anti-oxidants (Amir *et al*.,2016).

Most of the past studies had analyzed the composition of macronutrients and micronutrients in sweet potatoes. However, there have not been any studies on steamed or oven dried sweet potatoes with regards to its biochemical composition. Furthermore, in Malaysia, sweet potatoes are usually steamed or fried before they are consumed which is believed to affect the nutritional composition. The preparation method is considered critical where optimum nutritional value should be preserved and the best method adopted.

Biochemical analysis with regards to this study will focus specifically on the carbohydrates, protein, fat, fibre and crude ash content. It is anticipated that different cultivars may have different biochemical content concentration. Thus, in this study, two antioxidant rich cultivars (Chad, 2013 & Amir *et al*. 2015) were selected which are the purple cultivar, noted for its high anthocyanin content (Philipott *et al*. 2004 & Deroles, 2009) and the orange flesh Vitato, which is the most popular in the market and contains high amounts of beta carotene (Sakamoto *et al*., 1987 & Yamakawa *et al*., 1997). This study aimed to determine and compare the composition of nutritional values in two different cultivars of sweet potatoes under dry heat and moist heat treatments. The findings of this study is expected be used as a guideline in selection between the two cultivars and whether to dry heat or moist heat cooking methods is better in order to gain its maximum benefits.

STUDY SITE METERIAL AND METHOD

The sites were chosen based on the availability of the samples and must be BRIS derived soils (Beach Ridges Interspersed with Swales), since this is the soil type widely cultivated with sweet potatoes in the east coast of Peninsular Malaysia. One site was located at Pasir Putih, Kelantan and the other at MARDI Research Station in Telong, Bachok, Kelantan, and approximately 18 Km apart. BRIS soil originates from sediment or sand from the sea that accumulated due to tidal movements and erosion process (Nossin, 1964). According to Ministry of Agriculture of Malaysia, (1993) this soil belongs to the order Spodosols. The topsoil texture is dominated by 97-98% sand fraction, with less than 3% clay fraction. This soil is highly nutrient deficient, too sandy, weakly structured, low water retention capability and acidic in nature (Amir & Wan Rashidah, 1992 Amir, *et al*. 1993, Amir, 1999, Marlia *et al*., 2004).

METHODOLOGY

Two sweet potatoes cultivars, the orange-fleshed sweet potatoes (Vitatio) and purple fleshed potatoes (All purple) were randomly collected from the farm of 2-ha, both approaching 4 months old and ready for harvesting. A minimum of 50 tubers were sampled from each plot. The orange fleshed sweet potatoes were from Pasir Puteh, Kelantan while purple-fleshed sweet potatoes were from Bachok, Kelantan. Both samples were washed thoroughly with distilled water to remove all soiled materials, air dried and weighed before being peeled and sliced into 0.5 cm to 0.8 cm thickness and subjected to dry heat and moist heat treatment. The dry heat samples were incubated in oven at temperature of 50°C to 60°C for 3 days. The dried sample was then grounded and kept in desiccators for further analysis. The other set of samples were steamed for 30 minutes, using a steamer and temperature set at 100°C. The samples were incubated in oven at temperature of 50°C for 4-5 days. The dried sample was grounded and kept in desiccators for analysis.

The Ash content was determined using the method described by Muller and Tobin (1980) and that of Eze and Agbo (2011). Crude fat was analysed using Soxhlet method, pioneered by Soxhlet (1987) and modified by Buddhi, (2009), which shortened the extraction time and extraction efficacy. Crude fibre reading was adopted from Gerhardt (2011) and crude protein reading using the classic method developed by Kjedahl (1883); whilst digestible protein availability was analysed using Bradford assay (1976); carbohydrate by subtraction as illustrated by Merrill & Watt (1973), FAO, United Nation, (2003) and by Amir, *et al*. (2013). In addition, moisture readings were taken from both the cultivars using evaporation method as described by Sneha *et al*. (2012) and pH reading using Hanna pH meter from USA, calibrated at 4.0, 7.0 and 10.0; all set at 25°C

RESULT AND DISCUSSION

It can be seen that the Vitatio cultivar is superior to All purple cultivar in all biochemical compounds content investigated except, carbohydrate (Table1). In terms of preference for energy supply, the All purple cultivar is more superior to Vitatio cultivar, where the content of carbohydrate is one to one and a half fold higher. The amount of carbohydrate recorded in Vitatio is 15.87-16.52%, whilst as much as 20.20-26.57% was found in the All purple (Table 1). Furthermore, the All purple cultivar is rich in vitamins (Anonymous, 2013), and has high anti-oxidant activity (Amir *et al*. 2016) compared to Vitatio cultivar.

