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MASTER THESIS

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GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

T.R.
NİĞDE ÖMER HALİSDEMİR UNIVERSITY
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DEPARTMENT OF ANIMAL PRODUCTION AND TECHNOLOGIES

DETERMINATION OF NUTRITIVE VALUES OF PEANUTS SHELLS, PEANUT SKINS AND ALMOND HULLS AS RUMINANT FEED

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SEPTEMBER 2021

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Supervisor

Asst. Prof. Dr Sema YAMAN FIRINCIOĞLU

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The study titled "***Determination of Nutritive Values of Peanuts Shells, Peanut Skins and Almond Hulls as Ruminant Feed***" presented by **Nida IRSHAD** under the supervision of Dr. **Sema Yaman Firincioğlu**, has been recognized as Master thesis by the jury at the Department of Animal Production and Technologies of Niğde Ömer Halisdemir University, Graduate School of Natural and Applied Sciences.

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It is certified that I have written this thesis by myself. I further confirm that all information included in this thesis is scientific and is in accordance with the university rules and regulations. Any materials that I have used from external sources as well as help received and all sources used in finalizing this research work and preparing this thesis, all have been acknowledged in the thesis.

Nida IRSHAD

SUMMARY

DETERMINATION OF NUTRITIVE VALUES OF PEANUTS SHELLS, PEANUT SKINS AND ALMOND HULLS AS RUMINANT FEED

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Graduate School of Natural and Applied Sciences
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This study was conducted to examine the chemical composition, nutritive values, in-vitro digestibility, and total phenolic contents of peanut shells, peanut skins, and almond hulls. Samples were divided into three main groups and six subgroups, based on urea treatment and non-treatment i.e., peanut shell (PSc, PSU 5%, PSU 10%), almond hull (AHc, AHU 5%, AHU 10%), and peanut skin (PSk). Chemical analysis of AHU5%, AHU 10%, AHc, and PSk showed lower NDF and ADF values as compared to PSU 5%, PSU 10%, and PSc. In-vitro dry matter digestibility values of AHU 5%, AHU 10%, AHc and PSk were 90.0%, 85.2%, 81.1%, and 67.1% respectively. These results indicated that urea treatments have a significant impact ($p<0.001$) by enhancing NDFD values of almond hulls and peanut shells especially in AHU 5% and PSU 5%. Almond hulls had non-significantly higher ($p>0.05$) total phenolic content than the other samples. It is concluded that PSk, AHU 5%, and PSU 5%, may offer good potential as non-conventional feed sources for ruminants, and play a significant role in the food-feed-food system.

Keywords: Almond hulls, peanut shells, peanut skins, chemical composition, in vitro digestibility

ÖZET

RUMİNANT YEMİ OLARAK YER FISTIĞI İÇ VE DIŞ KABUKLARI VE BADEM KABUĞUNUN İN VİTRO SİNDİRİLEBİLİRLİĞİ VE BESİN BİLEŞİMİNİN BELİRLENMESİ

IRSHAD, Nida
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Bu çalışma, yerfıstığı kabuğu, yerfıstığı iç zarı ve badem kabuğunun kimyasal kompozisyonu, besleme değeri, in-vitro sindirilebilirlik ve toplam fenolik içeriğini incelemek için yürütülmüştür. Örnekler, yerfıstığı kabuğu (PSc, PSU %5, PSU %10), badem kabuğu (AHc, AHU %5, AHU %10) ve yerfıstığı iç zarı (PSk) olarak, üre muameleli ve muamelesiz olmak üzere üç esas grup ve altı alt gruba ayrılmıştır. AHU %5, AHU %10, AHc ve PSk'nin kimyasal analizi, PSU %5, PSU %10 ve PSc ile karşılaştırıldığında daha düşük NDF ve ADF değerleri gösterdi. AHU %5, AHU %10, AHc ve PSk' nın in-vitro kuru madde sindirilebilirlikleri sırasıyla % 85.2, % 81.1, ve % 67.1 dir. Bu sonuçlar, üre muamelerinin özellikle AHU %5 ve PSU %5 badem kabukları ve fıstık kabuklarının NDFD değerlerini artırarak önemli bir etkiye sahip olduğunu ($p<0,001$) göstermektedir. Badem kabuklarının toplam fenolik içeriği diğer öreneklerinkinden önemli derecede yüksektir. PSk, AHU %5 ve PSU %5, geviş getiren hayvanlar için geleneksel olmayan bir yem kaynağı olarak iyi bir potansiyel sunabileceği ve gıda-yem-gıda sisteminde önemli bir rol oynayabileceği sonucuna varılmıştır.

Anahtar Sözcükler: Badem kabuğu, yerfıstığı kabuğu, yerfıstığı iç zarı, kimyasal kompozisyon, in-vitro sindirilebilirlik.

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SYMBOLS AND ABBREVIATIONS

Symbols	Abbreviations
%	Percentage
C^o	Degrees Celsius
G	Gram
Kg	Kilogram
L	Liter
Mg	Milligram
mL	Milliliter

Abbreviations	Descriptions
ADF	Acid Detergent Fiber
AH	Almond Hull
AHc	Almond Hull Control
AHU 10%	10% Urea Treated Almond Hull
AHU 5%	5% Urea Treated Almond Hull
CP	Crude Protein
DM	Dry Matter
IVTD	In Vitro True Digestibility
NDF	Neutral Detergent Fiber
PS	Peanut Shell
PSc	Peanut Shell Control
PSk	Peanut Skin
PSU 5%	5% Urea Treated Peanut Shell
PSU10%	10% Urea Treated Peanut Shell
TPC	Total Phenolic Contents

CHAPTER I

INTRODUCTION

The increase in human population to more than 9 billion by 2075 and the concern about food security highlights the challenge of land use (Zari and Maibritt, 2018). According to latest figures around 33% of croplands are utilized for feed production in livestock sector meanwhile 15% of global greenhouse gas is emitted by enteric and manure fermentation (Mekonnen et al., 2018). An upsurge in demand of animal-based food tended to become the biggest challenge as livestock is the source of one-quarter of total protein intake. By providing livestock recycling biomass from agro-food systems which are usually unsuitable for food cycles, an increase in total efficiency and a good impact on livestock systems can be achieved.

There are two general ways to reduce food-feed–food competition among many 1) The regeneration of natural resources 2) by-products from the agro-food system (Henchion et al., 2017). Eventually the use of agricultural by-products in animal feeding signifies a circular economy model to ensure the creation of nutritious and inexpensive feed by decreasing the livestock system influence from an ecological and social perspective (Van et al., 2016).

The issue of using agro-industrial by-products as animal feeds has been a hot topic of discussion from the last few years (Salami et al., 2019). Nevertheless, there are various factors associated with their chemical composition such as treatments during collecting and handling, botanical origins and climate changes during their cultivation are more important among many others. This unpredictability presents in a broad range of possible ingredients that could be a partial or total replacement for various feeds in ruminant rations (Sol et al., 2017). Roughages can be replaced by the agro-industrial by-products with fibre content and concentrates can be exchanged by contents of reusable grains in ration (Molina-Alcaide et al., 2008; Salman et al., 2014).

An alternative protein supplement is the use of some by-products rich in nitrogen (Lashkari et al., 2013; Oltramari et al., 2016; Zeid., 2017). Therefore, instead of making suggestions about their insertion in ruminant diets researchers need to expand their knowledge and get complete information related to nutritive value and chemical structure of substances obtained from agriculture cultivation.

Agricultural residues can be in form of plant by-products (PBP) or crop residue. PBP is secondary biomass acquired after harvesting the crops, while crop residue signifies primary biomass left on the field following harvesting (Johnson and Linke-Hepp, 2007). The nutritional portfolio of PBP is better than crop residues and can be a better source of fibre, protein, and energy to maintain the requirements of animals. Meanwhile, the technical situations occurred during the manufacturing of primary residues may affect the feeding quality of PBP. A major problem that limits the use of PBP is the need of better preservation techniques because current techniques sometimes effect the nutritional quality of PBP which leads to formation of deteriorated quality feed (Ajila et al., 2012; Wadhwa and Bakshi, 2013).

As compared to monogastric animals the forestomach of ruminants contains a diverse microbial environment. This kind of environment is suitable for the use of PBP because it contains fungi, protozoa, phages, archaea and most importantly bacteria which engaged by mutual interactions with these ruminants. In process of microbial fermentation, the rumen produces VFA (volatile fatty acids) by interacting with nutrients present in low quality and high-fibre diets. The microbial protein become a good source of high digestible protein and energy for animals (McCann et al., 2016). The structure and range of the rumen microbiome is indeed depending on the diet. To raise the feeding value of PBP there are many dietary options. Several of them focus on microbial protein manufacturing and the efficacy of fermentation in rumen (Wadhwa et al., 2016). There are policies like balancing ration by cleansing of phytotoxins, use of nutritional enhancements (feed enzymes, botanical additives, and probiotics), the dietary supplementation of non-protein nitrogen and use of energy, protein, and minerals which can be implemented for use of such by-products (Wadhwa et al., 2016).

By-products from agriculture industry have been extensively used in ruminant nutrition for a long time now (Wadhwa and Bakshi, 2013). There are several researchers working on using these recycled by-products to encode them in food-feed-food systems. An emerging curiosity is the use of polyphenolic by-products from fruits such as grape pomegranates, by products of peanuts and almonds among many others. These polyphenol-rich extracts can supply natural antioxidants to animals for improving their production and performance.

The peanut is considered to have originated from South and Central America and then its farming spread to other parts of globe. Peanut is a legume classified as *Arachis hypogaea* and generally known as groundnut or goober. Now a days with more than 300 varieties peanut farming is done in Japan, Africa, South America, India, USA and China (Settaluri et al., 2012). Peanut by product is used for oil production at commercial level but apart from this it contains many functional components like antioxidants, minerals, vitamins, fibers, proteins, and polyphenols. Peanuts have compounds like flavonoids and resveratrol which help in blockage of cholesterol absorption from diet. All twenty essential amino acids are present in peanuts. They have enzyme Q10, and its bioactive compounds which are known to have disease preventive properties.

The useful effect of bailed peanut hay as livestock feed was observed in some studies conducted by Khan et al., (2013). Spend groundnut hay includes important plant nutrients and organic matter that may lead to great benefits within the soil of the field. The most substantial by-product of groundnut production is groundnut vine that is projected to be 60–65% of total groundnut production (Zhao et al., 2012).

These past twenty years due to market demand the nutrition aspects of groundnuts has been changed. New scientific research has been focused during past two decades. The prime thing is to optimize the original value of groundnut by-products. The secondary objective is to characterize and quantify the potential effects of groundnut edible fibre, their phenolic compounds, and proteins. The third and most important topic under observation was the effect of nutritional aspects of groundnut by-products on animal and human health. Such kind of studies are important to analyze the effects of potential by-products on living beings. This kind of topic has a lot of limitations and it require further investigation.

