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Study on the Nutritional Composition of Oil Cakes of Different Released and Line Cultivars of Mustard and Rapeseed (*Brassica* spp.)

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Abstract

An experiment was conducted to study the nutritional composition of oil cakes of four released and two line cultivars of mustard and rapeseed (*Brassica* spp.). SAU Sarisha-2 had the highest amount of oil cake (61.26%) while BARI Sarisha-9 contained lowest amount of oil cake (59.45%). The highest dry weights of cake (56.56%), ash content (14.00%) and protein content (28.05%) was obtained from SAU Sarisha-2 and the lowest value obtained from BARI sarisha-9 which was (54.68%), (11.00%) and (25.05%) respectively. The highest amount of carbohydrate was found in Tori-7 (19.08%) and it was lowest in SAU Sarisha-2 (14.51%). Calcium and Magnesium content ranged from 0.722% to 1.006% and 0.370% to 0.838% respectively. Significantly highest amount of calcium (Ca), Magnesium (Mg) and Iron (Fe) was observed in Tori-7 (1.006%), (0.838%) and (101.3 ppm) respectively while the lowest amount of Ca (0.722%) from SAU sarisha-2 and lowest Mg (0.370%) and Fe (30.0 ppm) was obtained from BARI Sarisha-9. Copper and Zinc content ranged from 1.205 to 3.955 ppm and 24.30 to 51.12 ppm respectively. Cu and Zn content was highest in Tori-7×BARI Sarisha-6 (3.955 ppm) and (51.12 ppm) respectively while they are lowest in SAU Sarisha-2 (1.205 ppm) and (24.30 ppm) respectively. Gross energy ranged from 518.9 to 540.3 kcal g^{-1} and it was highest in BARI Sarisha-9 (540.3 kcal g^{-1}) and lowest in SAU Sarisha-2 (518.9 kcal g^{-1}).

Keywords: Mustard, rapeseed, oil cake, nutritional composition, gross energy

1. Introduction

Rape seed and mustard are common names used for different species of the family Cruciferae (Bracicaceae). Rape seed includes *Brassica compestris* and *B. napus*. Mustard specifically refers to *Brassica juncea* and *Eruca sativa*. There are considerable differences in agronomic characteristics, yield, and fatty acid (FA) composition of seed oil between species and between varieties (Bauer, 2018). Mustard and rapeseed are major oilseed crops and the leading source of edible oil occupied the third most important position among the oilseed crop in the world and World area harvested under mustard and rapeseed is 38,509,853 MT and production is 75,711,806 MT (Anonymous, 2019). In Bangladesh, *Brassica rapa* is the main oil yielding species. *Brassica rapa* L. occupies the first position in respect of area and production (Naznin et al., 2018). About 787025 acres of land was under rape and mustard cultivation. The production rate of the seed was about 68 MT, and national average yield was 368987 MT in this country (Anonymous, 2019). *Brassica* is considered to be the most important source of vegetable and protein

