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Proximate composition analysis of commonly used raw materials in Bangladesh and the critical variables impacting soybean meal protein concentration

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Abstract

A total of 188 samples of Rice Polish (RP), De-Oiled Rice Bran (DORB), Soybean Meal (SBM), Rapeseed Meal (RSM), Fish Meal (FM), and Poultry by-Product Meal (PBM) were investigated for the proximate composition, focusing on Moisture, Crude Protein (CP), Ether Extract (EE), Ash, and Carbohydrate from diverse sources. Regarding the animal-based ingredients maximal crude protein was observed in Saudi Arabian PBM (67.53±1.01%), while FM had the minimal (59.82±3%). In contrast, among plant-based ingredients, South American region SBM dominated (46.42±0.23%), where RP had the lowest protein value (12.48±0.61%). In the instance of EE, ash, and carbohydrate content in both plant-based and animal-based ingredients Malaysian type 2 PBM (22.12±9.07) showed the highest EE value, where RP (55.68±2.86) and DORB (55.78±2.23) have the highest carbohydrates and FM has the highest ash content (17.81±5.93). Focusing on SBM, the relation of protein with moisture and non-protein nitrogen was observed (NPN), and the result shows a higher degree of variability in NPN (R^2=75.94%) rather than moisture (R^2=12.24%). NPN with protein solubility (PS) was also observed where PS varies from 77.28% to 56.94% based on the presence of NPN and it defines a 34.04% relationship. The cost analysis revealed that FM was the priciest protein source (0.31 Tk/g) in the present context, followed by PBM (0.19 Tk/g). SBM was a more economical and accessible replacement (0.17 Tk/g) while RSM was the most cost-effective (0.11 Tk/g). This study provides insight into the nutritional composition and economic reflections of different feed ingredients for feed industry applications in Bangladesh.

Keywords: Raw materials**;** proximate composition; moisture and protein relation; protein and NPN relation; NPN and protein solubility relation; protein cost; soybean meal.

1. Introduction

With an increasing demand for high-quality animal protein, the fish, and livestock sectors have expanded at a noteworthy step for this growing industry, animal feed production has become a key focus, with feed accounting for a considerable portion of production costs for farmers, typically ranging from 40% to 60% (Agboola *et al.*, 2019) [3]. Despite having a significant domestic demand for fish protein, Bangladesh continues to become one of the leading exporters in the global fish market, leveraging its extensive freshwater and marine resources to drive fisheries production. According to the statistics of the Department of Fisheries, Bangladesh (2022) [15], the country has approximately 8.45 lakh hectares of inland closed-water resources for aquaculture. Bangladesh is globally positioned as the 3rd highest producer in inland open-water capture and ranks 5th in worldwide aquaculture production. Also, Bangladesh is the 4th largest contributor to global tilapia production and the 3rd leading producer in Asia (FAO, 2022) [16].

From the perspective of livestock, the sector made a particular contribution of 1.85% to the National Economy of Bangladesh (2022-23) as Gross Domestic Product (GDP) at Constant Prices, with a GDP growth rate of 3.23% and accounted for 16.5% of the agricultural GDP (BBS, 2022-23). The feed industries contribute significantly to the GDP of agriculture with the production of feed for fish and farm animals and help our nation satisfy its massive protein needs. To fulfill the enormous demand, the country is facing a lack of smooth supply of raw materials for feed production, which obliges imports from foreign sources.

The import values of key primary commodities, e.g., rice, maize, and oilseeds, in FY 2021-22 were $427 million, $2,135 million, and $1,758 million, respectively (BER,2023). The industry experts assumed that the government's burden of Advanced Tax (AT) on the import of raw materials for livestock and fish feed is widely regarded as a significant hindrance and the nonstop rising price of raw materials is responsible for high-priced feed. This growth has emphasized the need for cost-effective solutions to address the expenses associated with protein-rich feed ingredients, a challenge obvious in exploring locally sourced alternatives (Abbasi *et al*., 2015; Kasapidou *et al*., 2015; Stein *et al*., 2016) [2, 24, 42]. However, certified data on feed production and actual feed sales in recent years are not always procurable. Islam (2021) [19] stated that the yearly need for animal feed in Bangladesh is between 6.3 and 6.4 million tons, which exceeded in 2020. The entire amount of commercial feed produced in that year was 6.57 million tons, with poultry feed production accounting for 4.45 million tons, fish feed for 1.59 million tons, and cattle feed for 0.53 million tons respectively. A constant supply of animal protein sources is mandatory for the rising demand for animal feed production. Maintaining the consistent nutritional value of feed is difficult as ingredients can account for 70-90% of production costs (Jones, 1989) [23].