Scientifically *Prunus dulcis* which is commonly called as almond belongs to Rosaceae family and it is also linked with stone fruits like cherries, plums, and peaches (Jahanban et al., 2009). Almond can be consumed with or without brown skin as a whole nut or it can used in production of sweets and chocolates and its discarded materials are used as feed for livestock (Takeoka et al., 2000). Use of such material as animal feed is an excellent way of recycling and environmental protection (Huber, 1981). The drying of almond fruit portion which surrounds the hard-shell leads to the obstinance of almond hull. Based on DM, the proption of nut, shell and hull is 25%, 25% and 50% respectively (Fadel, 1999).

In the past few decades production of almond by-products has been rising rapidly. Almonds are highly useful nuts as they can be consumed in various ways i.e., raw, roasted, ground in form of butter or almond milk. After peanuts almonds are the second most used nuts in the whole world. Total ingredient value of almonds in 2020 was valued at USD 8234.8 and it is estimated to reach USD 11680 million by the end of 2027, growing at a CAGR of 6.0% during 2022-2027 (Almond Ingredients Market 2021). Almond hulls are dried in process of harvesting unlike other by-products i.e., pulps or pomaces etc. Long-term storage, reducing transportation costs and low moisture contents are making this by-product attractive for animal feed (Reed., 1998). Global use of by-products as feed stuff is common practice now a days but still there is a big gap among the documentation and use of PBP as livestock feed.

This study aims at evaluating the nutritive value of selected agro-industrial by products of almonds (*Prunus dulcis, syn. Prunus amygdalus*) and peanuts (*Arachis hypogaea*) cultivated in Turkey, by determining chemical composition, in-vitro digestibility, and total phenolic contents. The huge inconsistency among plant-based by-products in chemical structure and nutritive value for ruminants signifies an essential problem, making it hard to ascertain general suggestions on their use as feed for livestock. This study is designed to determine and compare the chemical composition as well as in vitro digestibility of agro-industrial by-products as an indicator of their potential use as feedstuffs for ruminants.

Ruminant feeding systems based on locally available agro-industrial by-products are an economic, environmentally friendly, and practical alternative. Especially, for the conventional ruminant feeds, there has been increased interest in the evaluation of their nutritive value. Therefore, this research is important in establishing the vista of opportunities available in replacing or at least modifying conventional feed ration of ruminants through the evaluation of the nutritive potentials of widely available agro-industrial by-products such as peanut and almond by products for improved ruminant nutrition, reduced organic solid waste disposal and lowering of feed production cost

CHAPTER II

LITERATURE REVIEW

2.1 Biggest Challenge of the Era

The biggest challenge the world is facing these days is food production and supply especially during pandemic times. Increasing population is a key factor in this situation. World population is estimated to cross a number of 9 billion by the end of 2050 (Röös et al., 2017). Agricultural production must keep a pace with this ever-growing number. To over this hunger challenges the production for agriculture sector is estimated to increase up to 60% by the end of 2050. However, concerns about food-feed-food system are not unfolded properly. If the population number continues and growth tendency remained constant another 2.4 billion people will live in Sub-Saharan Africa and South Asia. Size of population is also expected to raise in urban areas in years 2000 and 2030 (Bommer et al., 2018).

More than 20% of world population staying is rural areas and suffering from food security and supply problems (Popp et al, 2014). Covid-19 has badly affected the food-feed-chains and cause a huge damage to overall production speed. To satisfy these demands a harmonized food-feed-food system is needed. Using agricultural by-product can work as a two-way mechanism to control hunger challenge and recycling problems (Irshad and Fırıncıoğlu, 2021).

2.2 What are Agricultural By-Products?

Agricultural by-product can be regarded as the organic waste products from animal and plant origin. There is a vast range of these by-products including plant stalk, plant leaves, skins, hulls and shells of various plants, skins, peels, and pomaces of different fruits, bedding materials and other vegetative discard and waste by-product after the processing of fruits and vegetables.

2.3 Use of Agricultural By-Products as Animal Feed

According to our current time zone, two billion more people will need to be fed in the upcoming twenty years, and because of the recent Covid-19 pandemic, the world is learning about the potential difficulties to transport necessities to far-off affected areas in drastic situations. This increasing population demand and irrepressible food wastage will defiantly lead to an uncontrolled hunger challenge in upcoming years. The use of agriculture by products as feed is one of the possible solutions that we can implement to overcome most of the production problems.

Two apparent possibilities for improving accessibility of feedstuffs are, effective utilization of accessible feed supplies and development of the feed supply base, particularly concentrating on those feed reserves that do not participate with human food. The production of farm-fresh vegetables has risen from 239.7 to 279.7 million tons, and it will go on increasing in the future, creating accessibility for a variety of waste materials and by-products that can be used as animal feed (FAO, 2015). Similarly, the use of fruit waste by-products can also be a good source to manage the hunger challenge and to balance the disturbed food-feed-food cycle. This use of agricultural by-products as feed for animals will not only boost food safety but also provide a good solution for elevated environmental problems caused by these waste products associated with their disposal.

2.4 Origin of Edible Peanuts and Almonds with their Specific Characteristics

Edible nuts have always been a part of our lives including condiments, oils, beverages, and spices etc. They have been playing an important role in food chain from prehistoric times and are considered the most nutritious portion of foods as they are higher in energy, minerals, oils, vitamins, and proteins. Peanut which are also famous as groundnuts, pindar, goober or monkey nut and taxonomically categorize as *Arachis hypogaea* is mostly a legume known for its edible seeds. Peanuts are widely produced in tropical and subtropical areas around the globe. They are considered as both oil crops and grain legumes due to their multi characteristics. Background of peanuts suggested their South American origin. 8500 years ago, these nuts shifted from in Northern Peru probably from Andes Mountains even though the shells found there didn’t have exact similarities with modern groundnuts. In past during the era of American discovery they were cultivated only in tropical and subtropical areas of this hemisphere. Indian cultivations of peanuts were found by Spanish and Portuguese explorers, and they transferred these varieties from West India to Brazil and Peru. Later from these areas groundnuts were distributed to Africa, Pacific Islands, Asia, and whole Europe. Finally, they reach the southeastern US, but the exact place and time was not recorded.

Almond trees belongs to Rosaceae family and subgenus Amygdalus which has over thirty species (Zohary, 1996). By the historical prospective almonds played an important economic role in Mediterranean human culture (Martinoli and Jacomet, 2004). Almond additionally expands well in different regions of Turkey (Özcan, 2011). Since last few decades almond oil has been used by medical and cosmetic producers (Hallabo et al., 1975). Furthermore, almond is an essential food crop, differing in usage from edible nut in its natural state to insertion as a key component in synthetic food commodities. Sometimes almond kernels are grounded and made into a paste for producing a variety of bakery products (Kester and Asay, 1979). Almond skins, hulls and shells are recycled and used in livestock feed and bedding.

2.5 Chemical Composition of Peanut Skins, Peanut Shells and Almond Hulls

Chemical composition of peanut skin showed that the moisture content ranged between 9.71 to 11.0 percent, XA values observed between 2.07 to 2.13%, fat content was seen between 9.59 to 10.2%, CP value was examined 8.88 to 12.7%, and dietary fibre was obtained from 38.8 to 42.8%. The major kind of amino acids observed in peanut skins were glutamine, phenylalanine, lysine, and glycine. Additionally, some important fatty acids were also observed i.e., linoleic, palmitic and oleic acids (Rodrigo et al., 2021). Toomer (2020) explained different varieties of by-products tends to give a bit different range of results.

Chemical composition of almond hulls was observed by many researchers. The value of crude protein usually ranges between 2-8 percent (Fadel, 1999). The values for crude ash showed a range between 5-12 percent (Getachew et al., 2002). There are a range of values that were observed for ADF composition i.e., 28-3849 percent (Norollahi et al., 2005). Shultz et al., 1993 found that apparent digestibility of DM for twenty-four hours in rumen is 56 percent for almond hulls by using in-sacco technique. Thus, almond hulls can be considered as a good source of energy. Almond can be consumed with or without brown skin as a whole nut or it can used in production of sweets and chocolates and its discarded materials are used as feed for livestock (Takeoka et al., 2000). Use of such material as animal feed is an excellent way of recycling and environmental protection (Huber, 1981). The drying of almond fruit portion which surrounds the hard-shell leads to the obstinance of almond hull. Based on DM, the proption of nut, shell and hull is 25%, 25% and 50% respectively (Fadel, 1999).

Chemical analyses of peanut shells showed 7.76 percent of crude protein. In terms of crude ash, the values are also high i.e., 7.17 percent. Peanut shells showed higher level of lignin contents around 29.26 percent (Gong et al., 2015). Peanut shells have lower digestibility as compared to other agricultural by-products (Rehrah et al., 2014). Peanut shells have higher amount tannins and strong lignocellulosic bonds (Pizzi, 2018) (Bobet et al., 2020). The high level of lignin is the basic cause of lower digestibility in peanut shells (Anike et al., 2016) (Shen et al., 2018). The useful effect of bailed peanut hay as livestock feed was observed in some studies conducted by Khan et al., (2013). Spend groundnut hay includes important plant nutrients and organic matter that may lead to great benefits within the soil of the field. The most substantial by-product of groundnut production is groundnut vine that is projected to be 60–65% of total groundnut production (Zhao et al., 2012).

2.6 Peanut Skins as Ruminant Feeding Material

There are some experiments done on the use of peanut by-products as ruminant feed. Only a little number of skins are used as cattle feed while the rest of them are wasted by peanut-processing industry (Sobolev and Cole, 2003). Peanut skins are a good source of antioxidants. It is very important to utilize this discarded by-product to increase the value of economy, to control the misuse of these skins and to use them as antioxidants by protecting the environment. Meanwhile these ground-skins can be a cheap source of polyphenols and be used as a functional component in dietary industry (Yu et al., 2006).

Groundnut is considered as a potentially rich source of procyanidin and a large amount of it is present in by-products of groundnuts. Peanut skins contain a very high concentration of phenolic compounds. A few studies suggest that peanut skins may contain compounds of procyanidin (Nepote et al., 2004). The study showed that by addition of skins (15 percent) to whole groundnut ration, the value of crude protein showed a lower but important reduction up to 7 percent. Nevertheless, the lowered crude protein digestibility with groundnut skins might not be ascribable to the unfavorable impact of tannin, particularly when the decrease is not significant, because groundnut skins themselves were computed to have a minimal crude protein digestibleness.

