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The Effects of Different Extraction Temperatures of the Screw Press on Proximate Compositions, Amino Acid Contents and Mineral Contents of *Nigella sativa* Meal

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ABSTRACT

Nigella sativa L. is from genus *Nigella* L. of the family Ranunculaceae which originated from Mediterranean Sea. This seed is very beneficial for human health as they contains a lot of nutrients. The extraction of *N. sativa* seed using Komet screw press produced oil and also *N. sativa* Meal (NSM). This study focuses on the *N. sativa* meal which is actually a residue from the extraction of *N. sativa* seeds and is believed to contain nutrients that are not fully extracted into the oil yield. The main focus of this work was to study the effect of different temperature applied on the extraction of *N. sativa* seeds on the proximate compositions of the NSM. This work also reported on the effect of different extractions temperature applied on the amino acid content and mineral content of NSM. Result obtained showed no significant difference among the proximate compositions, amino acids contents and mineral contents of NSM at different extraction temperature applied. It means that, different temperature does not really affect or influence the value or content of proximate compositions, mineral and amino acid in NSM. Only a few nutrients in NSM, which are affected with the different extraction temperature applied such as methionine and cysteine which showed a significant different between cold temperatures and hot temperatures applied. Therefore, it means that these two amino acids are sensitive to heat. Based on the result, it also showed that this NSM is high with proximate compositions especially the protein and carbohydrate, also high in amino acid content and mineral content, therefore, NSM is seemed to be as a potential source of nutrients for animal feed in replacing the soybean meal which is more expensive than this seed.

Key words: Extraction temperature, *N. sativa* seed meal, proximate composition, amino acid content, mineral content

INTRODUCTION

Nigella (*Nigella sativa* L.) known as black cumin is an annual herbaceous plant belonging to the Ranunculaceae family. These plants are native to Mediterranean Sea region (Adamu *et al*., 2010) The plants may stand up to 16-24 inches tall, with light-coloured foliage and annual white-petal flowers, yielding sharp-cornered rectangular seeds (approximately 3 mm long). In Egypt, people often use the *N. sativa* seeds for external uses such as to protect the skin and to aid digestion. In Persia, *N. sativa* seeds are used to stimulate the energy of the body and help to recover from fatigue. These seeds have the ability to detoxify and also has the anti-bilial effects which can help to treat the respiratory dysfunction (Wu *et al*., 1999). These seeds also have other important advantages, where it shows the anticancerous activity and also effective against Dalton's lymphoma ascites cells (Shah *et al*., 2006).

The seeds of *N. sativa* are believed to acquire good health for human being and also can be used to treat diseases such as, common cold, headache, fever, asthma, rheumatic diseases and also can be used to remove worms from intestines and also to treat various microbial infections. These are also important for kidney, hypertension, bladder, liver function, circulatory and also can be used to support immune system. These seeds were traditionally and frequently used by the people especially in Middle East and some Asian country in folk medicine (Al-Naqeep *et al*., 2009; Tasawar *et al*., 2011).

Nigella sativa seeds often used to feed animals (Al-Beitawi and El-Ghousein, 2008; El-Bagir *et al*., 2006). Since, the *N. sativa* seeds can be extracted to produce oil and meal, therefore, the meal of this seeds is seemed to be as an advantage in replacing the *N. sativa* seeds itself to feed the animal. This is because the NSM also contain high level of crude protein (33-84.6%) and crude fibre (54.5%) (El-Nattat and El-Kady, 2007; Zeweil *et al*., 2008). The use of NSM to replace the *N. sativa* seeds for animal feeds really help in improving the economic efficiency. There were many others example of seeds meal that had been used as animal feeds instead of using the seeds themselves to feed the animal, such as soybean meal (Wongputtisin *et al*., 2007; Kabir *et al*., 2002) rapeseed meal (Gasim-Boubaker *et al*., 2007; Riyazi *et al*., 2008), sunflower meal (Fernandez *et al*., 2003) etc., NSM is a by-product of *N. sativa* oil production which really important to be analyzed for its contents (e.g., proximate analysis, amino acid contents and mineral contents) in order to identify the suitability of it, to be utilized as animal feed and even for human consumption.