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rich meal worldwide (Cardoza and Stewart, 2003). Oil cakes/oil meals are by-products obtained after oil extraction from the seeds and are used for various purposes. It is a nutritious food items for cattle and fish. Hossain et al. (2013) observed that the growth of silver carp (*Hypophthalmichthys molitrix*) and bata (*Cirrhinus reba*) is faster by using feed containing rice bran and mustard cake. It is also used as a good organic fertilizer and ingredient of composts. Mustard cake is rich in nitrogen (4.8%), phosphorous (2% as P_2O_5) and potassium (1.3% as K_2O) which are essential requirement to maintain fertility of soil and proper growth of plant (Solvent extractor's association of India, 2014). Ibrahim and Mumtaz (2014) in their research observed that fungal inoculation with mustard cake increased the plant yield. The composition of mustard cake varies with the variety, growing conditions and processing methods. Edible oil cakes have a high nutritional value; especially have protein contents ranging from 15% to 50% (Ramachandran et al., 2007). The protein quality and quantity obtained from oil cake of *B. campestries* is high (Chowdhury et al., 2010). The amino acid composition of mustard protein is well balanced; it is rich in essential amino acids. This advantageous chemical composition and its relatively low price offer wide possibilities for usage of this valuable seed (Gadei et al., 2012). The crude protein content varies from 33–40% of which 80–83% is true protein with appreciable proportion of albumin, glutelin and globulin (Klockeman et al., 1997). The protein is rich in lysine and sulphur containing amino acid which are limiting in cereal protein, making it excellent complementary to cereals in completing biological value of protein. Moreover, the composition of amino acids is well balanced for application as protein supplement for human nutrition and some properties of the mustard protein have been reported to be comparable with casein and even better than other plant proteins including that of soybean, pea, and wheat (Ghodsvali et al., 2005). Mustard cake contains 21% carbohydrate. Carbohydrate constitutes mainly soluble sugars (≈10%), cellulose (4–5%), pectins (4–5%), hemicellulose (3%) and starches (<1%). 21% lipid, 8.5% crude fibre, and 8% ash (Devi and Devi, 2011). It is also a good source of bioactive components including phenolics (77–81 mg kg^{-1}), glucosinolates and phytates; phenolics can be present in free or esterified (upto 80%) forms or it can be conjugated with other insoluble compounds (Naczk and Shahidi, 1992). Several breakdown products of glucosinolate in mustard cake have pesticidal properties, including weed suppression capacity (Boydston et al., 2008). Oil cakes are also a good source of different minerals. Bachheti et al. (2012) found that mineral content of mustard seed oil (*Brassica campestris*) is (694.3 g 100 g^{-1}), (4.86 g 100 g^{-1}), (492.1 g 100 g^{-1}), (0.034 g 100 g^{-1}), (0.019 g 100 g^{-1}), (0.007 g 100 g^{-1}), (8.11 g 100 g^{-1}) and (0.84 g 100 g^{-1}) for P, Zn, Ca, Mg, K, Na, Fe and Cu respectively. Total minerals content of black mustard cake and yellow mustard cake were found to be 7.10% and 5.90% (Sarker et al., 2015). Sengupta and Das (2003) found that minerals content of rapeseed in 100 g edible portion was 4.2 g (calcium 490 mg, phosphorus 700 mg and Iron 17.9 mg and other minerals were present in negligible quantity). From the above discussion we can see that, oil cake have high nutritional value but very few research work has carried out in Bangladesh to measure the nutritional status of oil cakes, most of the research works are related to enrich the oil quality characteristics. Therefore, the objectives of the present work were to determine the nutritional composition of oil cakes of some selected released and line cultivars of mustard and rapeseed (*Brassica* spp.) for proper utilization of this proteinaceous resource as continuous production of mustard seed, concomitantly increasing the production of mustard cake.

2. Materials and Methods

The experiment was conducted in the laboratory of Biochemistry Department of Sher-e-Bangla Agricultural University and BARI (Bangladesh Agriculture Research Institute), Dhaka during January 2017 to July 2017. Four released and two line cultivars of mustard *(Brassica spp.)* namely BARI Sarisha-6, BARI Sarisha-9, BARI Sarisha-9 x BARI Sarisha-6, Tori-7, Tori-7×BARI Sarisha-6, SAU Sarisha-2 were selected for the study. In this study following parameters were considered.

2.1. *Determination of 1000 grain weight*

The mass was determined by randomly selecting 100 samples and weighing in an electronic balance of 0.001 g sensitivity. The weight was then converted into 1000 seed mass.

2.2. *Determination of moisture*

Moisture content of mustard sample was determined by conventional method. Empty aluminum moisture dish was weighted (w_1) and 2.5 g sample was taken in a moisture dish and weighted (w_2). The sample was spread evenly and placed without lid in oven and dried samples overnight at 100°C. The dishes were transferred to desiccators to cool. Aluminum dish was weighed after cooling (w_3).

$$\% \text{ Moisture} = \{(W_2 - W_3)/(W_2 - W_1)\} \times 100$$

2.3. *Determination of dry matter content*

2.4. *Estimation of oils/fats content*

Dried mustard flour sample was weighed out into an extraction thimble. Weight of thimble and sample were recorded in laboratory book. The thimble was placed into the soxhlet. 50-100 ml ethyl ether was added to the soxhtet flask, then it was connected to holder and condenser. Soxhlet flask was placed on hot plate and distilled at low temperature for 16-20 hours. After extraction it was turned off and allowed to cool. When distillation was ceased, the extraction thimble was removed and allowed to air dry for 30-40 minutes the thimble was weighed out. The loss of weight was cured fat.