To determine the performance and digestibility of beef cattle two feedlot trails were conducted with a metabolism study. In the trail treatments like urea supplementation and ammoniation were done on groundnut skin diets as a technique for the purpose of tannin reduction in those diets. After the process of ammoniation tannin reduction was obvious with a percentage of 42%. Coefficient of digestibility were higher for values of energy, DM, CP, NFE and total nutrient composition. When steers were given fed-limited diet containing urea supplanted groundnut skins no improvement were seen in N retention and digestibility. Nevertheless, to overcome the impact of tannins on feedlot performance of heifers and steers an ammoniated ad libitum groundnut skin feeding was highly effective (Hill et al., 1986).

2.7 Peanut Shells as Ruminant Feeding Material

Harvested groundnuts are graded on the bases of their size, flavor, quality and after passing through the shelling machine we obtain hulls and kernels. In groundnut industry hulls are considered as an abundant by-product. According to an estimation a total 230-300grams of peanut hulls are produced by processing of 1-kilogram peanuts (Zhao et al., 2012). These hulls are a very important source of fiber as the contain almost 43.7% crude fibre (CP) (Collins and Post, 1981).

Different concentrations of urea (0, 2, 3 and 5 gram urea per 100 gram dry matter) or of different doses of gamma irradiation (0, 100, 150, 200 kGy) were used to check the effects on gross energy (GE), in-vitro digestible energy (IVDE), in-vitro organic matter digestibility (IVOMD) and cell-wall constituents of peanut shell, soybean shell, cotton seed shell, extracted olive cake, wheat straw and extracted unpeeled sunflower seeds (M.R et al., 1999).The findings suggested that urea treatments or gamma irradiation were ascribed to reduces cell-wall constituents, rises IVOMD and boosted the digestible energy values significantly ($P < 0.05$). There was no major impact of irradiation and urea treatments on gross energy. The investigational agronomic by-products didn't react to the treatments in the same amount in increasing the IVOMD. There was no major impact of irradiation and urea treatments on gross energy. Pooled treatments had somewhat less influence in rising in-vitro digestible energy as the addition of both effects. By using 5 percent urea or a dose of 200 kGy gamma irradiation showed a better result i.e., an increase in IVDE and decrease in cell-wall material concentration as compared using a single treatment. However, in some studied agricultural by-products the applied irradiation doses could decrease by increasing the IVDE (M.R et al., 1999). Meanwhile these groundnuts have a high amount of tannins which precipitates the dietary proteins to make them inaccessible to the digestive tract of both ruminant and non-ruminant (Karchesy and Hemingway, 1986).

2.8 Almond Hull as Ruminant Feeding Material

Sixteen lactating yearling Alpine goats were used in an experiment where 4 chopped rations of related chemical composition were provided ad libitum and period. The rations contain 58.4, 42.5, 32, and 22 percent alfalfa hay on dry matter basis, 0, 15, 25, and 35% almond hulls (AH): 0, 0.5, 1, and 1 percent of urea. In this experiment chromic oxide was used as a digestibility marker. Standard nutrient makeup of diets was 4.39 Mcal gross energy per kilogram, 9% ash, 32% NDF, 20% CP and 91% DM. A randomly assigned structure was used for goats as one of four diet orders in repetitions of a four × four Latin square. The collection of data was started in the third week of each period. A visible rise in dry matter intake was observed with the reduction in percentage and digestibility of milk protein, ash, NDF, organic matter and DM. DMI and weight gain were above average for the diet comprising 35% AH and 1% urea. Findings suggest that AH and urea can be given to lactating goats up to these quantities with no negative influence on lactation (Reed and Brown., 1988). Chemical analyses indicate that AH have 50 to 60 percent NFE, 10 to 30 percent moisture, 4 to 7 percent ash, 10 to l7 percent fiber, 2 to 5 percent protein and 1 to 4 percent fat. This high value of NFE includes sugars and other readily available carbohydrates. The overall sugars vary from 50 to 55 percent of the finely ground hulls are soluble in in hot water, 41 to 45 percent in cold water and some18.3 to 30.56 percent. About 10 percent moisture is present usually in AH under air dry conditions. By raising each 1 percent moisture from 10 percent, a visible 1% decrease in the value of AH was observed.

Six different varieties of almonds named Nonpareil variety, IXL, Ne Plus Ultra, Drake, Mission and Peerless were used to determine the mix effect of hull and shell. Chemical analysis was performed and in actual analysis values might deviate between higher or lower but predicted values for CP would be 18.3, 20.5, 22.6, 26.6, 28.9 and 30.8 for above mentioned varieties respectively (Velasco *et al.*, 1965).

In situ nylon bag technique was used to determine the nutritive contents of AH, alfalfa, and sugar beet pulp. Four different types of AH i.e. Rabbi (RAB), Mamaii (MAM), Shahrud 15 (SH15), and Shokufe (SH) were compared with sugar beet pulp and alfalfa on basis of ruminal DM degradation kinetics. Sample were incubated for 0, 4, 8, 12, 16, 24, 48, 72 and ninety-six hours in three rumen-fistulated steers in form of triplicates. Alfalfa had lowest total degradability fraction (TDF) (67%), sugar beet pulp had highest (89%) meanwhile AH stand in middle with 86.5% TDF. Hower in comparison with alfalfa (20 percent) and sugar beet pulp (SB pulp) (20 percent) the soluble fraction of AH was higher i.e., fifty-five percent. This higher fraction indicated that AH was imputed to their comparatively lower neutral detergent fiber content and higher nonfibrous carbohydrate than alfalfa and sugar beet pulp. The experiment revealed that AH is possible feed supply for ruminants (Jafari *et al.*, 2015).

Can *et al.*, (2007) checked the effect of substituting wheat straw with AH and almond shell (AS) in diets on nutrient digestibility and blood parameters of goat. In experiment 8 male Kilis goats were placed in 4x4 Latin square design using 4 animal groups (2 animals of each), four periods and four diets. Diets were 20 or 40 percent wheat straw or AH and AS, offset being a compound feed. AH and AS ingesting goats had better DMI with no impact on digestibleness or blood parameters apart from reduced blood urea level. Consequently, AH and AS appear to be a secure and acceptable roughage for goats and can supplant wheat straw.

Jairo *et al.*, (2019) observed the nutritive value of twenty-six different agro-industrial by-products. In the experiment parameters like chemical composition, IVD and rumen fermentation kinetics. By-products from SB, almond, artichoke, broad beans broccoli, citrus, asparagus, green bean, grape, olive tree, peas, apple pomace, tomato, pepper, and lettuce were evaluated. Many of them can be considered as prospective components in rations of ruminants due to the large variety among by-products. each by-product can provide alternative sources of soluble fibre (SBP), protein (asparagus rinds), less digestible roughage (pepper skin or grape seeds) and energy (sugar beet pulp).

2.9 Present Research

Out of global agricultural production, roughly thirty percent consist of agriculture and food waste (FAO, 2015). This waste includes sugar-industry wastes, fruit and vegetable wastes, lignocellulosic materials as well as animal and fisheries rejected byproducts. Many bioactive compounds such as polyphenols, dietary fibers and carotenoids are present in big quantities in these agriculture-by-products. By-products of almond and peanuts are enriched with these components. Although some in-vitro studies have been carried out on the nutritive value of almonds and groundnuts, there is no study comparing the nutritive value of both. So present study was done to fully explain and compare their nutritive values and in-vitro digestibility in ruminants. The opportunity to further assess and adequately understand the nutritive value of both by-products for use in ruminant nutrition still poses itself.

CHAPTER III

MATERIAL AND METHODS

3.1 Materials

Almond hulls, peanut skins and peanut shells are three main materials that we used in this experiment. Two kilograms of each sample was collected from different harvesting farms present in central Anatolian region. The chemical value, in-vitro digestibility and total phenolic contents of these samples were determined in the animal nutrition laboratory of the Ayhan Sahenk Faculty of Agricultural Science and Technologies in Niğde Ömer Halisdemir university, Turkey. Prior to chemical analysis and in-vitro digestibility the samples were treated with urea to reduce the content of tannins and to break the strong lignocellulosic bond present in cell wall of almond hulls and peanut shells.

3.2 Preparation of Samples

All three samples were weighed and putted in the hot air oven for forty-eight hours at 55^0C. After completing the time, they were removed from the hot air oven and placed to cool down at ambient laboratory temperature. The samples were then weighed by electric weighing balance till four digits. The process of grinding is done by using laboratory mill (Retsch ZM 200) with 1mm sieve at 1400 rpm. After grinding samples were placed in plastic bags and labelled accordingly.

Figure 3.1. Drying of raw samples in hot air oven for 48 hours

3.3 Urea Treatment of Almond Hulls and Peanut Shells

Samples were divided into three different groups and six subgroups. In first group simply peanut skins (PSk) were kept. In second group peanut shells were putted and they were further divided in subgroups i.e., control peanut shell (PSc), 5% urea treated peanut shell (PSU 5%) and 10% urea treated peanut shell (PSU 10%). In 3rd and last group almond hulls were kept and further divided into almond hull control (AHc), 5% urea treated almond hull (AHU 5%) and 10% urea treated almond hull (AHU10%). A good mixing of the samples of groups one and two was done with 5% and 10% of urea solutions (50 g urea dissolved in 950g of water and 100g urea dissolved in 900g of water). Treated samples were stored in prelabelled and sealed nylon bags in the laboratory (22±24◦C) for 21 days. After 21 days the samples were putted again in hot air oven at 55◦C for 3 days. Then, the samples were stored at -20◦C in sealed nylon bags for later analyses.

Figure 3.2. Urea treated samples after labelling

3.4 Analytical Procedures

Dry matter (DM), and ash (XA) were determined according to procedures described by AOAC (1995). Crude protein (CP) values were calculated using Kjeldahl apparatus. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) evaluation was done using the method of Van Soest (1991). In vitro true digestibility (IVTD) was performed by using DAISY II incubator by ANKOM Technology (Macedon, NY). Furthermore, total phenolic contents (TPC) were examined from untreated samples by using the Folin-Ciocalteu technique.