N. sativa seeds meal can be used as a protein-rich-meal as animal feed and fertilizers for plants. Zeweil *et al*. (2008) stated that NSM can be used to replace the imported Soybean Meal (SBM) and reduce the cost of rabbits feeding. They have recommended to use NSM as a rabbits feed, as a non-traditional source of plant protein without harmful effects on its growth performance, kidney or liver function. NSM could be used as a basic ingredient in formulation of feed-diet for growing lambs without any adverse effects, thus, helping in reducing feed costs and more importantly increase economic efficiency of local industries (Abdel-Magid *et al*., 2007).

Screw press method is an age old technique or method used in many countries, for example the United States since 1930 until 1950 have used this method in extracting the oilseeds from vegetables or fruits (Bredeson, 1978). This method has been developed in various designs and produces the highest oil yield with best quality of oil (Singh and Bargale, 2000). Mechanical screw presses can recover 86-92% of the oil from oil seed. The screw press method is economical, technically less extensive compared to solvent extraction method and is less labour-intensive than the aqueous method of extraction (Oyinlola *et al*., 2004).

Nigella seeds can be extracted using the screw press machine to produce oils of about 32-40% and also residual meal rich in macro (protein, fibre, mineral) and micronutrients (vitamin and minerals). In the present study, effect of different extraction temperatures of screw press on proximate compositions, amino acids and mineral content in NSM were evaluated.

MATERIALS AND METHODS

Preparation of *N. sativa* seeds meal: *N. sativa* seeds were extracted using screw press machine (D 85-1G IBG, Germany) at different temperatures. The seeds were pressed at 50, 60, 70, 80, 90 and 100°C with nozzle size 6 mm and speed of screw at 21 rpm. The crude oil obtained was kept in amber bottle and flushed with nitrogen gas prior to storage in freezer (-18°C) until further analysis. The seed meal wad grinded using warring blender and kept refrigerated (+4°C), packed in a vacuum plastic, until further analysis.

The meal obtained was weighed and calculated with the formula:

$$\text{Meal yield (\%)} = \frac{wo}{ws} \times 100$$

where, wo is weight of residual meal and ws is weight of samples

Proximate analysis: The moisture content of seed meal was determined by oven-drying method (945.38 B) (AOAC, 2000). The protein content were determined with Kjedahl method (979.09) (AOAC, 2000) while the crude fat content was estimated with Soxhlet extraction method (945.38 F) (AOAC, 2000). Ash content of the seed meal was determined by using the dry ash method (900.02A) (AOAC, 2000). The crude fibre content of the seed meals was carried out using AOAC (2000) method (945.38 D), while the carbohydrate of *N. sativa* seed meal was calculated by subtracting the total of protein, fat, moisture and ash from 100 (Cheikh-Rouhou *et al.*, 2007; Barminas *et al.*, 1999).

Amino acid profile of *N. sativa* seeds meal: The samples were hydrolysed in triplicate with 6N HCl at 110°C for 24 h and derivatized with AccQ reagent (6-aminoquinolyl-N-hydroxysuccinimdyl carbamite) (Cohen, 2000). The chromatographic separation was carried out using an AccQ Tag™ reversed phase (3.9×150 mm) analytical column (Waters®). Theamino acid analysiswas performed on a HPLC system consisted of waters 1525 binary HPLC pump, 717 plus autosampler (Waters®) and waters 2475 multi λ fluorescence detector (wavelength excitation 250 nm, emission 395 nm). Chromatographic peaks were integrated, identified and quantified using Breeze™ software version 3.20 by comparing it to the known standards (Amino acid standard Pierce and Rockford, Illinois). Methionineand cystiene were determined from the same method of acid hydrolysis after treatment using performic acid oxidation. Triptophan was analyzed in this study using alkali hydrolysis. All amino acids analysis was done in Biology school of Universiti Sains Malaysia.