To keep up with the agricultural sector's growth, the feed business must grow in parallel with farming by providing quality feed. Every feed mill's performance is largely dependent on maintaining quality standards of raw materials employed in feed production and should meet the stated standards for essential proximate nutritional composition to attain optimal feed quality (Islam *et al*., 2016) [21]. The main raw materials for producing animal feed in Bangladesh are maize, soybean meal, rapeseed meal, rice polish, de-oiled rice bran, fish meal, and poultry meal, almost 70% of these must be imported. During feed formulation, most of the nutritionists assume ingredient values from recognized databases, which may result in lower nutrient levels in the final diet than expected. Nutritionists aim to mitigate the risks associated with lower-than-predicted component values by increasing the target nutrient levels by a certain percentage. This approach, however, can result in increased feed production costs and nutritional waste if over-formulation occurs (Masagounder *et al.*, 2016) [28]. That's why the formulators need to know the appropriate nutrient content existing in raw materials to address the dietary requirements of animals, which can fluctuate based on region, seasons, sources, and batches. Therefore, it is essential to carefully evaluate them before adding them to animal diets (Islam *et al.*, 2015; Frank, 2008) [20, 17].

Many small and medium-scale feed industries often lack complete laboratory facilities for evaluation of the composition of raw materials. Consequently, they face challenges in identifying variations among suppliers, sources, and batches, which are essential aspects of feed processing. The variation in supplies, particularly for the protein content, increases concerns, as it is found that there is a possible use of non-protein nitrogen (NPN) to meet the declared protein content (Cassel, 1996) [10]. Protein content has substantial consequences for feed producers and farmers, making it a vital factor in industry. Although nitrogen is present in all proteins, not all nitrogen is cohesive in protein structures. Urea and anhydrous ammonia, for instance, are two compounds that possess substantial nitrogen content, but they do not belong to the category of dietary protein. Instead, they are referred to as non-protein nitrogen (NPN) compounds (Kirchgessner, 1985; Burgstaller, 1983) [25, 9]. It is safe to add some of these proteins to ruminants' diets because they can use various protein sources due to their stomach physiology, with microorganisms synthesizing protein from nitrogen compounds, but pigs, chickens, and other monogastric animals cannot use large concentrations of NPN compounds due to a lack of enzymes and bacteria (Tadele & Amha, 2015) [44]. Most of the time, poisoning from consuming too much urea or other NPN sources is acute, fast escalating, and lethal to animals (Thakur, 2007) [45]. Non-protein nitrogen compounds can denature proteins, affecting their structure and solubility. Besides that, inadequate or excessive heating is also responsible for taking down the raw materials' quality. Feed-producing industries thus need a way to differentiate between sufficiently processed raw materials that have been over- or under-processed (Căpriță *et. al.*, 2010) [11]. A common method of evaluating potential processing-related protein denaturation is solubility (Smith, 2017) [41]. Protein solubility refers to the equilibrium concentration of protein with a crystalline phase under specific conditions (McPherson A, 1999) [29]. Solubility is a significant thermodynamic feature that provides a perception of protein interactions (McManus *et, al.*, 2016) [30].

It is mandatory to consider parameters such as moisture, fat, and ash content to assess the quality and endurance of essential feedstuffs considering shifting market prices. These variables play a key role in the potential outcomes of the final product and the effects of prolonged storage. Due to the instability in the pricing of essential raw materials, many companies have decided to store their raw materials for future use. This strategy requires a complete understanding of the fundamental values of the feedstock to make informed decisions regarding storage and processing. By analyzing and knowing the moisture, fat, and ash content of these feedstuffs, companies can better navigate market dynamics, optimize product quality, and mitigate risks associated with prolonged storage periods. Whereas this study could be a feed mill's point of reference, the quality of that data depends on the analysis strategy used and the laboratory's quality assurance procedure. Therefore, the present study investigates the nutrient composition of commercial feed raw materials available in Bangladesh.

2. Materials and method

2.1 Sample Source

Matber Agro Industries Ltd. obtained raw ingredients from various countries, for example, soybean meal from the South American region (Brazil, Argentina), India, and locally sourced, rapeseed meal from India, fish meal and poultry meal from Malaysia and Saudi Arabia, rice polish and de-oiled rice bran from locally available sources.