% Crude Oils/Fats (on a dry weight basis)={(Wt. of thimble & sample before extraction - Wt. of thimble & sample after extraction)/Weight of sample before extraction}×100

The fat determined by the above procedure (Hughes, 1965) contains usual lipids including waxes pigments, certain gums and resins. A better name for these constituents would be "ether soluble extract."

2.5. Oil cake content

2.6. Dry weight of oil cake

2.7. Determination of Ash

The sample was ignited at 600°C to burn off all organic material. The inorganic material which was not volatilize at that temperature is called ash. The procedure was described by Ranganna (1986).

2.8. Estimation of total protein content

The protein content of food stuff is obtained by estimating the nitrogen content of the material and multiplying the nitrogen value by 6.25 (according to the fact that nitrogen constitutes on average 16% of a protein molecule). This is referred to as crude protein content, since the non-protein nitrogen (NPN) present in the material is not taken in consideration. The estimation of nitrogen is done by Kjeldhal method (AOAC, 2010).

2.9. Estimation of carbohydrate

The method was described by Raghuramula et al. (2003). The content of the available carbohydrate was determined by this equation: Carbohydrate=100-[(Moisture+Protein+Ash+Oil/Fats) g 100 g^{-1}]

2.10. Estimation of minerals

It includes digestion of seed sample for determination of Ca, Mg, Cu, Fe and Zn. Digestion was done by weighing 500 g dry seed sample and put into a 50 ml boiling flask. 5 ml of nitric-perchloric solution was allowed on cool hot plate and turned temperature to 375°C. It was allowed to digest for 1 hour and 30 minutes. The flask was removed from digestion chamber and was cooled and 15 ml water was added. The flask was agitated and heated to dissolve the ash and filter. Analytical procedure involves a combination diluter-dispenser, 1 ml aliquot was taken from filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For Ca and Mg determination, 1 ml aliquot from dilution 1, 9 ml of water and 10 ml of 1% lanthanum solution were mixed together. It was analyzed by AA procedure. For Fe, Cu and Zn determination, the original filtrate was used to analyze these elements by AA procedure.

2.11. Estimation of energy

The chemical energy content of food ingredients is usually expressed in terms of heat units (since all forms of energy are convertible into heat energy). The gross food energy was estimated by multiplying the crude protein, crude fat and total carbohydrate by at water factors 4, 9 and 4 respectively (Okwu, 2006; Osborne and Vooget, 1978).

2.12. Statistical analysis

The recorded data for each character from the experiments was analyzed statistically to find out the variation resulting from experimental treatments using MSTAT package program. The mean for all the treatments were calculated and analysis of variance of characters under the study was performed by F variance test. The mean differences were evaluated by least significance difference test. To determine the relationships among the different traits, Pearson correlation coefficients were calculated for every pair of traits using PROCCORR of SAS.

3. Results and Discussion

The Nutritional composition of the oil cakes was determined by standard procedure. The results of cake analysis were presented in graphs and tables.

3.1. 1000 seed weight

The seed weight varied with their size and shape. Weight of thousands of grains were determined at 13% moisture level. The highest weight of thousands of grains was found in BARI Sarisha-9×BARI Sarisha-6 (4.892 g). The lowest thousand seed weight was found in SAU Sarisha-2 (4.459). The present values are consistent with the results reported by Chowdhury et al. (2014), Banga et al. (2013) and Siddiqui et al. (2004). Chowdhury et al. (2014) reported range of weight of thousand seed 2.5 to 4.9 g among different Bangladeshi mustard varieties and advanced lines. Banga et al. (2013) and Siddiqui et al. (2004) found that the highest amount of 1000 seed weight were 5.15 g and 3.95 g respectively. The present values are higher than the reported value of Mondal and Wahhab (2001); who found that thousand seed weight varies from 2.50-2.65 g.