Mineral content of *N. sativa* seeds oil and meal: Some of the minerals content of *N. sativa* seeds oil and meal present such as sodium, calcium, mangan, nickel, cuprum, cadmium, iron, lead and zinc were analyzed by with Perkin-Elmer Analyst 100 with Induction Coupled Plasma Atomic Emission spectroscopy (ICPAES) (AOAC, 1990). The sample (oil was 1 g and meal 0.5 g) was digested (ETHOS 900 milestone, microwave lab station) with 6 mL concentrated nitric acid and 1 mL acid peroxide (30%) until a transparent solution was obtained. The instrument was calibrated with known standards and the samples were analyzed at corresponding wavelengths.

Statistical analysis: ANOVA and Tukey's test (Post Hoc test) were used to determine the optimum condition machine of screw press, physicochemical and antioxidants properties of *N. sativa* seeds oil and meal among the six different extraction temperature at the 5% significance level were presented as Mean±standard deviation (Mean±SD). Statistical analysis was conducted using SPSS 12.0 for windows (Pallant, 2005).

RESULTS AND DISCUSSION

Effect of pressing temperatures on the proximate composition of *N. sativa* seeds meal: *N. sativa* seeds are reported to be a good source of protein and nutrients (Takruri and Dameh, 1998). The NSM could be used as a relatively good source of energy and protein supplement due to its high protein content and could also be used as alternative food and protein supplement for human diet (Akhtar *et al*., 2003). Requirements for food applications of seeds should have the following characteristics; health benefits, safety for long term consumption, cost effectiveness, stability during storage, food formulating and processing with minimized damage on sensory evaluation of the food products (Parry *et al*., 2008).

El-Nattat and El-Kady (2007) reported NSM to contain essential amino acid and crude protein of about 33%. In this study, the meals from *N. sativa* seeds were characterized for proximate composition, mineral profile and amino acid contents. The analyses reported the characteristics of *N. sativa* seeds meal pressed at six different temperatures.

Table 1 shows the result on the effects of different extraction temperatures on proximate composition of NSM. From the result, it is clear that, the crude protein from NSM increased as the temperature increased with the highest crude protein recorded was at 100°C (31.48%) and lowest at 60°C (27.23%). Kjedahl method representation of the crude protein content caused this in the meal and the seeds since nitrogen also come from non-protein nitrogen and measures total organic nitrogen. Protein was stable with relation to temperature but non-protein nitrogen increased as the temperature rose (Howell and Cartter, 1958). The similar result was also found by other researchers in their study on soybean meal, where they found the crude protein in soybean meal to be increased with the increase of temperature (Piper and Boote, 1999; Wolf *et al*., 1982; Dornbos and Mullen, 1992; Gibson and Mullen, 1996).

Based on the result obtained, (Table 1) at temperature of 80 and 100°C, higher value of crude fat content were recorded in NSM which were 23.52±3.74 and 24.68±2.97, respectively and these two temperatures is under the category of hot temperature. This result supported the previous theory mentioned where; crude fat content in meal increases with the increase of temperature. However, at 90°C the value of crude fat content is quite low. Similar trends were observed at the value of crude fat content at 70°C where the value recorded is lower than the value of crude fat content recorded for temperature below than 70°C. This result not really supports the theory of crude fat value increase as the temperature increases. However, this might be due to the pressing condition or other factors that influenced this to occur. As, Leming and Lember (2005) stated that differences between protein and fat content are caused by various pressing and conditions during processing which influence the effectiveness of oil removal and thereby also the nutrient content and value of meal cake from rapeseed.

Some researchers also mentioned about the influences of some factors (such as the method used for the extraction of the essential oil of herbs and chemical compositions of the extract and culinary herbs or seeds) on the outcomes of a test which are actually depending on the geographical and climatic different of where the seeds had grown (Erener *et al*., 2010).

The value of crude fat from NSM (Table 1) showed that the value of the crude fat recorded from the temperature of 50°C until 100°C to be not significantly different, which means that the value recorded is close to each other. It also means that difference in temperature applied slightly changes the crude fat of the NSM recorded. During pressing process of the *N. sativa* seeds, the oil content oozed out from the seed and this might have influenced the percentage of crude fat content

Table 1: Comparison proximate analysis of *N. sativa* meal (NSM) pressed at different temperatures