2.2 Collection and Preparation of Samples

A total of 188 samples of 06 different feed ingredients (Rice Polish, DORB, Soybean Meal, Rapeseed Meal, Fish meal, and Poultry Meal) were collected during the study period (January to December) of 2023. Large amounts of the feed ingredients were collected from different batches of raw materials. A sampling of each feed ingredient from an entire lot was done following the "Quartering" method followed by Jacobs (1973) [22] and Lovell (1975) [27]. An electrical grinder was used to crush a sample of each feed item into tiny particles, and a 60 µm screen sieve was used to filter out the garbage. Following sieving, the materials were kept dry and securely sealed in containers until they were analyzed.

2.3 Analysis of Proximate Composition

The proximate analysis *viz*. moisture, crude protein, ether extracts, and total ash of the ingredient samples was accomplished in the laboratory of Matber Agro Industries Ltd. Gazipur, Dhaka, Bangladesh. The proximate compositions of each sample were ascertained by a triplicate analysis using a completely randomized design (CRD).

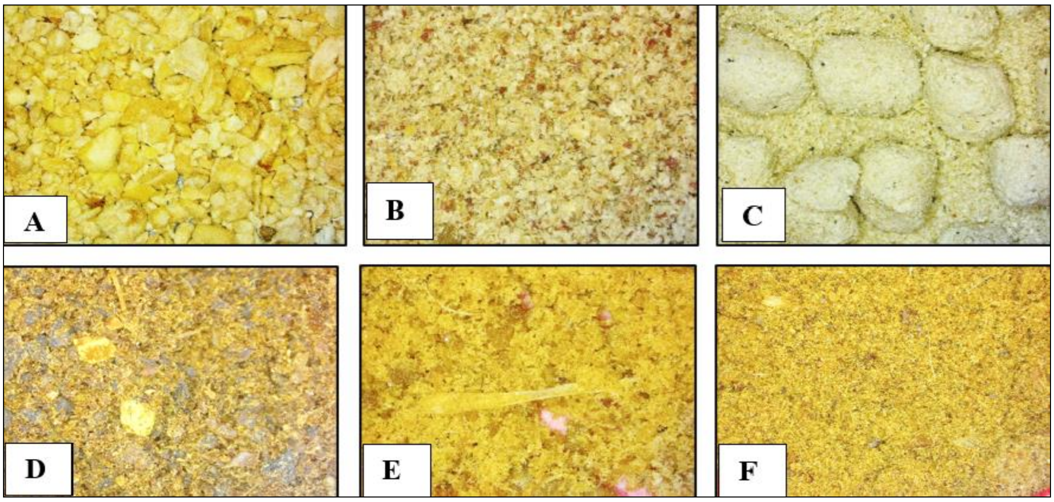


Fig 1: Different Types of Raw Materials. (A) Soybean meal, (B) Rice polish, (C) De-oiled rice bran, (D) Rapeseed meal, (E) Poultry by-product meal, and (F) Fish Meal. N.B Photographs are captured by RF4 Trinocular Stereo Microscope.

2.3.1 Moisture (M): The oven method (Shreve *et al*., 2006) [39] was followed for the moisture content determination of the ingredient samples. All the samples were dried at 105°C for 3 h. The moisture content was calculated as:

$$Moisture\ (\%) = \frac{The\ weight\ of\ fresh\ sample\ -\ The\ weight\ of\ dried\ sample}{The\ weight\ of\ fresh\ sample} \times 100$$

2.3.2 Dry Matter (DM): The dry matter percentage was determined as per the procedure by the following formula (Sonone *et al.*, 2018) [43].

Dry matter (%) = Weight of sample - the weight of moisture in the sample

2.3.3 Crude Protein (CP): Crude protein was determined followed by the Kjeldahl method (Jacobs 1973, Crampton *et. al.* 1969, Pearson 1976) [22, 12, 36] according to the following formula:

$$Nitrogen\,\% = \frac{Volume\ used\ of\ H2SO4\ \times No\ of\ H2SO4 \times 14}{Weight\ of\ original\ sample} \times 100$$

$$\%\ Crude\ protein = \%\ N\ in\ sample\ \times Conversion\ factors *$$

*= Conversion factors for components originating from plants and animals are 6.25 (Silva 2002) [40].