3.2. Moisture content

The moisture content of different released and line cultivars of mustard and rapeseed was ranged from 4.3 to 5.1%. The highest moisture content (5.1%) was observed from BARI Sarisha-6 followed by 4.9% and 4.7% in Tori-7×BARI Sarisha-6 and SAU Sarisha-2 respectively while the lowest moisture content (4.3%) was found in BARI Sarisha-9×BARI Sarisha-6. The results for the moisture content were significantly lower than that of Sarker et al. (2015), Marnoch and Diosady (2012), BARI annual report (2012-13). According to Sarker et al. (2015) moisture content of mustard cakes ranges from 9.20±0.5% to 9.73±0.6%; and the moisture content 8.3±0.2% reported in literature by Marnoch and Diosady, (2012). BARI (2012-13) reported that moisture content ranges from 7.41 to 8.38%. These may be influenced by different level of sun drying after harvesting.

3.3. Dry matter content

A statistically significant variation was observed for dry matter content of different released and line cultivars of mustard and rapeseed that has been presented in Table 1. Significantly highest amount of dry matter was recorded in BARI Sarisha-9×BARI Sarisha-6 (95.7%) and he lowest amount of dry matter was found in BARI Sarisha-6 (94.9%) which was significantly lowest among all the variety & advanced lines.

Table 1: 1000 seed weight, moisture and dry matter content of different released and line cultivars of rapeseed and mustard (*Brassica* spp.)

Name of the released and line cultivars	1000 seed weight (at 13% moisture level) (g)	Moisture (%)	Dry matter (%)
BARI Sarisha-6	4.72^{ab}	5.10^{a}	94.90^{e}
BARI Sarisha-9	4.54^{b}	4.60^{cd}	95.40^{bc}
BARI Sarisha-9×BARI sarisha-6	4.89^{a}	4.30^{e}	95.70^{a}
Tori-7	4.64^{ab}	4.50^{d}	95.50^{b}
Tori-7×BARI Sarisha-6	4.74^{ab}	4.90^{b}	95.10^{d}
SAU Sarisha-2	4.45^{b}	4.70^{c}	95.30^{c}
LSD (*p*=0.05)	0.3355	0.1908	0.1908

Figure in a column followed by a common letter do not differ significantly at (*p*=0.05) level by DMRT

These variations might be due to environmental factor, soil and crop management practices. The result agreed with Sarker et al. (2015) and Chowdhury et al. (2014) who reported that dry matter content of different mustard and rapeseed was 95.2 to 96.5% and 94.5 to 95.0% respectively.

3.4. Oil content

The oil content of different released and line cultivars of mustard and rapeseed varied from 38.74% to 40.55% (Table 2). The variety SAU Sarisha-2 had the lowest amount of oil contained (38.74%), while the variety BARI Sarisha-9 contained significantly highest amount of oil (40.55%) followed by Tori-7 (39.62%) and BARI Sarisha-9 X BARI Sarisha-6 (39.44%). The results clearly indicated that variety BARI Sarisha-9 (40.55%), Tori-7 (39.62%) and BARI Sarisha-9×BARI Sarisha-6 (39.44%) can be considered as better source of oil. Present values are higher than the reported value of Gadei et al. (2012) and Moser et al. (2009), who found that oil content of mustard seed ranges from 28–32%; whereas Arif et al. (2012), Bhowmik (2003), Novoselov et al. (2007) reported that oil content of rapeseed ranges from 45.67-43.87%, 42-46% and 45-46% respectively, which are slightly higher than present results. On the other hand, the present investigations were more or less similar the reported values of Niraz et al. (2001), Sengupta et al. (2003), Mondal et al. (2001). These variations might be due to biological factor, environmental factor, soil and crop management practices.

Table 2: Oil content, Oil cake content and dry weight of cake of different released and line cultivars of rapeseed and mustard (*Brassica* spp.)