Temperatures (°C)	Moisture (% wb)	Protein (% wb)	Ash (% wb)	Crude fat (% wb)	CHO (% wb)	Crudefibre (% wb)
50	7.33±0.15^{d}	28.61±2.58^{a}	5.65±0.60^{ab}	19.38±2.14^{a}	39.02±4.69^{a}	22.58±0.54^{a}
60	7.20±0.17^{d}	27.23±5.61^{a}	5.93±0.14^{ab}	19.86±1.38^{a}	39.77±4.53^{a}	23.20±0.71^{a}
70	6.66±0.35^{cd}	29.03±1.44^{a}	4.87±0.78^{a}	18.36±0.94^{a}	41.08±1.97^{a}	26.28±2.91^{a}
80	6.19±0.07^{bc}	30.06±2.69^{a}	5.85±0.20^{ab}	23.52±3.74^{a}	34.39±4.78^{a}	22.62±1.47^{a}
90	5.81±0.39^{ab}	30.07±3.20^{a}	6.15±0.22^{b}	20.71±1.62^{a}	37.26±3.67^{a}	23.37±0.54^{a}
100	5.19±0.46^{a}	31.48±2.43^{a}	5.57±0.32^{ab}	24.68±2.97^{a}	33.08±0.40^{a}	23.77±2.11^{a}

Means with common superscript in the same column are not significantly different for each other (n = 3±s.d.) At $p<0.05$. CHO: Carbohydrates, Wb: Wet basis

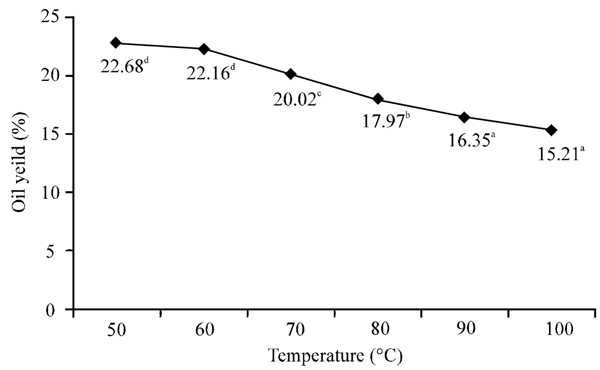

Fig. 1: Percentage of oil yield from *N. sativa* seed pressed at six different temperatures, Mean values with different letters are significantly different ($p<0.05$) (n = 3±s.d.)

recorded in the meal produced. Theoretically, as more oil oozes out from the seed, this results in, the crude fat content to be lower in NSM (Wolf *et al*., 1982).

From Fig. 1 which shows the graph of the relationship between percentages of oil yield with different extraction temperature, it shows that, the oil yield decreased with the increase of temperatures. The result of the graph had been supported with the graph obtained for the relationship between percentages of meal yields with different extraction temperature, where as can be seen from the graph obtained in Fig. 2, the percentage of meal yields increase with the increase of temperature. Therefore, it means that; when the oil yield lower or decreases, the NSM produced will be increase or higher, thus result the fat that come out in oil yield will be reduced as the crude fat is more in NSM.

However, it must be noted that, the value of crude fat content recorded for all temperatures is not significantly different, which means that the different between those values are not too far eventhough, different extraction temperature had been applied. Therefore, one thing to be highlighted here is that, the temperature between 50°C until 100°C that was applied to the extraction of *N. sativa* seeds not really influence the changes of crude fat content in NSM that had been produced.

Based on previous study on soybean seeds, the researchers had found that, the value of crude fat in soybean seeds was increased with increase in temperatures (Chapman and Robertson, 1977).

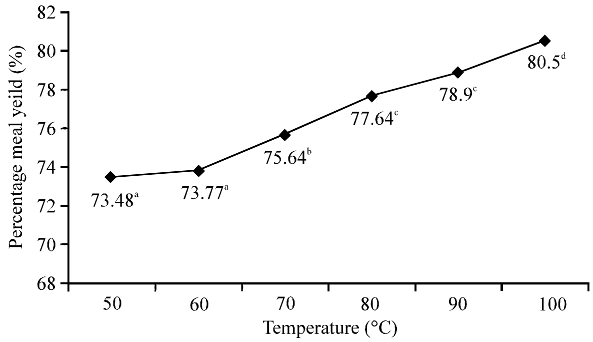

Fig. 2: Percentage of meal yield from *N. sativa* seed pressed at six different temperatures, Mean values with different letters are significantly different ($p<0.05$) (n = 3±s.d.)