2.3.4 Ether Extracts (EE): The Soxhlet extraction technique was adapted by using the solvent "Hexane" (65-70 °C) to determine the ether extract content of ingredient samples (Jacobs, 1973) [22]. The content of ether extract was determined using the following equation:

$$Eather\ extract\ (\%) = \frac{weight\ of\ fat}{weight\ of\ sample} \times 100$$

2.3.5 Total Ash (Ash): Total ash content was quantified by the incineration method (AOAC, 2005) [1]. Ash content is determined by the following equation:

$$ASH(\%) = \frac{weight\ of\ ash}{weight\ of\ sample} \times 100$$

2.3.6 Carbohydrate: Carbohydrate content was determined by the difference that is by subtracting from hundred the sum of the values for moisture, ash, protein, and fat contents per hundred gm of the sample (Bhuyian *et. al.*, 2018) [8]. Calculation-

% of Carbohydrate = 100 – (Moisture + Ash + Protein + Fat)

2.3.7 Non-Protein Nitrogen (NPN): % NPN was determined by the Kjeldahl method (Jacobs 1973, Crampton *et. al.*, 1969, Pearson 1976) [22, 12, 36] and then the following method described by Jonathan W. DeVries 2017. %NPN was calculated using the following equation:

$$Nitrogen\,\% = \frac{Volume\ used\ of\ \mathrm{H2SO4}\ \times No\ of\ H2SO4 \times 14}{Weight\ of\ original\ sample} \times 100$$

%NPN in sample = (%N in filtrate) × DF

Where, $DF = \frac{g\ sample + g\ water}{g\ sample}$

2.3.8 KOH Protein Solubility (PS): KOH protein solubility content was quantified by following as van Eys (2004) [46] described method.

2.4 Statistical Analysis

One-way Analysis of Variance (ANOVA) was performed on the moisture (%), dry matter (%), crude protein (%), total ash

(%), crude fat (%), and carbohydrate (%) data obtained from the proximate analysis using the Statistical Package for Social Science (SPSS) version 25 and Microsoft excel to make the graphs.

2.5 Determining the Cost per Gram of a Unit Protein

Following the purchase date and determination of the protein content of each component, the cost per kilogram of the feed was noted and calculated by the following formula (Kwikiriza *et al.*, 2016) [26].

Amount of the protein = Percentage crude protein of the ingredient × One kilogram of the ingredient (g)

$$Cost\ per\ kg\ protein = \frac{Cost\ of\ the\ ingredients\ (TK)}{Ammount\ of\ protein\ in\ an\ ingredient\ (g)}$$

3. Results and discussion

3.1 Proximate Analysis

Animal feed has been formulated for an assessment of feed ingredients containing the percentage of crude protein, ether extract, crude fiber, and the amount of ash (Anjum *et al.*, 2014) [5]. A total of 188 distinct samples were received and examined from different sources for this investigation. Table 1 and Table -2 compare the approximate composition of the basic ingredients used in animal feed. There were substantial variances ($p<0.05$) in the mean values of the components' proximate composition.

Table 1: Proximate composition of plant-based feed ingredients (dry matter basis)

Raw Materials Name	N	Moisture	Dry Matter	Crude Protein	Ether Extract	Ash	Carbohydrate
Soybean Meal (South America)	25	11.37±0.59^{b}	88.62±0.59^{c}	46.42±0.23^{a}	1.26±0.48^{bc}	7.22±0.74^{c}	33.70±1.02^{d}
Soybean Meal (Local)	25	11.54±0.63^{b}	88.45±0.63^{c}	44.51±0.50^{c}	0.86±0.74^{c}	7.27±1.08^{c}	35.71±1.65^{c}
Soybean Meal (India)	25	11.59±0.79^{b}	88.40±0.79^{c}	45.48±0.77^{b}	1.27±0.40^{bc}	7.27±0.74^{c}	34.36±1.42^{d}
Rice Polish Atop	25	7.09±1.74^{d}	92.90±1.74^{a}	12.48±0.61^{f}	15.52±1.17^{a}	9.21±1.53^{b}	55.68±2.86a^{a}
DORB	25	13.41±1.09^{a}	86.58±1.09^{d}	16.29±1.77^{e}	1.37±0.55^{b}	13.13±0.93^{a}	55.78±2.23^{a}
Rapeseed Meal	25	10.74±0.52^{c}	89.25±0.52^{b}	36.04±0.74^{d}	1.51±0.55^{b}	8.82±1.14^{b}	42.87±1.28^{b}
F Value		111.957	111.957	7091.624	1725.974	113.990	779.6
P Value		0.000	0.000	0.000	0.000	0.000	0.000

Values with different letters in the same row indicate significant differences ($p\leq 0.05$).