Name of the released and line cultivars	Oil content (%)	Oil cake (%)	Dry weight of oil cake (%)
BARI Sarisha-6	39.22^{bc}	60.78^{ab}	55.68^{b}
BARI Sarisha-9	40.55^{a}	59.45^{c}	54.68^{c}
BARI Sarisha-9×BARI sarisha-6	39.44^{bc}	60.56^{ab}	56.26^{ab}
Tori-7	39.62^{b}	60.38^{b}	55.88^{ab}
Tori-7×BARI Sarisha-6	38.80^{c}	61.20^{a}	56.30^{ab}
SAU Sarisha-2	38.74^{c}	61.26^{a}	56.56^{a}
LSD (*p*=0.05)	0.7254	0.7256	0.6880

Figure in a column followed by a common letter do not differ significantly at (*p*=0.05) level by DMRT

3.5. Oil cake content and dry weight of oil cake

From the Table 2 we can see that oil cake content highest in SAU Sarisha-2 (61.26%) followed by Tori-7×BARI Sarisha-6 (61.20%) and BARI Sarisha-6 (60.78%). The lowest value was found in BARI Sarisha-9 (59.45%). The highest dry weight of cake was obtained from SAU Sarisha-2 (56.56%) followed by Tori-7×BARI Sarisha-6 (56.30%) and BARI Sarisha-9×BARI Sarisha-6 (56.26%) while it was lowest in BARI sarisha-9 (54.68%). The results were supported by Chowdhury et al. (2014) and Appelqvist and Ohlson (1992). Chowdhury et al. (2014) found that percentage of oil cake range from 58.14 to 59.95% and Appelqvist and Ohlson (1992), reported that rape seed oil contain 58% cake.

3.6. Ash content

Ash content ranged from 11.00% to 14.00% (Table 3). Significantly highest amount of ash contained was recorded in SAU Sarisha-2 (14.00%) followed by Tori-7×BARI Sarisha-6 (13.50%) and lowest in BARI Sarisha-9 (11.00%). The present values were significantly higher than the reported value of Sarker et al. (2015).

3.7. Protein content

The statistically highest amount of protein was obtained from

Table 3: Protein, ash and carbohydrate content of the different released and line cultivars of rapeseed and mustard (*Brassica* spp.)

Name of the released and line cultivars	Ash (%)	Protein (%)	Carbohydrate (%)
BARI Sarisha-6	12.10^{d}	26.60^{c}	16.98^{c}
BARI Sarisha-9	11.00^{f}	25.05^{f}	18.80^{a}
BARI Sarisha-9×BARI sarisha-6	12.20^{c}	26.15^{d}	17.91^{b}
Tori-7	11.25^{e}	25.55^{e}	19.08^{a}
Tori-7×BARI Sarisha-6	13.50^{b}	27.15^{b}	15.65^{d}
SAU Sarisha-2	14.00^{a}	28.05^{a}	14.51^{e}
LSD (*p*=0.05)	0.01819	0.01819	0.6928

Figure in a column followed by a common letter do not differ significantly at (*p*=0.05) level by DMRT

SAU Sarisha-2 (28.05%) followed by Tori-7×BARI Sarisha-6 (27.15%) and BARI Sarisha-6 (26.60%) while BARI Sarisha-9 contained lowest amount of protein (25.05%) (Table 3). The present values are more or less similar with the reported values of other researchers (Sarker et al., 2015; Chowdhury et al., 2010; Mirza et al., 1998) but these results are lower than the reported value (34.0-45.0%) of Prapakornwiriya and Diosady (2004). Sengupta and Das (2003) revealed that protein content of rapeseed were ranges from 44.2-44.7%. This might be due to the nitrogen fertilizer application, ecology and agronomics practices.

3 8. Carbohydrate content

The higher amount of carbohydrate was found in Tori-7 (19.08%) which was statistically similar with BARI Sarisha-9 (18.80%). The lowest amount of carbohydrate was obtained from SAU Sarisha-2 (14.51%). The present values are slightly lower than the reported values of Bachheti et al. (2012) and Gopalan et al. (1981). Bachheti et al. (2012) found that mustard seeds contain 23.8% carbohydrate and Gopalan et al. (1981) stated that dry mustard seeds contained 20-23% carbohydrate.