Wolf *et al.* (1982) found that in soybean seeds, crude protein and fat content increased when the temperature was increased and there was a positive correlation between protein and fat. At temperature of 50 and 60°C, the crude fat content in NSM was lower compared to at other temperature. These two temperatures provide a suitable condition for oil to be oozed out more. Since, the amount of oil that oozed out is higher, it means that the crude fats already come out in the oil, result the value of crude fat to be higher in the oil compared to NSM. This statement is supported by the graph obtained, which can be seen at Fig. 1 and 2, where Fig. 1 shows that, the oil yield is high in lower temperature and getting decrease when the temperature rise. While, Fig. 2 shows the NSM was decreased at lower temperature and getting increase as the temperature increases. This also showed that the percentage of oil and meal yield was inversely proportional.

The moisture content decreased from 7.33% (50°C) to 5.19% (100°C). The moisture content at 50°C (7.33%) was similar with value at temperature 60°C (7.20%) and this value was significantly different ($p<0.05$) with moisture at 100°C (5.19%) (Table 1). Moisture contents may be greatly influenced by storage conditions after harvest. However, as all the seeds were stored in the same place under the same conditions, any different temperature probably would be noticeable (Wolf *et al.*, 1982). Moisture content loss is evident with extraction temperature. Ash content from NSM at 70°C (4.87%) was lowest and significantly different with the temperature at 90°C (6.15%).

Carbohydrate of NSM increased from temperature 50°C (39.02%) to 70°C (41.08%) and decreased at temperature 100°C (33.08%). The values were not significantly different with increase in temperature. The result obtained for crude fibre of NSM also was not significantly different with increasing temperatures. The crude fibre increased at temperature 50°C until 70°C (22.58-26.28%) and decreased at temperature of 80°C (22.62%) and increase again at temperature 90-100°C (23.37% and 23.77%, respectively). As, it has been mentioned, the decline of carbohydrate content and crude fibre content in NSM was not significantly different ($p<0.05$) with increase in temperature, therefore, it means that, the change in temperature does not really effect the value of carbohydrate and crude fibre recorded in NSM produced. The major thing to be noted is that, the percentage of carbohydrate and crude fibre is quite high in NSM and thus renders NSM to be a good source of carbohydrate and fibre as a feed for livestock.

Leming and Lember (2005) found that crude protein and crude fibre was substantially low in cake produced at lower temperature compared to the cake produced at higher temperature but crude fat was higher. Different factor caused different contents of meal seeds and this includes processing technology and condition, type of oil press, temperatures and humidity during processing, etc. The finding of these researchers mentioned regarding the crude protein and crude fibre content in cake was similar to the one that had been obtained from this study.

Cake residue (meal) from oil extraction of *N. sativa* seeds can be used as animal feed because the seed contains high protein, fibre and antioxidant which can improve the nutrient quality of animal feed and also can be used as an alternative to replace soybean meal (Zeweil *et al*., 2008). Soybean meal is quite expensive, therefore, the introduction of NSM which is cheaper than soybean meal can be advantageous as, especially to improve economic efficiency (Abdel-Magid *et al*., 2007). These facts indicate that the oil extraction of *N. sativa* seed to be not suitable at high temperature since at a very high temperature all the nutrients can be reduced or destroyed thus, resulting in the low quality of expressed oil and deoiled cake (Mrema and McNulty, 1985).

Effect of pressing temperatures on the amino acid content of *N. sativa* seeds meal: Table 2 shows the amino acids composition of *N. sativa* meal divided into two categories, essential amino acids and non-essential amino acids (recorded at different extraction temperature). Based on the total value of essential amino acids and non-essential amino acids that had been obtained, it can be seen that *N. sativa* seeds meal contains higher non essential amino acids compared to essential amino acids.