3.4.1 Determination of dry matter

The freeze samples were thawed for 24 hours at room temperature to start the chemical analysis. Crucibles were cleansed and placed in hot air oven for two hours to a constant weight (W1) so that they can be dried. One gram of each urea treated, and non-treated samples were weighed using weighing balance and their weight was calculated as W2 and sample was putted in pre-weighed crucibles. Then all the samples were placed in hot air oven for 24 hours at 105^0C. After the period of twenty-four hours these samples were taken out and putted in a desiccator for cooling at ambient room temperature and after that they were weighed as W3. Finally, the value of DM was computed by using the following equation 3.1.

$$DM\ \% = ((W3 - W1)/W2) \times 100 \tag{3.1}$$

3.4.2 Determination of ash

Crucibles containing samples were kept for 4 hours in muffle's furnace at the temperature of 600 degree Celsius. After the period of 4 hours the samples were evacuated and kept in a desiccator so that they can cool down to room temperature (25^{0}C). W4 was the final weight that was recorded as weight of crucibles plus samples. XA of each group of skins, shells and hulls was calculated using equation (3.2). Organic matter was determined by deducting the % ash content from 100.

$$XA\% = ((W4 - W1)/W2) \times 100 \tag{3.2}$$

3.4.3 Determination of crude protein

Sweden based Opsis LiquidLine KjelROC analyzer was used for digestion, distillation, titeration and the final estimation of samples to determine the CP values. Each one gram of sample was considered and placed in Opsis tube as repeats. Each tube also contained 12 milliliter of sulfuric acid and 2 Kjedahl tablets. Protein digester was adjusted at 420^{0}C for 60 minutes after placing the tubes in digestion block. Fumes were released during the process which were neutralized to regulate the suction during the process of digestion. The block was placed to cool down at ambient temperature after the completion of heating. Distillation and titration of Opsis LiquidLine KjelROC analyzer were operated to determine the protein values. The analyzer was attached with a distil water tank, 40 percent solution of NaOH (sodium hydroxide) and 1 percent boric acid containing mixture of indicators (70 milligram methyl red solved singly in 100 milliliter of methanol and 100 milligrams of bromocresol green) for the process of distillation and titration. Blank was calculated before CP analyses and instrument was auto cleaned. The nitrogen factor 6.25 for % CP determination was set already in the analyzer. The weights of samples were included into the machine before analyzing and the matching weighed tubes were examined for CP. On completion of titration and distillation the CP value for the sample in each tube was shown on the display screen. A gentle tapping was given to the bags for uniformity of sample and exclusion of any clump.

3.4.4 Determination of neutral detergent fiber

To determine NDF ANKOM 200 fiber analyzer was used. Fifteen filter bags (F57) were labelled with solvent resistant marker. Firstly, the weight of each empty filter bag was calculated. Then after that 0.5 gram of each sample was added into the bags, and these bags were weighed again. A heat sealer was used to seal the bag up to 4 millimeters at the top. For measurement of blank bag correction factor C1 one blank bag was also weighed to add in the run. To make 1 littler solution of NDF 10 mL triethylene glycol, 4.56 grams Sodium phosphate dibasic, 6.81grams Sodium borate, 18.61grams of ethylenediaminetetraacetic disodium salt and 30 grams Sodium dodecyl sulfate were mixed in 1 litter of distilled water. Each tray was arranged in 120^0 rotation and a total of three bags were arranged in all sections separately. The tray then placed in Fibre analyzer vessel and a suspender weight was putted on the top for the submersion of bags. After arranging the tray, a 2000 milliliters of neutral detergent solution were poured into the analyzer. During the process of extraction another twenty gram of sodium sulphite and four milliliters of alpha amylase was added. Firstly, the tray was agitated for 5 minutes after closing the lid. After agitation the heating button was turned on and set the timer for next 75 minutes. After that period was over both buttons were turned off and drainage of hot solution (by opening the valve before the lid) was done. The process of rinsing was performed (two times for 5 minutes) by adding 900^0C of water with another 4 milliliters of alpha amylase. In the third rinse tap water was used instead of hot water without further adding alpha amylase. After ending the rinsing process one by one removal of bags were performed by gently tapping them to extract extra water. Then prior to drying them for almost twenty minutes on a filer paper, the bags were soaked in acetone for whole five minutes. At 105^0 temperature for the period of 2 hours the bags were putted in hot air oven for complete drying. A collapsible desiccant pouch was used to place the bags for cooling after oven drying. In the final step the bags were weighed by using weighing balance as W3 and the NDF% was determined by using equation 3.3.

$$NDF\ \% = ((W3-(W1\times C1))/W2) \times 100 \quad (3.3)$$

Where W1=Bag tare weight

W2 = Sample weight

W3 = Dried weight of bag with fiber after extraction process

C1 = Blank bag correction (final oven – dried weight divided by the original blank bag weight).

3.4.5 Determination of acid detergent fiber

To determine ADF ANKOM 200 fiber analyzer was used. Fifteen filter bags (F57) were labelled with solvent resistant marker. Firstly, the weight of each empty filter bags was calculated as W1. Then after that 0.5 gram of each sample was added into the bags, and bags were weighed again i.e., W2. A heat sealer was used to seal the bag up to 4 millimeters at the top. For measurement of blank bag correction factor C1 one blank bag was also weighed to add in the run. To make 1 littler solution of ADF 20 g cetyl trimethylammonium bromide (CTAB) with 1 L of 1.00N suphuric acid. Each tray was arranged in 120^0 rotation and a total of three bags were arranged in all sections of tray separately. The tray then placed in Fibre analyzer vessel and a suspender weight was putted on the top for the submersion of bags. After arranging the tray, a 2000 milliliters of acid detergent solution were poured into the analyzer. Firstly, the tray was agitated for 5 minutes after closing the lid. After agitation the heating button was turned on and set the timer for next 75 minutes. After that period was over both buttons were turned off and drain the hot solution by opening the valve before the lid was set off. The process of rinsing was performed (two times for 5 minutes) by adding 900^0C of water. In the third rinse tap water was used instead of hot water without further adding alpha amylase. After ending the rinsing process one by one removal of bags was performed by gently tapping them to extract extra water. Then prior to drying them for almost twenty minutes on a filer paper, the bags were soaked in acetone for whole five minutes. At 105^0 temperature for the period of 2 hours the bags were putted in hot air oven for complete drying. A collapsible desiccant pouch was used to place the bags for cooling after oven drying. In the final step the bags were weighed by using weighing balance as W3 and the ADF% was determined by using equation 3.4.

$$ADF\ \% = ((W3-(W1 \times C1))/W2) \times 100 \tag{3.4}$$

Where W1=Bag tare weight

W2 = Sample weight

W3 = Dried weight of bag with fiber after extraction process

C1 = Blank bag correction (final oven – dried weight divided by the original blank bag weight).

3.5 Determination of In-vitro True Digestibility (IVTD)

Determination of IVTD of all three groups of skins, shells and hulls were performed in ANKOM DAISY II incubator (Macedon, NY). The instrument has four different containers of 2000 milliliter capacity for incubation. To complete this number 400 milliliter of rumen liquor was mixed in 1600 milliliter of buffer solution. The filter bags were putted in the containers.

3.5.1 Preparation of filter bags and samples

ANKOM F57 filter bags were completely air-dried after rinsing in acetone for 3 minutes. The weight of each bag was determined by analytical balance as W1. Then after that 0.5 gram of each sample was added into the bags, and bags were weighed again i.e., W2. A heat sealer was used to seal the bag with 4 millimeters of the top. For measurement of blank bag correction factor C1 one blank bag was also weighed to add in the run. The experiment was run in two batch with triplicates of each group of skins, shells and hulls.

3.5.2 Preparation of buffer solution (A and B)

By using the reagents present in Table 3.1 two different solutions of Buffer A and Buffer B were prepared 12 hours before period of incubation. The basic solution B was added in a volume of 266 milliliter into an acid solution of 1330 milliliter. To obtain a final pH of 6.8 at 39^{0}C the addition of solution A into solution B was adjusted by pH meter.

3.5.3 Preparation of rumen liquor

From a commercial slaughterhouse in Niğde the rumen liquor of two matured and slaughtered Holstein cattle was obtained in two 2000 milliliter capacity thermos flasks which was preheated at 39^0C and to store the collective liquor purged carbon oxide was used. Before coming back to the laboratory two wads of fibrous mat from the cattle rumen were added in one of the flasks. The rumen liquor was emptied into an electronic mixer that was preheated to 39^0C.

Table 3.1. Arrangement of reagents for buffer solution A and B

Reagents	g/L
Buffer solution A	
KH_2PO_4	10
$MgSO_4.7H_2O$	0.5
NaCl	0.5
$CaCl_2.2H_2O$	0.1
Urea	0.5
Buffer Solution B	
Na_2CO_3	15
$Na_2S.9H_2O$	1

Before blending the rumen liquor for thirty seconds, CO_2 gas was used to purge for almost same period. A nineteen-litter preheated (39ºC) flask was used to pour the filtrate by using a four-layer cheesecloth. Same process was repeated with residual liquor present in the other flask. A continuous CO_2 was repeated into the 5-liter flask until the digesta was transferred into the containers.

Figure 3.3. Blending the rumen liquor for thirty seconds

3.5.4 Sample incubation

In the containers/ jars of Daisy II incubator, 1600 milliliter of Buffer (A and B mixed) was poured with 400 milliliter of rumen liquor and CO_2 was used again to purge them for 30 seconds. In three of Daisy II incubator jars the blank Filter bags for C1 were equally divided. After CO_2 purging the digestion containers were sealed tightly. All these containers were placed in ANKOM Daisy II incubator for forty-eight hours at temperature of 39±0.5ºC. After the completion of digestion time the Filters bags were rinsed with tap water (after removal from ANKOM jars) to stop any further microbial activity. Prelabelled sealed bags were used to put the F57 Filter bags in refrigerator before any further determination of NDF. For the next step ANKOM200 Fiber Analyzer was used and weight of bags for NDF determination was calculated as W3. Equations 3.5 and 3.6 were used to determine % IVTD.

$$\%IVTD \text{ (As fed basis)} = ((W3-(W1\times C1))/W2) \times 100 \tag{3.5}$$

$$\%IVTD\ (DM\ basis) = ((W3-(W1*C1))/(W2*DM)) \times 100 \quad (3.6)$$

W1 = Bag tare weight

W2 = Sample weight

W3 = Final bag weight after in-vitro and consequent ND treatment

C1 = Blank bag correction (last oven-dried weight/initial blank bag weight).