3. 9. Minerals content

3.9.1. Major minerals

Calcium content ranged from 0.722% to 1.006% (Table 4). Highest amount of calcium Ca was observed in Tori-7 (2.7%) followed by BARI Sarisha-6 (0.840%) and lowest amount was obtained from SAU Sarisha-2 (0.722%). The result were supported by some other workers (Sarker et al., 2015; Arif et al., 2012; Bachheti et al., 2012, Josefson, 1988; Sengupta and Das, 2003). Bachheti et al. (2012) and Sengupta and Das (2003) reported that mustard contain 492.1 mg and 490 mg respectively, while Josefson (1988) stated that mustard contain 0.7% Ca. Magnesium content ranged from 0.370% to 0.838% (Table 4). The highest amount of Mg was found in Tori-7 (0.838%); followed by BARI Sarisha-6 (0.730%) and the lowest amount was in BARI Sarisha-9 (0.370%). The present investigations were supported by reported value of Sarker et al. (2015), Arif et al. (2012), Bachheti et al. (2012), Josefson (1988), Sengupta and Das (2003).

Table 4: Major and minor minerals content of the different released and line cultivars of rapeseed and mustard (*Brassica* spp.)

Name of the released and line cultivars	Ca (%)	Mg (%)	Cu (ppm)	Fe (ppm)	Zn (ppm)
BARI Sarisha-6	0.8400[b]	0.7300[b]	3.200[c]	32.00[e]	42.10[c]
BARI Sarisha-9	0.8200[c]	0.3700[e]	3.250[b]	30.00[f]	44.30[b]
BARI Sarisha-9×BARI sarisha-6	0.7380[e]	0.6170[d]	2.105[e]	78.54[b]	40.02[d]
Tori-7	1.006[a]	0.8380[a]	3.001[d]	101.3[a]	33.42[e]
Tori-7×BARI Sarisha-6	0.7970[d]	0.6640[c]	3.955[a]	75.30[c]	51.12[a]
SAU Sarisha-2	0.7220[e]	0.6020[d]	1.205[f]	37.86[d]	24.30[f]
LSD (*p*=0.05)	0.01819	0.01819	0.01819	0.09965	0.1286

Figure in a column followed by a common letter do not differ significantly at (*p*=0.05) level by DMRT

3.9.2. Minor minerals

From Table 4 we found that Copper content ranged from 1.205-3.955 ppm. Highest amount of Cu observed in Tori-7×BARI Sarisha-6 (3.955 ppm) and lowest amount of Cu observed in SAU Sarisha-2 (1.205 ppm). Which were supported by Sarker et al. (2015), Arif et al. (2012), Bachheti et al. (2012), Josefson (1988), Sengupta and Das (2003). Iron content ranged from 30.0 to 101.3 ppm. Highest amount of Fe was observed in Tori-7 (101.3 ppm). The variety BARI Sarisha-9 showed lowest amount of Fe (30.00 ppm). The present values were higher than the reported values of Bachheti et al. (2012) and Josefson (1988); who found that Fe content of mustard seed oil were 8.11 (g 100 g^{-1}) and 18 ppm respectively. The zinc content ranged from 24.30 to 51.12 ppm. Highest amount of Zn was found in Tori-7×BARI Sarisha-6 (51.12 ppm). The lowest amount was found in SAU Sarisha-2 (24.30 ppm). The present values were supported by Bachheti et al. (2012) and Josefson (1988).

Correlation was estimated between the eight traits are given in Table 5. Ash content was significantly and positively correlated with protein content (0.972**) but negatively correlated with carbohydrate (-0.973**), Ca (-0.636**) and Cu (-0.366*). Protein content was negatively correlated with carbohydrate (-0.975**), Ca (-0.570**) and Cu (-0.432*). Among the minerals, Ca had significant positive correlations with Mg (0.550**), Cu (0.487**) and Fe (0.491**). Mg and Cu had positive correlations with Fe (0.625**) and Zn (0.864**) respectively. Carbohydrate is positively correlated with Ca (0.642**). In the present study though the protein content was high in most of the treatment but it was negatively correlated with Ca and Cu content but the result was disagreed with Ashok et al. (2016) and Olkhovych et al. (2016) who found that protein content was positively correlated with copper in different sorghum species and in *Pistia stratiotes* respectively. Iron content was positively correlated with Mg and Ca suggesting the possibility of combining selection for both micronutrients the result agreed with Ashok et al. (2016) who reported that Mg and

Table 5: Correlation coefficients for minerals, ash, protein, and carbohydrate traits of different released and line cultivars of mustard and rapeseed (*Brassica* spp.)