Based on the result in Table 2, even though, all the amino acid composition showed inflexible results (decrease in amino acid value followed by an increase in value and decrease back again as the extraction temperature increasees), the difference in the value recorded for each temperature was not significantly different. It means that difference in temperature applied not really affects the amino acids recorded in NSM. However, the important thing to highlight here is that, eventhough, different extraction temperature had been applied, the NSM that had been produced still contained with the essential amino acids which are beneficial and important for human health. Amino acid in rice bran and soybean meal such as methionine, histidine, tyrosine, tryptophan and proline are examples of essential amino acids which have the benefit to exhibit antioxidant activity (Saiga *et al*., 2003; Renuka Devi and Arumughan, 2007). These amino acids were found in *N. sativa* seeds meal pressed at different temperatures (Table 2).

Based on the result that had been obtained (Table 2) methionine, arginine, glutamic acid, cysteine and aspartic acid are among the essential amino acids that recorded high in value in *N. sativa* seeds meal compared to others. Methionine at temperature 50°C was significantly different with other extraction temperature where it recorded the highest value which is 6.53±4.37. The difference between methionine recorded at 50°C with other extraction temperature varies quite much and this showed that methionine is sensitive or unstable to heat. From the result obtained, it can be seen that cysteine also have similar characteristic where it is unstable or sensitive to heat where, the value of cysteine recorded at temperature 70°C (12.05 mg/100 g) was significantly different with value at temperature 90°C (3.40 mg/100 g). Thus, from the result, it can be concluded that the value of methionine and cysteine can be influenced by extraction temperature or heat applied according to their suitability.

This result was similar to the result of Fevrier *et al*. (2001) who found that methionine and cysteine were inconsistent in cotton seeds meal because of heat treatment. Heating condition was able to modify appreciably the true digestible amino acid contents. Commonly, value of amino acid contents in *N. sativa* seeds meal decreased with increase in extraction temperatures significantly different between 50 and 100°C. Lysine digestibility was also sensitive to heat treatment and would be low because of heat treatment and high level of non starch polysaccharides.

Table 2: Amino acid composition of *N. sativa* seed meal (% from total amino acid) at different temperatures

	Temperature (°C)					
Amino acid	50	60	70	80	90	100
Essential						
Methionine	09.96±0.13^{c}	05.31±0.70^{a}	05.28±0.09^{a}	05.16±0.33^{a}	07.58±0.13^{b}	06.43±0.83^{ab}
Threonine	03.09±0.22^{a}	03.07±0.08^{a}	02.89±0.06^{a}	02.99±0.00^{a}	03.51±0.08^{a}	03.06±0.37^{a}
Phenylalanine	02.94±0.25^{a}	02.97±0.11^{a}	02.77±0.06^{a}	02.85±0.03^{a}	03.35±0.09^{a}	02.95±0.32^{a}
Valine	03.39±0.12^{a}	03.49±0.12^{a}	03.34±0.01^{a}	03.43±0.00^{a}	03.97±0.05^{a}	03.57±0.42^{a}
Isoleucine	02.88±0.14^{a}	02.91±0.16^{a}	02.79±0.01^{a}	02.84±0.06^{a}	03.25±0.02^{a}	02.94±0.35^{a}
Arginine	07.26±0.47^{a}	07.33±0.15^{a}	06.89±0.10^{a}	07.39±0.39^{a}	08.32±0.21^{a}	07.39±0.94^{a}
Lysine	03.14±0.20^{a}	03.37±0.14^{a}	03.13±0.07^{a}	03.21±0.10^{a}	03.43±0.02^{a}	03.26±0.24^{a}
Leucine	04.70±0.20^{a}	04.73±0.29^{a}	04.54±0.05^{a}	04.59±0.12^{a}	05.23±0.02^{a}	04.72±0.57^{a}
Histidine	02.24±0.19^{a}	02.27±0.11^{a}	02.10±0.03^{a}	02.16±0.05^{a}	02.52±0.06^{a}	09.22±9.86^{a}
Tryptophan	00.39±0.04^{a}	00.56±0.02^{a}	00.58±0.01^{a}	00.48±0.08^{a}	00.46±0.05^{a}	00.33±0.38^{a}
Total EAA	39.99	36.01	34.31	35.10	41.62	43.87
Non-essential						
Glycine	04.99±0.32^{ab}	05.05±0.23^{ab}	04.66±0.01^{a}	04.92±0.12^{ab}	05.75±0.13^{b}	05.00±0.42^{ab}
Proline	03.69±0.03^{a}	03.86±0.19^{a}	03.59±0.05^{a}	03.74±0.02^{a}	04.24±0.10^{a}	03.83±0.37^{a}
Alanine	03.20±0.09^{a}	03.49±0.12^{a}	03.27±0.01^{a}	03.40±0.07^{a}	03.70±0.00^{a}	03.52±0.35^{a}
Serine	03.97±0.61^{a}	03.84±0.12^{a}	03.52±0.03^{a}	03.52±0.03^{a}	03.59±0.00^{a}	04.32±0.00^{a}
Glutamic acid	17.62±1.81^{a}	20.08±0.56^{a}	18.75±0.25^{a}	18.89±0.33^{a}	21.07±0.76^{a}	19.98±1.80^{a}
Tyrosine	02.88±0.63^{a}	03.09±0.30^{a}	02.79±0.19^{a}	02.75±0.02^{a}	03.60±0.37^{a}	02.99±0.33^{a}
Cysteine	17.52±0.06^{b}	17.27±2.22^{b}	22.44±0.20^{c}	20.74±0.38^{bc}	08.60±0.33^{a}	09.99±1.26^{a}
Aspartic acid	06.14±1.10^{a}	07.29±0.25^{a}	06.66±0.01^{a}	06.88±0.02	07.13±0.58^{a}	07.17±0.58^{a}
Total AA	100	100	100	100	100	100