Table 2: Proximate composition of animal-based raw materials (dry matter basis)

Raw Materials Name	N	Moisture	Dry Matter	Crude Protein	Ether Extract	Ash	Carbohydrate
Poultry By-product Meal Type 1 (Malaysia)	11	6.93±1.82^{ab}	93.06±1.82^{ab}	61.56±1.34^{b}	19.50±2.59^{ab}	9.04±1.74^{b}	2.95±1.18^{b}
Poultry By-product Meal Type 2 (Malaysia)	11	7.91±3.08^{a}	92.08±3.08^{b}	56.65±2.40^{c}	22.12±9.07^{a}	7.51±1.11^{b}	5.80±5.77^{ab}
Poultry By-product Meal (Saudi Arabia)	11	5.59±0.62^{b}	94.40±0.62^{a}	67.53±1.01^{a}	15.49±.80^{b}	9.43±0.57^{b}	1.95±0.48^{b}
Fish Meal (Miscellaneous)	5	8.84±1.9^{a}	92.92±2.29^{b}	59.82±3^{b}	5.20±1.03^{c}	17.81±5.93^{a}	8.31±7.51^{a}
F value		3.686	3.686	62.126	13.552	23.439	3.657
P value		0.021	0.021	0.000	0.000	0.000	0.022

Values with different letters in the same row indicate significant differences ($P\leq 0.05$).

Choosing materials that are more than 12% moistened speeds up the breakdown process during storage, therefore moisture level is an important consideration (Akiyama, 1988) [4]. The evaluated plant-based feed materials' moisture levels varied from 7.09±1.74% (rice polish) to 13.41±1.09% (de-oiled rice bran). For the animal-based feed materials' moisture levels were varied from 5.59±0.62% (poultry meal- Saudi Arabia) to 8.84±1.9% (fish meal). According to the national guidelines for animal feed components in Bangladesh, soybean meal, rice polish, and rapeseed meal were either within or slightly below, but the fish meal and poultry by-product meal have moisture levels within the declared range (MoFL, 2013) [32]. On the other hand, de-oiled rice bran surpasses Bangladesh's national fish feed component specifications (MoFL, 2011) [31]. According to dry weight basis proteins are the major organic material in animal tissue, making up about 65 to 75% of the total body weight. Farming prioritizes a minimum dietary requirement for protein or a balanced amino acid mixture to ensure animal growth and health, while providing excessive protein intake is often too expensive due to its high cost (Wilson, 2003). The evaluated plant-based feed materials' protein levels varied from 12.48±0.61% (rice polish) to 45.48±0.77% (Soybean Meal -Local). The evaluated protein content of rice polish (12.48±0.61%) was slightly higher than Moniruzzaman *et al.*, (2022) [33] findings (12.12±0.09%). Plant species varieties can be a major factor in nutrient variation. The evaluated protein content of soybean meal-India (45.48±0.77%), which is below the findings of Galkanda-Arachchige *et al.*, (2021) [18] (49.7 ± 1.4%) and Ravindran *et al.*, (2014) [37] (46.4 ± 1.03%) findings. Where the soybean meal from South America is (46.42±0.23%), and the local soybean meal is (44.51±0.50%). DORB protein content (16.29±1.77%) is also lower than Bhuyain *et al.*, (2018) [8] findings (18.47±1.77%). The protein content of rapeseed meal (36.04±0.74%) was the same with Anjum *et al.*, (2014) [5] findings (36.36± 3.50%). In animal-based ingredients, protein levels varied from 67.53±1.01% (poultry by-product meal- Saudi Arabia) to 56.65±2.40% (poultry by-product meal Type 2, Malaysia). The evaluated protein content of poultry by-product meal Type 1 (Malaysia) was (61.56±1.34%) whereas the fish meal (miscellaneous) was (59.82±3%), which is higher than Bhuyain *et al.*, (2019) findings (57.27±6.66%).

Lipids are a highly concentrated energy source, containing approximately 2.25-fold more energy than carbohydrates (9.44kcal/g or 39.5kJ/g) (Nates, 2015) [34]. The evaluated feed materials fat levels varied from 0.86±0.74% (soybean meal-local) to 15.52±1.17% (rice polish). Soybean meal- South America (1.26±0.48%), Soybean meal- India (1.27±0.40%), De-oiled rice bran (1.37±0.55%), and rapeseed meal (1.51±0.55%) had fat levels exceeding Bangladesh's national animal feed guidelines (MoFL, 2013) [32]. Ravindran *et al.*, (2014) [37] (1.09 ± 0.23%) and Galkanda-Arachchige *et al.*, (2021) [18] (1.20 ± 0.6%) findings are lower than our Indian soybean meals fat level. DORB (1.37±0.55%) fat content is above the findings whereas rice polish (15.96±2.55%) is below of Moniruzzaman *et al.*, (2022) [33] (0.92±0.32%, 20.02±0.87%) findings and rapeseed meal (1.51±0.55%) fat content are also below than Anjum *et al.*, (2014) [5] (6.26± 2.35%). The evaluated animal-based feed materials fat levels varied from 22.12±9.07% (poultry by-product meal Type 2 Malaysia) to 5.20±1.03% (fish meal -miscellaneous) where poultry by-product meal type 1 Malaysia is (19.50±2.59%), poultry by-product meal- Saudi Arabia is (15.49±.80%). We found the highest fat level in poultry meal than the fish meal.