Crude fat content is higher in dry heat samples compared to moist heat samples for both cultivars, indicating that moist heat treatment (steaming) reduces the fat content, believed to be due to dilution process, which is leached away into the cooking liquid as the enzymes were degraded and destroyed (Schneider, 1985). The content of crude fat from this study is in agreement with those of Meludu (2010) and Jonathan et al. (2012), of less than 1% but in contrast Mateljan Foundation (2014) placed a figure of 5%. The huge difference is believed to be due to sweet potato cultivar, weather, climate and terrestrial factor as one main dominating issue (Abubakar *et al*. 2010).

Protein from plant sources are considered incomplete (Lehman, 2016 & Anne, 2016), where some amino acids may be found to be missing, and choosing a combination of plant sourced protein is essential to get complete essential amino acids, particularly for the vegetarians. Animal source protein is considered a complete source of essential amino acid. It is interesting to note that, five potatoes will be able to satisfy all the essential amino acids required and as recommended by World Health Organisation (Anonymous, 2008). In fact, Purcell *et al*. (1978) isolated eight essential amino acids from sweet potato, except valine and found lysine to be abundant, but all are below the FAO recommended level (Burton, 1965, Purcell et al., 1972). Furthermore, Purcell, *et al*. (1978) also isolated eight non-essential amino acids, except Asparagine, Glutamic acid and Glutamine, but most of these amino acids are deficient in sulphur fraction, thus limiting its nutritional value (Purcell *et al*, 1972).

The amount of crude protein isolated in this study is significantly superior in the dry heat samples of both cultivars in comparison to their corresponding moist heat samples of 3.51% vs 3.18% in Vitatio cultivar and 3.40% vs 3.04% in all purple cultivar. This is a clear indication that protein is lost when subjected to moist heat treatment, where it may be leached and accumulated in the cooking liquid (Cindy, 2016); whilst, dry heat treatment preserved it all. The same phenomenon can be seen in the digestible protein, where dry heat sample had a value of 2.72%, and after undergoing moist heat treatment the digestible protein value reduced to 1.09% (60% loss) in Vitatio cultivar.

Table 1: Analysis of Variance (ANOVA) of Biochemical Analytical results of two sweet potato cultivars within means and between means of moist heat and dry heat samples, expressed as percentage (%) sampled and some selected physical analyses.

Biochemical Compound/ Physical Analyses	Orange Sweet Potato (Vitatio)		Purple Sweet Potato (All Purple)	
	Dry Heat	Moist Heat	Dry Heat	Moist heat
Crude Protein	3.51±0.07a	3.18±0.11b	3.40±0.15a	3.04±0.13b
Digestible Protein	2.72±0.01a	1.09±0.01b	2.44±0.04c	1.06 ±0.01b
Non-digestible protein	0.79±0.01a	2.09±0.01b	0.96±0.01a	1.98±0.01b
Carbohydrate	16.52±0.73c	15.87±1.47c	26.57±2.96a	20.20±1.46b
Crude fat	0.81±0.08a	0.65±0.03b	0.32±0.09c	0.15±0.04d
Crude Fibre	3.91±0.05a	3.67±0.06b	3.25±0.03c	2.94±0.03d
Crude Ash	2.67±0.23a	2.00±0.21c	2.34±0.23b	2.23±0.21bc
Moisture Content	72.59±0.73ab	74.63±1.33a	64.11±2.84c	71.43±1.40b
pH	5.68±0.09c	6.20±0.02b	6.28±0.03a	6.32±0.01a

However, in All purple cultivar, a loss of 57% was noted where the reduction was from 2.44% to 1.06%. The steaming process, where the sweet potatoes are without skin, may have expanded and enlarged the pore sizes and leached away the protein since it is soluble in water. However, non-digestible protein retainment is significantly high in moist heat samples of both cultivars, where 2.09% is noted in Vitatio and 1.98% in All purple cultivar. In contract the amount in dry samples of Vitatio is only 0.79% and 0.96% in All purple. The large amount of indigestible protein remained in the moist dry treatment may suggest that these proteins are not water soluble or the heat used (100°C for 30 minutes) may not be long enough to dissolve the remaining protein. In contrast, dry heat (50-60°C for 3 days) is found to be efficient to convert most crude protein into digestible protein, where only 0.79% (23%) is noted to remain in Vitatio and 0.96% (28%) in All purple samples.

Based on this study the crude protein content of Vitatio and All purple cultivars showed no significant difference, with 3.51% and 3.40% recorded for dry heat and 3.18% and 3.04% for moist heat, respectively. These results are closer to the figure of 2.27 % from Abubakar et al. (2010), under boiling treatment. These results differ from those of Ingabire & Hilda (2011), where under raw state their figures were 0.71-0.91%, Johnathan *et al*. (2012), with a figure of 7.6% under raw treatment (two-fold of this study) and that of Meluda (2010), where toasted granule sweet potato yielded 1.76%, boiled 1.65% and raw 1.65% (half-fold of the current study).