EAA: Essential amino acid, AA: Amino acids

The amino acid contents in soybean meal and fish meal which was reduced contents of arginine, lysine and cysteine during heat treatment and no effect for other contents. Soybean meal and fish meal at 130°C had reduced levels of all essential amino acids and non-essential amino acids except tyrosine (Ljokjel *et al*., 2000). Here, it means that the value of certain amino acids such as cysteine, methionine, lysine etc., can be influenced by heat treatment according to their suitability, but most of the other amino acids content were not influenced by the heat treatment. This also had been proved from this research.

During heat treatment, Maillard reaction does not occur if the seeds meal contain low or no carbohydrate (Pike *et al*., 1990). Lysine, cysteine and tryptophan reacts by oxidising lipids during heat treatment (Nielsen *et al*., 1985). These results show that seeds meals with higher crude fat contants at the different temperature have lower lysine, methionine, cysteine and tryptophan. Free radicals or hydroperoxides react with the proteins and thereby, affect the digestibility.

Effect of temperatures pressing on mineral contents of *N. sativa* seeds meal: Mineral contents of *N. sativa* seeds meal pressed at six different temperatures are shown in Table 3. Based on the results, mineral contents in NSM was high with iron (Fe), lead (Pb), manganese (Mn) and zinc (Zn) and were in the ranges of 78.25-119.80, 10.45-32.06, 18.00-19.44, 16.56-28.40 mg/100 g, respectively. These results are similar with the result obtained by Toko *et al*. (2008) on soybean meal and cotton seeds meal, where iron, zinc, calcium and phosphorus were found to be higher in content in those meal.

The value of lead and cadmium increased with decline of heat temperature of the screw press. The screw press machine is made out of steel and at elevated temperatures can be catalysed to

Table 3: Content of certain minerals in *N. sativa* seeds meal (mg/100 g seed meal) by pressed at different temperatures