3.5.5 Determination of neutral detergent fiber

To determine NDF ANKOM 200 fiber analyzer was used. The F57 filter bags were labelled with solvent resistant marker. Firstly, the weight of each empty filter bags was calculated. Then after that 0.5 gram of each group of samples was added into the bags, and bags were weighed again. A heat sealer was used to seal the bag up to 4 millimeters at the top. For measurement of blank bag correction factor C1 one blank bag was also weighed to add in the run. To make 1 littler solution of NDF 10.0 mL triethylene glycol, 4.56 grams Sodium phosphate dibasic, 6.81 grams Sodium borate, 18.61 grams of ethylenediaminetetraacetic disodium salt and 30 grams Sodium dodecyl sulfate were mixed in 1 litter of distilled water. Each tray was arranged in 120^o rotation and a total of three bags were arranged in all sections of tray separately. The tray then placed in Fibre analyzer vessel and a suspender weight was putted on the top for the submersion of bags. After arranging the tray, a 2000 milliliters of neutral detergent solution were poured into the analyzer. During the process of extraction another twenty grams of sodium sulphite and four milliliters of alpha amylase was added. Firstly, the tray was agitated for 5 minutes after closing the lid. After agitation the heating button was turned on and set the timer for next 75 minutes. After that period was over both buttons were turned off and drain the hot solution by opening the valve before the lid was set off. The process of rinsing was performed (two times for 5 minutes) by adding 900^{o}C of water with another 4 milliliters of alpha amylase. In the third rinse tap water was used instead of hot water without further adding alpha amylase. After ending the rinsing process one by one removal of bags were performed by gently tapping them to extract extra water. Then prior to drying them for almost twenty minutes on a filer paper, the bags were soaked in acetone for whole five minutes. At 105^o temperature for the period of 2 hours the bags were putted in hot air oven for complete drying. A collapsible desiccant pouch was used to place the bags for cooling after oven drying. In the final step the bags were weighed by using weighing balance as W3 and the NDF% was determined by using equation 3.7.

$$NDF\ \% = ((W3-(W1*C1))/W2) \times 100 \quad (3.7)$$

Where W1=Bag tare weight
W2 = Sample weight
W3 = Dried weight of bag with fiber after extraction process
C1 = Blank bag correction (final oven – dried weight divided by the original blank bag weight).

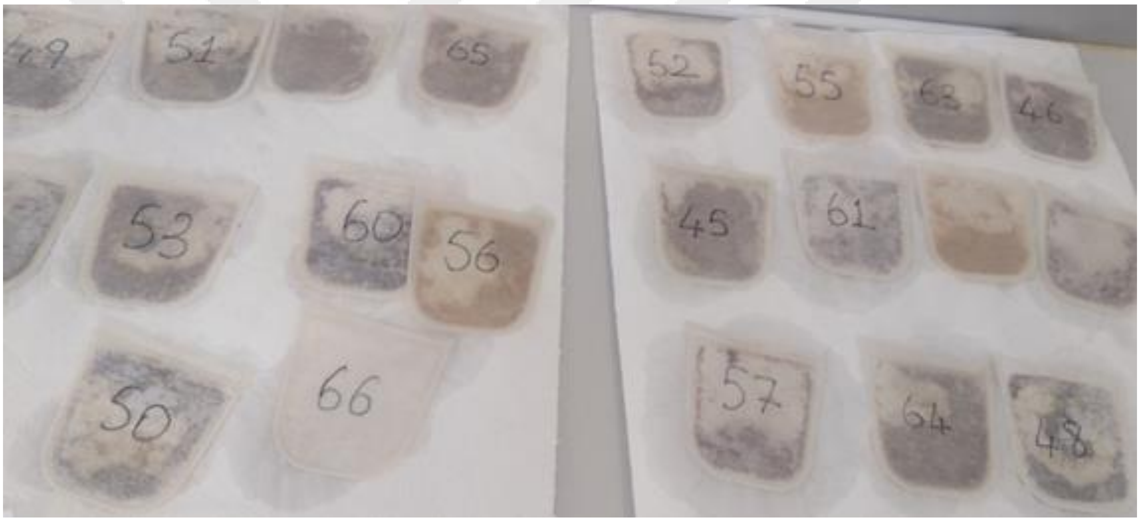

Figure 3.4. Drying of filter bags on a filter paper after rinsing

3.6 Total Phenolic Content (TPC)

The evaluation of total phenolic content is centered on a redox reaction. The samples have their phenolic compounds and by adding a reagent named Folin-Ciocalteu they turned into an oxidized form. To prepare a standard graph a chemical named gallic acid is used as a standard. Different concentrations of this standard were used with methanol (0.1, 0.06, 0.05 and 0.04 (mg/mL) to read the absorbance by spectrophotometry. The graph was drawn against values of different concentration. Total phenolic contents were suggested according to the graph (Slinkard and Singleton, 1977). For these 20 grams of each sample was mixed with two hundred millilitter of 80% of methanol. The samples were kept in prelabelled flasks for 6 hours in a dark space. The excerpts were then filtered through Whatman No 4-filter paper. A rotatory evaporator was used to evaporate the supernatants mixed with methanol under a vacuum at temperature of 55ºC. After completion of extraction the remaining 20% liquid was stored at -80ºC in a freezer until further evaluation. Five milliliters of 0.2N Folin-Ciocalteu was mixed with 900 µL of distilled water for the formulation Folin-Ciocalteu reagent. 100 µL of the solution diluted from the extract of each group of skins, shells and hulls were mixed in 4 milliliter of saturated sodium carbonate (Na_2CO_3) solution (7.5 gram/litter). Before checking the absorbance curve in spectrophotometer at 765 nm the samples were putted in dark place for 2 hours. TPC of samples were calculated as mg gallic acid/ 100 gram of dry weight applying an equation acquired from standard Gallic acid graph.

3.7 Statistical Analysis

All statistical analysis was done by using a software Jamovi which is mainly used to get an ordinariness, homogeneousness, and individuality of data. Each ground of skins, shells and hulls were subjected by chemical limitations to Kruskal-Wallis' nonparametric one-way ANOVA while Tukey's multiple comparison test for ANOVA was done to further analyze the impact of groups on IVTD. Statistical connotation was described at $P \leq 0.001$ and findings achieved from these analyses were stated as tables and graphs.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Chemical Analysis

There was no statistical significance in the mean of the DM, XA, CP, NDF, and ADF acquired for each group of samples at (P> 0.05) using the Kruskal Wallis, one-way ANOVA on defenses by using a non- parametric technique. By ranking the means (Table 4.1 and 4.2), peanut skins had highest DM value among peanut groups while almond hull followed it closely. Also, PSc had the highest XA values while PSk had the highest CP values followed by AHU 10%. Untreated peanut shells (PSc) have highest NDF and ADF values. Appendix I shows the comprehensive result of analysis for chemical parameters of all samples.

This study shows that almond hulls do have some higher nutritive value followed by peanut skins as compared to peanut shells. Although there was no statistical significance in the mean of dry matter, ash content, crude protein, neutral detergent fiber, and acid detergent fiber obtained for the skins, shells, and hulls at (P >0.05).

Further to this, the almond hulls and peanut skins had the highest dry matter (Table 4.1) amongst all other groups. Peanut shells also had the highest NDF (Table 4.1) value amongst the group of skins, shells, and hulls. The differences in the values obtained for the chemical parameters of the different groups of skins, shells and hulls can be due to the source, maturity stage and methodology.

4.1.1 Dry matter contents

All the groups of skins, shells and hulls had dry matter of over 89%. Peanut skins (PSk) had higher dry matter compared to the AHU 10% lowest dry matter of 89% (Table 4.1).

The dry matter value obtained for control group of almond hulls (95.1%) falls in the range described by Yalchi, (2011). While DM values for 5% and AHU 10% (89-90.7%)

falls in the range of values according to Rad et al, (2016). However, DM values for 5 and 10% PSU is 90.7-91.1% which is slightly lower than mentioned by Donia et al., 2014 (92.1%). Dry matter composition for PSk (96.9%) is a bit higher than DM value mentioned by Palmer, (2010) and Saito et al., (2016). The slight variations in values can be caused due to environment, methodology or species of peanut skins.

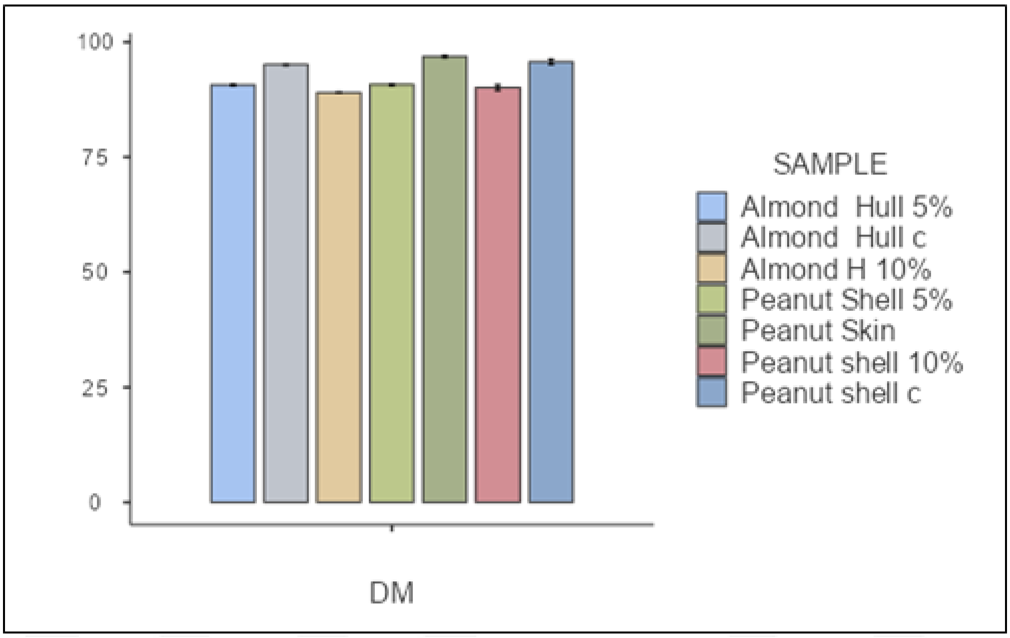

Figure 4.1. Graph showing the DM (dry matter) values of each group of skins, shells, and hulls (p>0.05)

4.1.2 Ash contents

The ash content of all groups of samples was ranged between 3.46% – 5.43% (Table 4.1). Peanut shells generally had the highest XA for all three treated and untreated groups among all other groups. Conversely, AHU 5% showed the lowest XA.

The XA value obtained for control group of almond hulls is 5.15% which is closer to the range describe by DePeters et al., (2020) and Swanson et al., (2021). The values of crude ash for peanut shells are according to the values determined by Palmer, (2010). XA values for peanut skins are slightly higher 4.27±0.09 than described by Saito et al., (2016).