Traits	Ash (%)	Protein (%)	Carbohydrate (%)	Ca (%)	Mg (%)	Cu (ppm)	Fe (ppm)	Zn (ppm)
Ash (%)	1							
Protein (%)	0.972**	1						
Carbohydrate (%)	-0.973**	-0.975**	1					
Ca (%)	-0.636**	-0.570**	0.642**	1				
Mg (%)	0.087	0.195	-0.010	0.550**	1			
Cu (ppm)	-0.366*	-0.432*	0.344	0.487**	0.072	1		
Fe (ppm)	-0.110	-0.183	0.314	0.491**	0.625**	0.161	1	
Zn (ppm)	-0.220	-0.340	0.225	0.044	-0.199	0.864**	0.039	1

**: Significant at the (p=0.01) probability level ; * Significant at the (p=0.05) probability level

Ca content increases with Iron in different sorghum species.

3.10. Energy obtained from oil cakes

From the Figure 1 we can found that highest amount of energy from carbohydrate was obtained in Tori-7 (76.33 kcal g^{-1}) and lowest amount found in SAU Sarisha-2 (58.05 kcal g^{-1}) while highest energy from protein observed in SAU Sarisha-2 (112.2 kcal g^{-1}) whereas lowest amount of energy (100.2 kcal g^{-1}) from protein observed in BARI Sarisha-9. The Gross energy obtained from the oil cake ranged from 170.25 to 178.53 kcal g^{-1}. The highest amount of gross energy found from Tori-7 (178.53 kcal g^{-1}) followed by BARI Sarisha-9×BARI Sarisha-6 (176.23 kcal g^{-1}); while lowest amount of gross energy recorded from SAU Sarisha-2 (170.25 kcal g^{-1}).

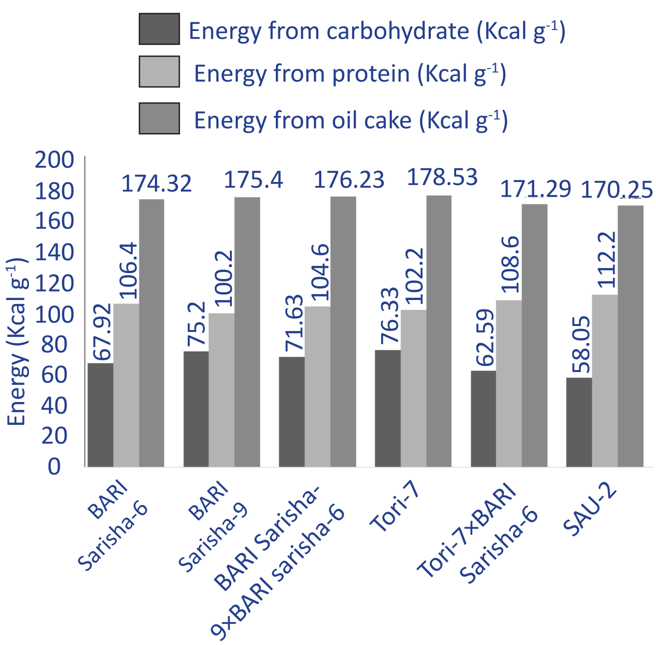

Figure 1: Energy obtained from carbohydrates, proteins and oil cakes of different released and line cultivars of rapeseed and mustard (*Brassica* spp.)

4. Conclusion

None of the released and line cultivars of rapeseed and mustard oil cake performed best by all nutrient parameters. SAU Sarisha-2 performed best considering the oil cake, protein and ash contents while Oil cake of Tori-7, Tori-7× BARI Sarisha-6, BARI Sarisha-6 showed the good performance for the most mineral contents. So, it may be concluded that, these released and line cultivars can be grown in large scale as a source oil cake.

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