On dry weight basis, protein content of sweet potatoes from United States and Japan were reported to be over 9%, but world-wide from 2.46-11.8% (Juritz, 1921, Cooley, 1948, Darlow et al.

1950, Murthy & Swaminathan, 1954; Crosby & Donald;1964, Purcell et. al. 1972). The current study, involved Vitatio and All purple cultivars grown on Spodosols, expressed on dry weight basis, having a figure of 9.47% and 12.81% for dry heat treatment and 10.64% and 12.53% for moist treatment, respectively (Table 2). The differences in the results obtained world-wide may be attributed to the type of cultivars used, weather and climatic conditions, geographical location and terrestrial factor (Abubakar *et al*., 2010).

Dry heat samples of both cultivars are superior in biochemical content than their corresponding moist heat treatment, suggesting that dry heat samples is preferred over the latter and this result is equally shared by Bernhardt & Schlich (2006). Dry heat treatment has been found to be able to preserve the biological nutritional concentration of sweet potatoes compared to moist heat treatment. However, it must be noted that high temperature of 130°C for a period of 10 minutes has been shown to reduce the protein digestibility (Oste, 1991). This study may open a new avenue on how best sweet potato should be prepared to get total goodness from it. However, the choice of cultivars may have some effect on the objective. The orange maybe good for diet control since it is low in carbohydrate, rich in protein and low in fat and rich in fibre and high in moisture content (Tables 1 & 2). The All purple is noted for its high carbohydrate content, moderate in protein, fat, fibre but rich in nutrient and anti-oxidant and should be suitable for distribution to poverty stricken areas.

Table 2. Analytical results of orange fleshed sweet potato (Vitatio) and all purple fleshed sweet potato as sampled and on dry matter basis expressed in percentage (%).

	As Sampled Percentage (%)				Percentage (%) on Dry Matter Basis			
Sweet Potato Cultivar	Vitatio (Orange)		Purple (All Purple)		Vitatio (Orange)		Purple (All Purple)	
Treatment	Dry Heat	Moist Heat	Dry Heat	Moist Heat	Dry Heat	Moist Heat	Dry Heat	Moist Heat
Crude Protein	3.51	3.18	3.40	3.04	12.81	12.53	9.47	10.64
Digestible Protein	2.72	1.09	2.44	1.06	9.92	4.30	6.80	3.71
Non-digestible Protein	0.79	2.09	0.96	1.98	2.89	8.23	2.67	6.93
Carbohydrate	16.52	15.87	26.57	20.20	60.27	62.55	74.03	70.70
Crude fat	0.81	0.65	0.32	0.15	2.95	2.56	0.90	0.54
Crude Fibre	3.91	3.67	3.25	2.94	14.26	14.47	9.06	10.29
Crude Ash	2.67	2.00	2.34	2.23	9.47	7.88	6.52	7.81

CONCLUSION

Based on this study, the moisture content of moist sweet potatoes ranged from 71.43 to 74.63%, whilst dry heat at 64.11-72.59%. The pH of moist heat sweet potatoes is approaching alkaline values (6.20-6.32), whilst dry heat samples are acidic (5.68 to 6.20). The crude ash (2.34 to 2.67%), crude fiber (3.25 to 3.91%), crude protein (3.51 to 3.40%), digestible protein (2.44 to 2.72), non-digestible protein (0.79-2.09) and total carbohydrates (26.57 to 16.52) content were significantly higher dry heat sweet potatoes compared to moist heat sweet potatoes. It is interesting to note that digestible protein is significantly higher in dry heat treatment than in moist heat sample and the reverse was true for non-digestible protein. Dry heat sweet potatoes were found to be more nutritious when compared to the moist heat sweet potatoes and their findings are discussed. Based on the overall data, Orange fleshed sweet potato cultivar (Vitatio) is found to be more nutritious compared to Purple fleshed cultivar (All purple), under dry heat treatment and also under moist heat treatment; albeit at some lower degree. Based on this study, the amount of biochemical compositions in sweet potatoes is seen to be influenced by cultivars, heat treatment, geographical location, climate, weather and terrestrial factors when compared with data elsewhere.

This current study opens a new avenue for research endeavours covering in-depth future research into sweet potatoes to cover all the available potato cultivars in Malaysia and the world at large. The future research should also study in-depth into the types and quantities of amino acids (protein), carbohydrate, fat and presence of other biological minerals. In addition, the best cooking method to be adopted for sweet potato, either using dry heat, moist heat, microwave oven, conventional oven, direct heat, direct boil, with or without skin needs to be identified. Other parameters to be closely monitored are time frame and temperature usage. The current study reveals an interesting issue in which the amount of digestible protein in the sweet potato is governed by heat and time frame and may influence its total availability.

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