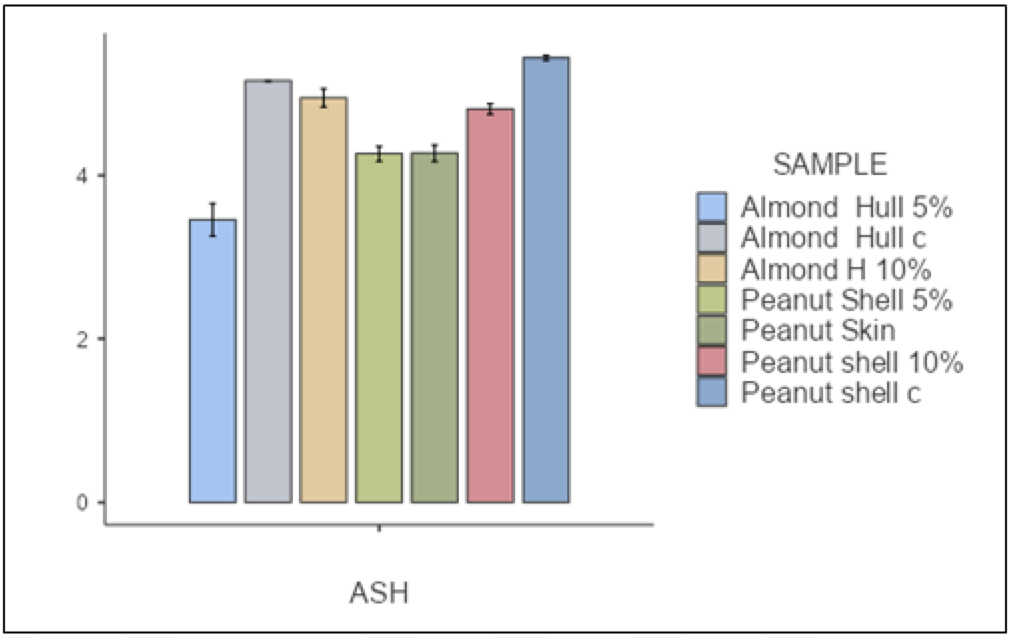

Figure 4.2. Graph showing the XA (crude ash) values of each group of skins, shells, and hulls (p>0.05)

4.1.3 Crude protein contents

The CP values for skins, shells, and hulls ranged from 2.67%- 15.2%. Peanut skins had the highest CP values of 15.2% followed by 10% urea treated almond hulls i.e., 14.3% (Table 4.1). The lowest crude protein values of 2.67% and 7.61% were found in untreated almond hulls and untreated peanut shells, respectively.

Crude protein value for peanut skin in this experiment is highest among the rest of groups is close to the range described by Palmer, (2010) and Saito et al., (2016). This little variation of two percent might happen due to the difference in variety of peanut skins or environment. Additionally, Ursula et al., (2021) mentioned almost same CP values for peanut skins. However, CP values for untreated peanut shells are exactly according to Palmer's experiment (7-8%). CP values for untreated almond hulls are close to the value described by Kordi and Naserian, (2020) and Swanson et al., (2021). CP value of 5% urea treated almond hulls is 10.8±0.15 which is close to the range mentioned by Rad et al., (2016). Meanwhile crude protein value for 5% urea treated peanut shells was a bit lower than attained by Donia et al., 2014. The difference may cause due to change in variety of shells used in experiment.

The results revealed that urea treatment is quite effective to increase the level of crude protein values. Higher CP values of almond hulls after treatments i.e., AHU 5 % and AHU 10% have showed the breakage the strong lignocellulosic bond. Although CP values of PSU 5% and PSU 10 % are lesser than treated almond hulls but still they have shown a visible difference from the control group. Meanwhile untreated PSk showed highest level of crude protein.

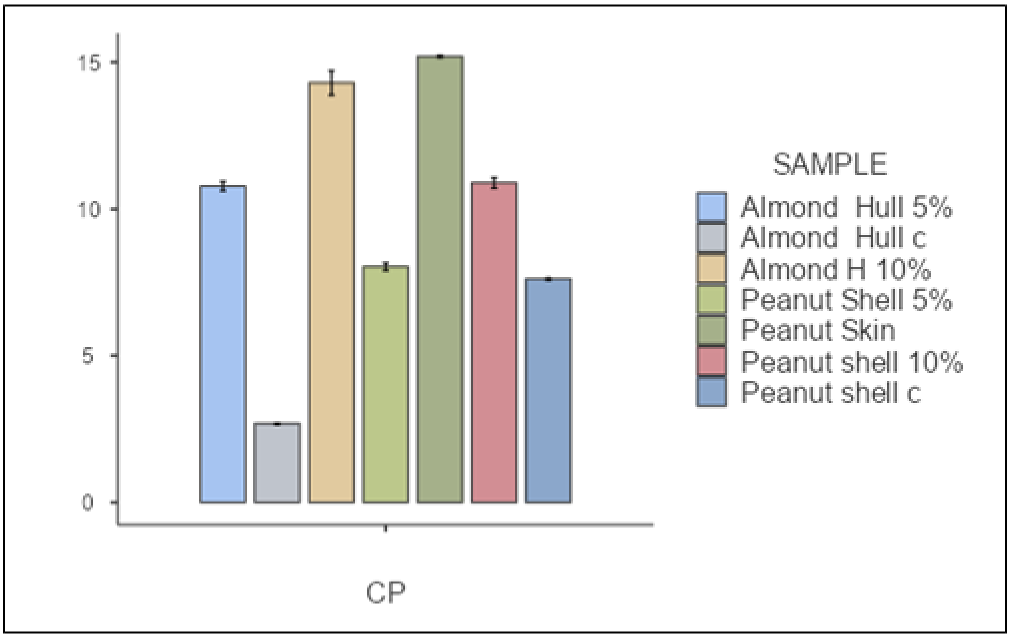

Figure 4.3. Graph showing the CP (crude protein) values of each group of skins, shells, and hulls (p>0.05)

4.1.4 Neutral detergent fiber contents

The Neutral detergent fiber (NDF) for each group of samples was ranged from 31.1% - 66.5% as seen in Table 4.1. PSc, PSU 10% and PSU 5% had the highest NDF of 66.5%, 57.9% and 55.4% respectively. All three subgroups of almond hulls had the lowest NDF values as compared to other groups followed by peanut skins.

NDF values for urea treated and untreated peanut hulls are close to the values attained by Donia et al., (2014). Neutral detergent fibre value for peanut skins is also near the range described by Palmer, (2010). Hower NDF values for untreated almond hulls is according to the range provided by Arosemena et al., (1995). Obtained values for urea treated almond hulls are a little lower than given by Rad et al., (2016). Which might be due to the mixed varieties of hulls used by Rad et al., (2016).

Higher NDF values of untreated peanut shells showed the presence of great amount tannins. The decrease in these values in PSU 5% and PSU 10% displayed the breakage of lignocellulosic bond between the cell wall contents by addition of urea. The decrease in NDF values of almond hulls after treatment also showed the reduction in level of lignin. It is quite visible that AHU 5% displayed lower NDF than AHU 10 % and AHc. PSU 5% also showed lowest values among PSU 10% and PSc. These results indicate that urea treatments showed a good difference by reducing the NDF values of almond hulls and peanut shells especially in AHU 5% and PSU 5%.

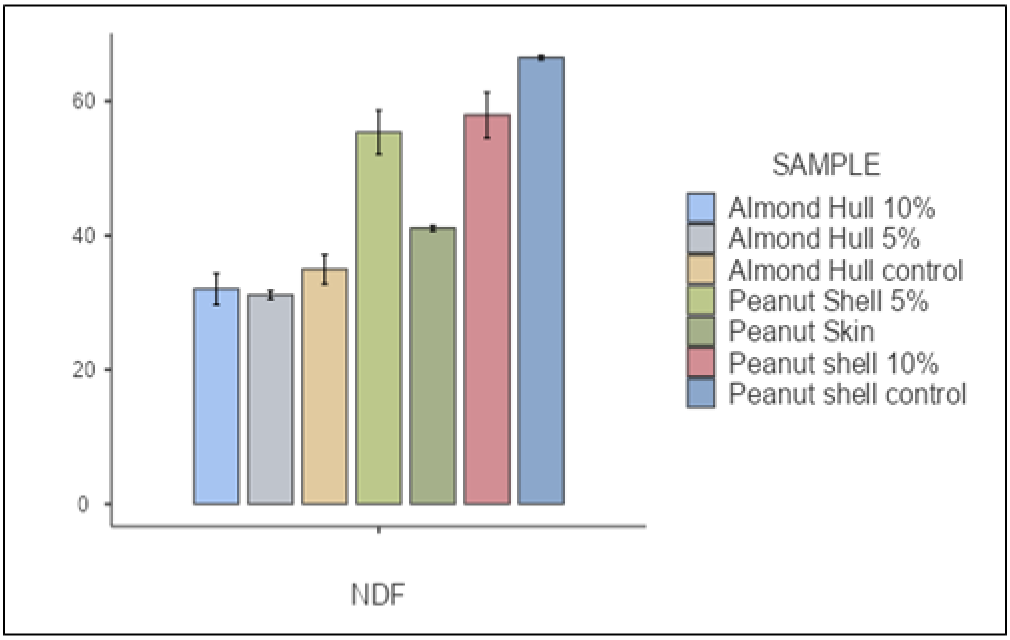

Figure 4.4. Graph showing the NDF values of each group of skins, shells, and hulls ($p>0.05$)

4.1.5 Acid detergent fiber contents

The Acid detergent fiber (NDF) for each sample was ranged from 15.4%-47% as seen in Table 4.1. PSc, PSU 10% and PSU 5% had the highest ADF of 47%, 40.8% and 41.6% respectively. All three subgroups of almond hulls had the lowest ADF values as compared to other groups followed by peanut skins.

ADF values for 5% urea treated (41.6±0.73) and untreated peanut hulls (47±0.02) are close to the values attained by Donia et al., (2014). ADF value for untreated almond hull (20.2±1.13) is according to the range defined by Arosemena et al., (1995) and Yalchi, (2011). Meanwhile ADF values for different subgroups of urea treated almond hulls are a bit lower than the values obtained by Rad et al., (2016). Which might be due to the mixed varieties of hulls used by Rad et al., (2016). Furthermore, ADF value for peanut skins falls near the range provided by Ursula et al., (2021).

Higher ADF values of untreated peanut shells showed the presence of great amount tannins. The decrease in these values in PSU 5% and PSU 10% displayed the breakage of lignocellulosic bond between the cell wall contents by addition of urea. The decrease in ADF values of almond hulls after treatment also showed the reduction in level of lignin. It is quite visible that AHU 5% displayed lower NDF than AHU 10 % and AHc. PSU 5% also showed lowest values among PSU 10% and PSc. These results indicate that urea treatments showed a good difference by reducing the ADF values of almond hulls and peanut shells especially in AHU 5% and PSU 5%.