In mammals and fish, carbohydrates are energy sources to run metabolic functions with little storage (Nates, 2015) [34]. A vital component of energy metabolism, glycogen is the main kind of carbohydrate storage in animal cells and is present in the liver, muscle, and other tissues (Sadasivam *et. al*., 2022) [38]. The total carbohydrate content of the components under analysis varies significantly (p<0.05) as well. DORB had the highest carbohydrate content (55.78±2.23%), while Soybean Meal (South America) had the lowest (33.70±1.02%). In the current study, we found Soybean Meal (South America) (33.70±1.02%), Soybean Meal (India) (34.36±1.42%), Rice Polish Atop (55.68±2.86%), and Rapeseed Meal (42.87±1.28%). Bhuiyan *et al.* (2018) [8], reported that the carbohydrate content of soybean meal and DORB was 15.67 and 56.78%, respectively; our results were nearly identical to those of DORB, but the soybean meal (South America, Local, and India) results were lower than our findings. The feed regulations of Bangladesh do not include a standard for the total carbohydrate content of all components. In animal-based ingredients, the total carbohydrate content of the components under analysis varies significantly (p<0.05) as well. Fish meal had the highest carbohydrate content (8.31±7.51%), while poultry by-product meal (Saudi Arabia) had the lowest (1.95±0.48%). In the current study, we found poultry by-product meal type 2 (Malaysia) is (5.80±5.77%), and poultry by-product meal type 1 (Malaysia) is (2.95±1.18%).

The total ash content of the feed components under analysis varies significantly (p<0.05) from one another as well. The DORB had the highest level of ash (13.13±0.93%), while the lowest (7.22±0.74%) was found in soybean meal (South America). Anjum *et al*. (2014) [5], stated in a study that the ash percentage of rapeseed meal, rice polish, and soybean meal was 11.25%, 11.25%, and 7.25%, respectively but for soybean meal our result is varied. We found Soybean Meal (India) (7.27±0.74%) ash is a little bit lower than Ravindran *et al.*, (2014) [37] (7.95 ± 0.82%) but higher than Galkanda-Arachchige *et al.*, (2021) [18] (6.91 ± 1.3%) findings. For DORB, Bhuyan *et al.* (2018) [8] discovered 14.09%, which is likewise more than our results for rapeseed meal (9.08±1.29%) and we found the level (8.82±1.14%) is below his study. In the following study, animal-based raw materials, fish meal (miscellaneous) had the highest level of ash 17.81±5.93%, while the lowest (7.51±1.11%) was found in poultry by-product meal type-1 (Malaysia). We found the level of poultry by-product meal type-2 (Malaysia) (9.04±1.74%), and poultry by-product meal (Saudi Arabia) (9.43±0.57%). According to Bangladesh's feed regulations, there is no standard for the total ash level of any item, but the tested samples met the national requirement.

3.2 Correlations of Soybean Meal's Key Contents

3.2.1 Protein and Moisture

From the regression analysis Fig 2 shows a negative relationship between moisture content and protein content in soybean meal, with the increase of moisture content, the protein content is decreased. However, this relationship doesn't indicate much significance, suggesting that other factors like storage conditions, processing techniques, soybean variety, and non-protein nitrogen may also impact protein content.