	Temperature (°C)					
Minerals	50	60	70	80	90	100
Sodium	0.16±0.13[a]	0.20±0.01[a]	0.19±0.00[a]	0.19±0.02[a]	0.18±0.01[a]	0.23±0.07[a]
Calcium	2.08±0.25[a]	1.97±0.30[a]	1.85±0.17[a]	1.65±0.09[a]	1.74±0.00[a]	1.70±0.01[a]
Manganese	18.00±0.28[a]	19.44±0.67[a]	18.80±0.31[a]	19.20±0.60[a]	18.84±0.73[a]	18.65±0.21[a]
Nickel	nd	nd	nd	nd	0.93±0.16[a]	nd
Cuprum	7.07±0.11[a]	8.00±0.30[a]	7.76±0.07[a]	7.49±0.36[a]	7.57±0.37[a]	7.62±0.15[a]
Cadmium	3.40±0.48[a]	2.35±2.75[a]	4.20±0.60[a]	5.20±0.12[a]	3.71±0.53[a]	3.40±0.16[a]
Iron	78.25±2.01[a]	103.07±14.63[a]	102.85±3.78[a]	83.11±0.52[a]	100.57±21.23[a]	119.80±5.54[a]
Lead	32.06±4.97[a]	30.38±0.45[a]	29.02±1.57[a]	27.55±6.60[a]	19.03±11.10[a]	10.45±0.45[a]
Zinc	16.56±14.10[a]	26.31±2.88[a]	27.22±0.64[a]	28.40±1.24[a]	26.44±1.82[a]	27.10±0.40[a]

Means with different superscript in the same row are significantly different ($p<0.05$) (n = 3±s.d.), nd: Not detected

breakdown and appear in the oil and meal in minute quantities. Friction inevitably fuels this process as the metal parts come into contact at high temperature causing some level of lipid oxidation in the presence of oxygen. But the mineral detected i.e., heavy metals like cadmium and lead must be lower for human consumption. Lead is suspected to be a human carcinogen which is dangerous for human. Lead poisoning can bring to renal dysfunction, anemia and liver cirrhosis and also can cause damage to central nervous system (Farrag *et al*., 2007). While, the cadmium also harmful to human when it is consumed in excessive amount, where this compound might accumulate in cortical tissues of kidneys and in liver causing disease to human (Kaplan *et al*., 2011) These two heavy metals are actually the non-essential toxic elements which can result to unbalancing effect on the essential trace elements balances towards the body's cell, when they are in excessive level (Dabak *et al*., 2009).

Therefore, in order to achieve a better or safe consumption of the meal seeds by human, it is suggested that, the *N. sativa* seed must be processed using hot pressing (100°C) rather than cold pressing in order to obtain low value of cadmium and lead which are not really safe or encouraged to be consumed. From the study on *Hibiscus sabdariffa* by Musa and Ogbadoyi (2012) it had been found that moderate boiling is able to reduce the levels of antinutrients and toxic substances and surprisingly, the application of this process still conserves some micronutrients in sufficient amounts that required in our diets.

The cadmium content at 50 and 100°C were significantly different at temperature 80°C. Increase of the extraction temperature increased zinc and iron content and decreased content of calcium, copper and lead. The sodium and manganese were stable with increase in extraction temperature. However, all meal seeds contained considerable amounts of minerals, albeit a low amount of nickel. The mineral contents in *N. sativa* seeds meal (calcium, zinc, copper, sodium, nickel, lead and iron) were not significantly different with increase in pressing temperature. This indicates that, the temperature between 50 to 100°C not really have major effect or influence on the mineral contents in NSM.

CONCLUSION

In conclusion, this experiment enables the identification of the effect of extraction temperature (50-100°C) on the yield, nutritional properties of *N. sativa* seeds meal. It can be concluded here that, some of the important proximate compositions including protein, crude fat and fibre are preferred high temperature (100°C) in order to obtain highest value among all other temperature applied. Results on the amino acids content in NSM indicates that, the best temperature among all the extraction temperatures applied for obtaining the highest value of both essential and non-essential amino acids content in NSM to be 50°C. Results on effect of extraction temperatures on mineral content in NSM, showed that, hot pressing temperature like 100°C can be preferred to be applied in order to obtain lower value of heavy metal content like cadmium and lead which are not really safe to be consumed by human. The hot temperature can prefer over cold temperature in order to obtain important minerals like iron, zinc etc., which are beneficial for human consumption. However, as overall, based on the result that had been obtained, it can be concluded that, most of the value recorded for proximate composition, amino acid content and mineral content of NSM at different extraction temperature show no significant different. It means that different temperature applied (from 50 to 100°C) does not really affect or influenced the value of proximate composition, mineral content and amino acid contents of NSM. NSM has the potential to replace the soybean meal as animal feed. Moreover, this *N. sativa* meal is cheaper than soybean meal and this is really an advantage for increase the economic efficiency.

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