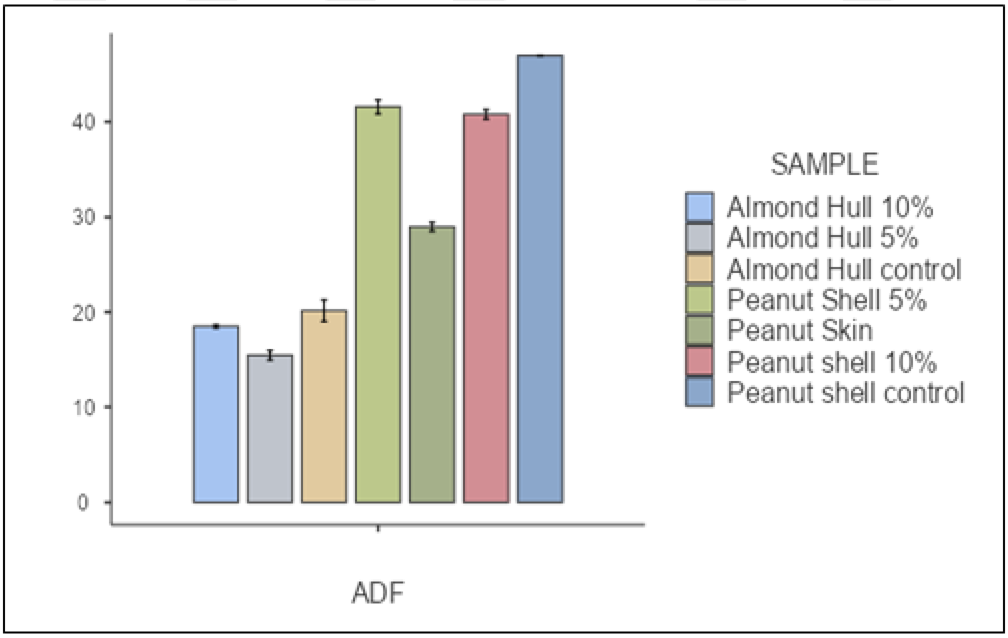

Figure 4.5. Graph showing the NDF values of each group of skins, shells, and hulls (p>0.05)

Table 4.1. Chemical composition of peanut skins, peanut shells, and almond hulls (%)

Unit	Sample	Treatment	DM	XA	CP	NDF	ADF
1	Almond Hull	Control	95.1±0.11	5.15±0.00*	2.67±0.02	35.0±2.20	20.2±1.13
2	Almond Hull	5% Urea	90.7±0.17	3.46±0.19	10.8±0.15	31.1±0.63	15.4±0.50
3	Almond Hull	10% Urea	89.0±0.05	4.94±0.11	14.3±0.41	32±2.33	18.5±0.17
4	Peanut Shell	Control	95.7±0.52	5.43±0.03	7.61±0.03	66.5±0.31*	47±0.02*
5	Peanut Shell	5% Urea	90.7±0.17	4.26±0.08	8.03±0.12	55.4±1.28	41.6±0.73
6	Peanut Shell	10% Urea	90.1±0.60	4.81±0.06	10.9±0.17	57.9±3.41	40.8±0.49
7	Peanut Skin	Untreated	96.9±0.23*	4.27±0.09	15.2±0.03*	41.1±0.39	29±0.47

At p>0.05 all samples and treatments were not significantly different for all parameters. However (*) shows the sample that ranked highest based on mean for each parameter.

4.2 In-vitro Digestibility

There were important impacts of different groups and subgroups of skins, shells, and hulls for the IVTD (DM) and neutral detergent fibre disappearance (NDFD%) in this experiment. The results showed a range of different results comparatively.

4.2.1 Invitro dry matter digestibility

Peanut shell control had the lowest in-vitro dry matter digestibility of 43.4% of the samples while AHU 5 % (90.0%) had the highest of the samples at (P ≤0.001). At P ≤0.001, there was a significant effect among the groups and subgroups of skins, shells, and hulls (Table 4.2). The high statistical significance between species was seen with Almond Hulls 5% U vs Almond Hull 10% U: AHc vs AHU 5% and AHU 10%, PSc vs PSU 5% and PSU10%. Also, between the samples (Skins, shells, and hulls) there was highly significant difference (P ≤0.001) (Table 4.2).

Invitro DM digestibility for untreated peanut hulls is 43.48±0.22 which is very close to the value given by Donia et al., (2014). However, values for urea treated peanut skins are bit higher than his results which might happen due to change in variety of peanut skins or environment.

In vitro DM digestibility for subgroups of urea treated and untreated almond hulls are a little bit higher than the results got on apparent digestibility by Rad et al., (2016). Apparently, there is only a few literatures present regarding urea treatment on almond hulls so the results in this experiment cannot be compared with the wide range of literature and can be considered an input in this specific field. West et al., (1993) used peanut mixed diets up to 24% and showed that mixing peanuts increase the invitro DM digestibility.

Table 4.2. IVTD values of peanut skins, peanut shells and almond hulls (%)

UNIT	Sample	Treatment	IVTD (As Fed)	IVTD (DM)	NDFD%
1	Almond Hull	Control	81.1± 0.41^{c}	81.1±0.56^{c}	43.4±1.25^{c}
2	Almond Hull	5% Urea	90±0.55^{a}	90.0±0.56^{a}	64.5±1.98^{a}
3	Almond Hull	10% Urea	85.2±0.56^{b}	85.21±0.56^{b}	49.5±1.47^{b}
4	Peanut Shell	Control	43.6±0.22^{g}	43.48±0.22^{g}	6.4±0.37^{d}
5	Peanut Shell	5% Urea	58.14±0.60^{e}	58.1±0.61^{e}	17.1±1.14^{cd}
6	Peanut Shell	10% Urea	55.1±0.43^{f}	55.0±0.43^{f}	14.1±0.82^{cd}
7	Peanut Skin	Un treated	66.9±0.08^{d}	67.1±0.22^{d}	17±0.22^{cd}

At $p<0.001$, the samples and treatments were significantly different for each parameter, and this is indicated by the superscripts a-g.

4.2.2 In-vitro NDF digestibility

Peanut Shell control had the lowest NDFD% among the groups and subgroups samples while AHU 5% (64.5%) had the highest within the sample at ($P \leq 0.001$). At $P \leq 0.001$, there was a significant difference among the groups and subgroups. The high statistical significance between them was seen with AHU 5% vs AHU 10%: AHc vs AHU 5% and 10%; PSc vs PSU 5 and 10%. Also, between the samples (skins, shells, and hulls) there was highly significant difference ($P \leq 0.001$).

Invitro NDFD value obtained for untreated almond hulls in the experiment is close to the value observed by Yalchi (2011). NDFD values for peanut skins are lower than the one obtained by Saito et al., (2015) and Farhat et al., (1998). NDFD values for peanut hulls have also shown a bit difference from the values described by Hadjipanayiotou et al., (1998). This can be due to variation in varieties of materials used, methodology of experiment or environment where it is performed. The effect urea treated almond hulls has observed only in vivo digestibility which showed 368 g /kg ash free NDF digestibility values in lambs. Apparently, there is only a few literatures present regarding urea treatment on peanut shells, and almond hulls particularly in terms of in-vitro digestibility so the results in this experiment cannot be compared with the wide range of literature and can be considered an input in this specific field.

Lower NDFD values of untreated peanut shells showed the presence of great amount tannins. The increase these values in PSU 5% and PSU 10% displayed the breakage of lignocellulosic bond between the cell wall contents due to presence of urea. The increase in NDFD values of almond hulls after treatment also showed the reduction in level of lignin. It is quite visible that AHU 5% displayed higher NDFD% than AHU 10 % and AHc. PSU 5% also showed highest values among PSU 10% and PSc. These results indicate that urea treatments showed a good difference by enhancing NDFD values of almond hulls and peanut shells especially in AHU 5% and PSU 5%.

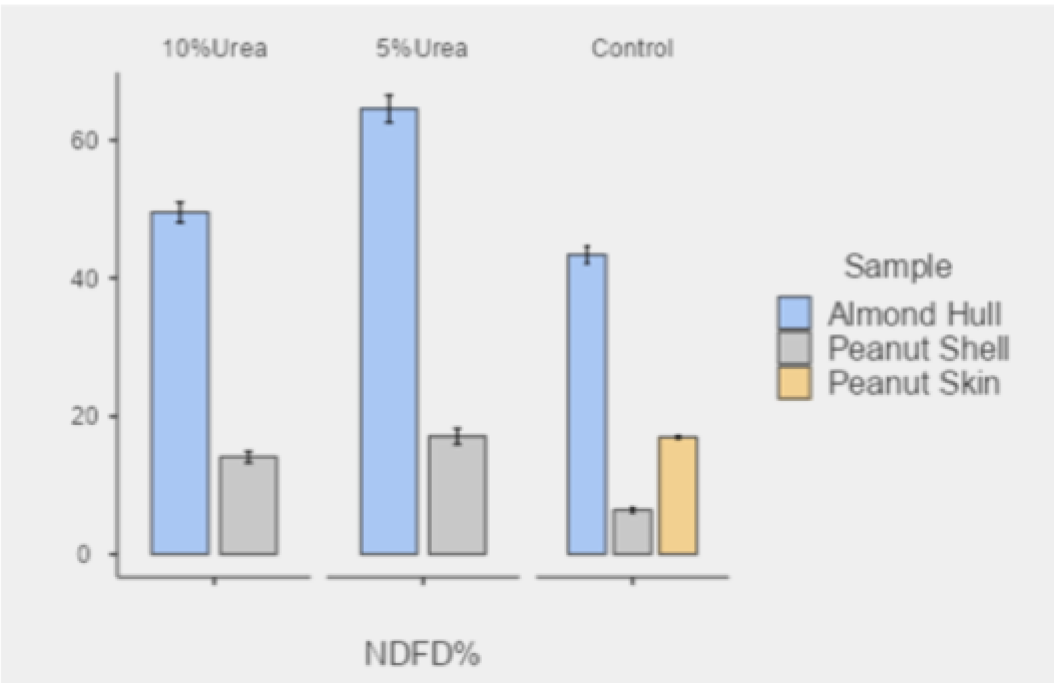

Figure 4.6. Graph showing the neutral detergent fibre digestibility (NDFD) of each group of skins, shells, and hulls

4.3 Total Phenolic Contents

TPC values in the groups of skins, shells and hulls are presented in table 4.3 and figure 4.3. The results revealed that significantly higher ($P < 0.05$) of almond hulls (1061±1.51) as compared to rest. However, peanut skins had significantly higher TPC as compared to the peanut shells (224.36 ± 1.20 vs. 75.12 ± 0.60; respectively), which indicates that Almond hulls have highest TPC values followed by Peanut skins.