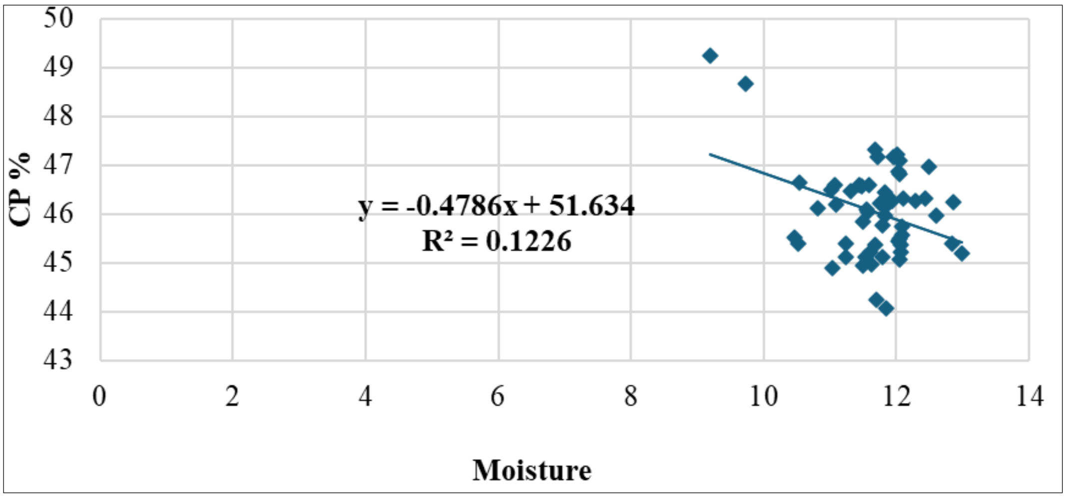


Fig 2: Relationship between Crude Protein (CP) and Moisture

3.2.2 Protein and NPN

A positive relationship is found between protein content and non-protein nitrogen (NPN) content in soybean meals in Fig 3, with 75.94% of protein content variability attributed to NPN content, while moisture content only explains 12.26%. From the linear regression analysis, the NPN content greatly influences soybean meal quality rather than moisture content. In this study protein above 46% of soybean meal shows an NPN level above 1%, whereas protein below or equal to 46% shows a 0.33-0.03% NPN level. DiCostanzo (1994) says the apparent protein content of SBM is increased by the addition of NPN sources.

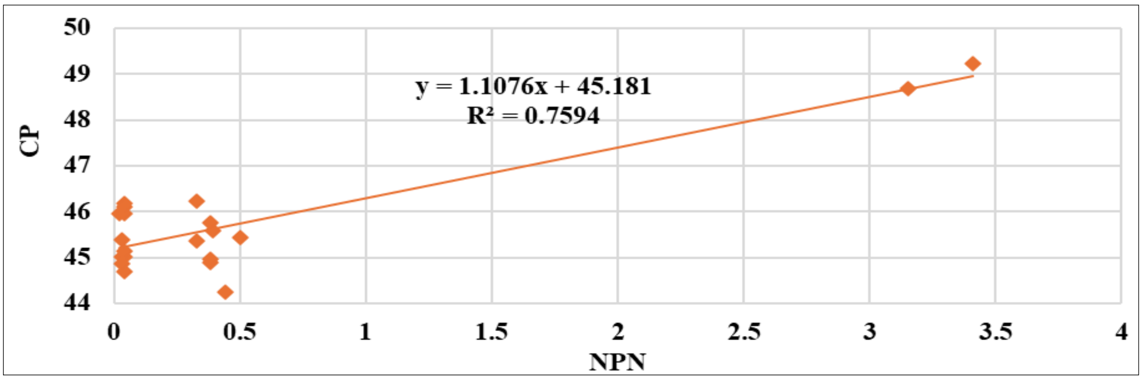


Fig 3: Relations between Crude Protein (CP) and Non-Protein Nitrogen (NPN)

3.2.3 NPN and Protein Solubility

Protein solubility in soybean meal ranges from 78-85% (Van Eys, 2004) [46], with values below 78% indicating over-processed with a reduced amount of lysine and cysteine (Parsons, 2000), and 85% above indicates under-processed, containing trypsin inhibitors, reducing soluble protein by breaking peptide bonds. In Fig 4, protein solubility is correlated with NPN concentration, while NPN concentration increases from 0.03 to 3%, protein solubility decreases from 77.28% to 56.94%, where 34.08% of the variability is explained by the model which indicates there may be some other factors present which influence the protein solubility.

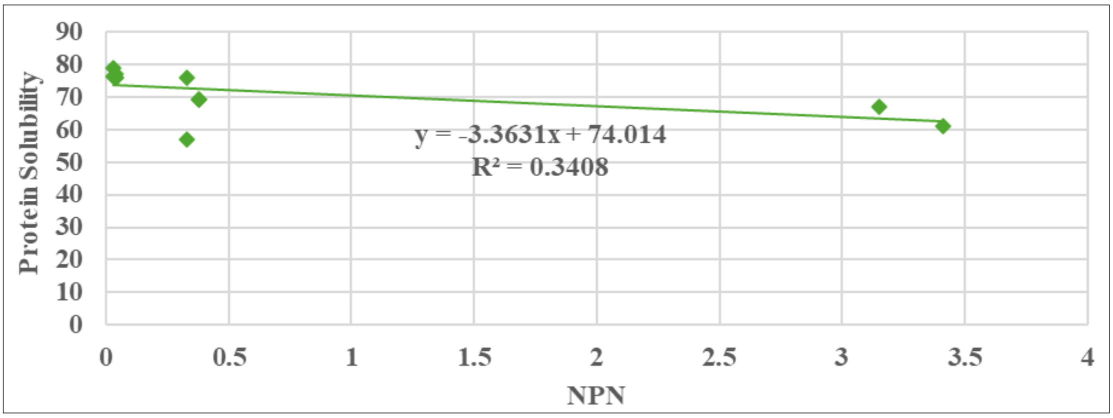
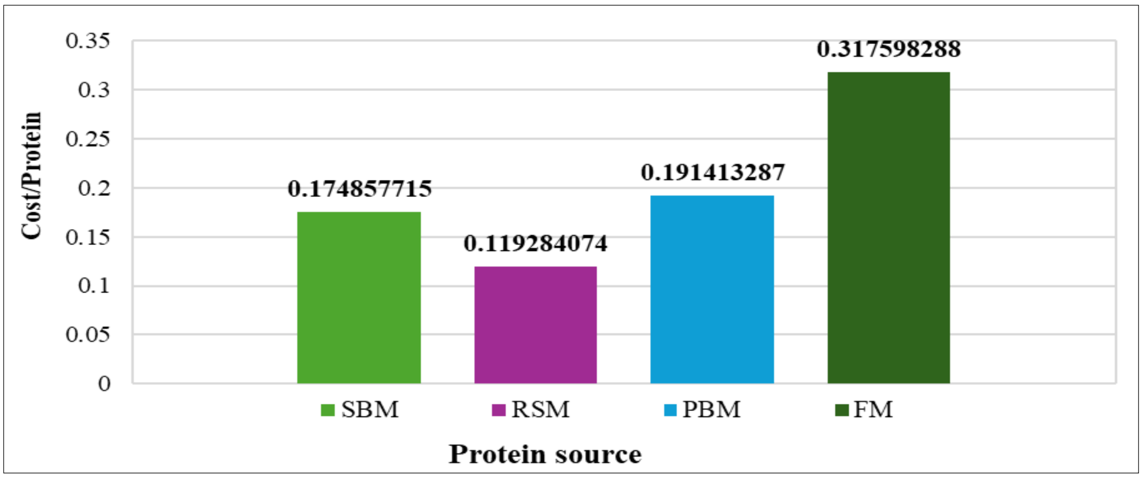


Fig 4: Relations between Protein Solubility (PS) and Non-Protein Nitrogen (NPN)

3.3 Cost Per Gram Unit Protein

In this study, the Fish meal cost the highest rate per gram crude protein (0.31Tk) followed by Soybean meal (0.17Tk), poultry by-product meal (0.19Tk), and rapeseed meal (0.11Tk) with the lowest rate per gram crude protein (Figure 5). Since feed prices, which are based in part on protein, affect profitability in both livestock and aquafarming, using cost-effective yet high-quality protein sources in feed is a primary goal for nutritionists, feed manufacturers, and farmers. Much research has been done on substituting plant-based protein sources for animal-based protein sources in the diets of fish and livestock. All the attempts were almost successful, suggesting that the expense and scarcity of protein sources like fish meal can be substituted by poultry by-product meal, soybean meal, or rapeseed meals if provided with an external essential amino acid supplement. This would lower the cost of the ingredients used in protein sources.



SBM= Soybean Meal, RSM= Rapeseed Meal, PBM= Poultry By-Product Meal, FM=Fish Meal

Fig 5: Estimated cost per gram of Crude protein for analyzed protein source ingredients

Conclusion
Our investigation of raw materials' proximate composition has explained a key function in manufacturing a balanced, reasonably priced, and nutritional animal diet. To evaluate raw materials the proximate study was not our main approach, our primary focus was to bring a short overview of the present status of raw materials composition, predominantly important on the relationship of nitrogenous compound (NPN) with protein content, moisture, and protein solubility. At present, feed mills in Bangladesh are facing ingredient shortages, especially the risen costs and production deficiencies of fish meal. Thus, complementary sources must expose proper vicinity and quality in composition. In these circumstances, our importance on NPN becomes significant, while limits in data availability and laboratory facilities. Even though these are opposed, the results offer valuable opinions on fundamental research activities related to protein contamination. Ensuring the appropriate nutritional constancy of ingredients is essential for the overall strength of the feed industry, assisting it to meet the nutritional needs of animals meritoriously.

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Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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