Toomer, (2020) described the phenolic contents in peanut skins and the values range according to experiment. In present experiment the UV absorbance for TPC is a bit higher than the value provided by the Nepote et al., (2002). This difference might possible due to different varieties of peanuts used in both experiments.

TPC values for almond hulls also showed a bit higher absorbance than the variety of almonds used by Pinelo et al., (2004). Toomer, (2020) explained different varieties of by-products tends to give a bit different range of results. Peanut shells on the other hand showed a bit closer result evaluated by Yen et al., (1993) and treatment range described by Lee et al., (2006).

The results of UV spectrum indicate that almond hulls showed highest level of absorbance which is due to higher phenolic contents present in almond hulls (Table 4.3). Peanut skins also showed good absorbance values under the UV spectrum presenting them as a good source of phenolic contents. However, the absorbance spectra for peanut shells are quite lower which is direct representation of lesser number of phenolic contents in them (figure 4.7).

Table 4.3. Total phenolic contents (mg GAE/100 g-[1] DW) of almond hulls, peanut skins, and peanut shells (p>0.05)

Groups	TPC
Almond Hulls	1061±1.51*
Peanut Skins	224.36 ± 1.20
Peanut Shells	75.12 ± 0.60

(*) Shows the highest TPC sample.

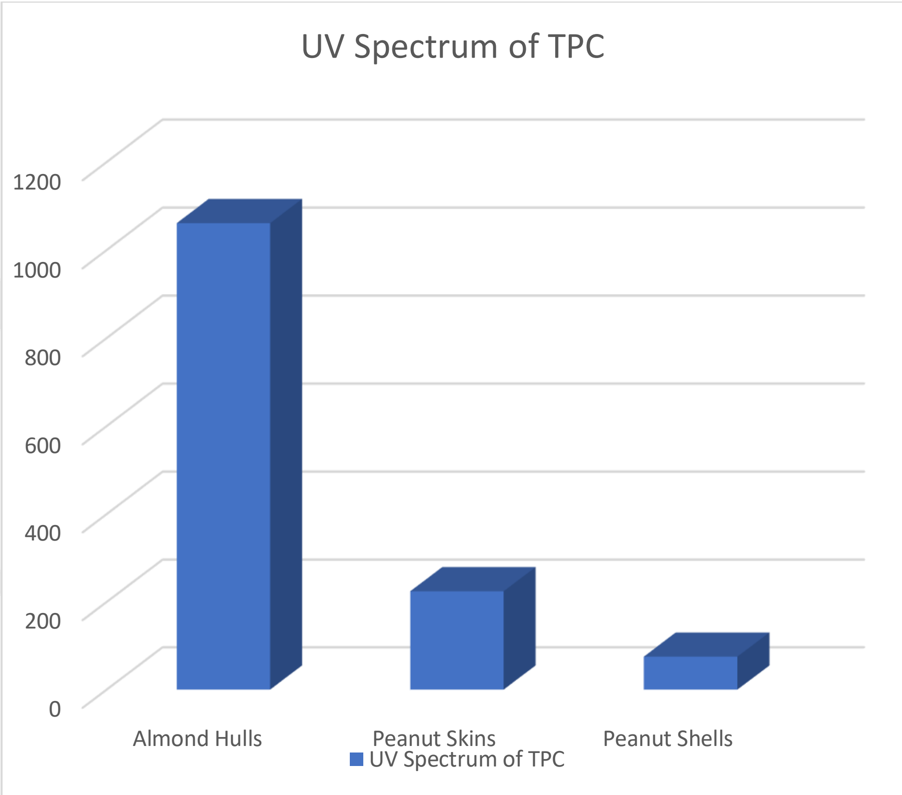

Figure 4.7. Total phenolic contents (mg GAE/100 g-[1] DW) of almond hulls, peanut skins, and peanut shells (p>0.05)

4.4 Scope for Future Research

Out of global agricultural production, roughly thirty percent consist of agriculture and food waste (FAO). This waste includes sugar-industry wastes, fruit and vegetable wastes, lignocellulosic materials as well as animal and fisheries rejected byproducts. Many bioactive compounds such as polyphenols, dietary fibres and carotenoids are present in big quantities in these agriculture by-products. By-products of almond and peanuts are enriched with these components. While some have been carried out to determine the nutritive values and invitro digestibility of almonds and groundnuts, there is no study comparing both. Although present study was done to explain and compare their nutritive values in ruminants. But there are a lot of areas which could not be covered due to lack of information and technology. Still there is a huge gap between the literature and its practical implementation. There is a big opportunity to further assess and adequately understand the nutritive value of both by-products and their use in ruminant nutrition. Countries like Turkey owes a big number of nuts and can be set standards by using these by-products as animal feed.

CHAPTER V

CONCLUSION

There were not statistically significant between groups and subgroups of skins, shells, and hulls effects for the chemical analysis. However, peanut shells showed higher NDF and ADF values as compared to other groups and subgroups. There were statistically significant differences among the skins, shells, and hulls for in-vitro digestibility. AHU 5% had the highest in-vitro true dry matter digestibility and neutral detergent fibre digestibility among the rest of groups and subgroups.

Higher NDF and ADF values of untreated peanut shells showed the presence of great amount tannins. The decrease in these values in PSU 5% and PSU 10% displayed the breakage of lignocellulosic bond between the cell wall contents. The decrease in NDF and ADF values of almond hulls after treatment also showed the reduction in level of lignin. The increase in NDFD values of PSU 5% and PSU 10% displayed the breakage of lignocellulosic bond between the cell wall contents. The increase in NDFD values of almond hulls after treatment also showed the reduction in level of lignin. These results indicate that urea treatments have a good impact by enhancing NDFD values of almond hulls and peanut shells especially in AHU 5% and PSU 5%. TPC absorbance for AHc showed greater values followed by PSk and PSc respectively. Overall, the data indicates that almond hulls and peanut shells showed a better performance after treatment with urea as compared to untreated almond hulls and peanut shells (especially AHU 5% and PSU 5%).

The use of cheap, available, and abundant sources of agro-industrial feeds such as skins, shells and hulls are a very important strategy to consider in ruminant nutrition. This research is important to providing significant information about the nutritive value and in-vitro digestibility of the skins, shells and hulls of different groups and subgroups as well as a vista of opportunities for researchers and nutritionist on the potentials of these agro-industrial by-products to replace or at least modify conventional feed ration of ruminants.

By applying, the vast number of nuts and varieties globally as well as their diverse use can be a good source of recycling of agro-industrial wastes. This would enable farmers and researchers to investigate without limits and boundaries, pave new ways for the improvement of animal feed which will be cost effective and environment friendly.

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APPNENDIX

Appendix I: Comprehensive Results of Statistical Analysis for Chemical Parameters Of Groups Of Skins, Shells And Hulls

Descriptives

	SAMPLE	ADF	NDF
N	Almond Hull 10%	2	2
	Almond Hull 5%	2	2
	Almond Hull control	2	2
	Peanut Shell 5%	2	2
	Peanut Skin	2	2
	Peanut shell 10%	2	2
	Peanut shell control	2	2
Mean	Almond Hull 10%	18.5	32.0
	Almond Hull 5%	15.4	31.1
	Almond Hull control	20.2	35.0
	Peanut Shell 5%	41.6	55.4
	Peanut Skin	29.0	41.1
	Peanut shell 10%	40.8	57.9
	Peanut shell control	47.0	66.5
Std. error mean	Almond Hull 10%	0.170	2.33
	Almond Hull 5%	0.500	0.630
	Almond Hull control	1.13	2.20
	Peanut Shell 5%	0.735	3.28
	Peanut Skin	0.470	0.395
	Peanut shell 10%	0.490	3.41
	Peanut shell control	0.0250	0.310
Standard deviation	Almond Hull 10%	0.240	3.30
	Almond Hull 5%	0.707	0.891
	Almond Hull control	1.61	3.10
	Peanut Shell 5%	1.04	4.64
	Peanut Skin	0.665	0.559
	Peanut shell 10%	0.693	4.82
	Peanut shell control	0.0354	0.438

Statistical analysis for ADF, NDF using ONE-WAY ANOVA (Non-parametric)

ONE WAY ANOVA NON – PARAMETRIC

Kruskal-Wallis				
	χ^2	**df**	**p**	**ε^2**
ADF	12.6	6	0.049	0.971
NDF	12.1	6	0.059	0.932

Dwass-Steel-Critch low-fligner pairwise Comparisons

Pairwise comparisons – ADF			
		W	**P**
Almond Hull 10%	Almond Hull 5%	-2.19	0.715
Almond Hull 10%	Almond Hull control	2.19	0.715
Almond Hull 10%	Peanut Shell 5%	2.19	0.715
Almond Hull 10%	Peanut Skin	2.19	0.715
Almond Hull 10%	Peanut shell 10%	2.19	0.715
Almond Hull 10%	Peanut shell control	2.19	0.715
Almond Hull 5%	Almond Hull control	2.19	0.715
Almond Hull 5%	Peanut Shell 5%	2.19	0.715
Almond Hull 5%	Peanut Skin	2.19	0.715
Almond Hull 5%	Peanut shell 10%	2.19	0.715
Almond Hull 5%	Peanut shell control	2.19	0.715
Almond Hull control	Peanut Shell 5%	2.19	0.715
Almond Hull control	Peanut Skin	2.19	0.715
Almond Hull control	Peanut shell 10%	2.19	0.715
Almond Hull control	Peanut shell control	2.19	0.715

Peanut Shell 5%	Peanut Skin	-2.19	0.715
Peanut Shell 5%	Peanut shell 10%	-1.10	0.987
Peanut Shell 5%	Peanut shell control	2.19	0.715
Peanut Skin	Peanut shell 10%	2.19	0.715
Peanut Skin	Peanut shell control	2.19	0.715
Peanut shell 10%	Peanut shell control	2.19	0.715
Pairwise comparisons – ADF			
		W	**P**
Almond Hull 10%	Almond Hull 5%	-2.19	0.715
Almond Hull 10%	Almond Hull control	2.19	0.715
Almond Hull 10%	Peanut Shell 5%	2.19	0.715
Almond Hull 10%	Peanut Skin	2.19	0.715
Almond Hull 10%	Peanut shell 10%	2.19	0.715
Almond Hull 10%	Peanut shell control	2.19	0.715
Almond Hull 5%	Almond Hull control	2.19	0.715
Almond Hull 5%	Peanut Shell 5%	2.19	0.715
Almond Hull 5%	Peanut Skin	2.19	0.715
Almond Hull 5%	Peanut shell 10%	2.19	0.715
Almond Hull 5%	Peanut shell control	2.19	0.715
Almond Hull control	Peanut Shell 5%	2.19	0.715
Almond Hull control	Peanut Skin	2.19	0.715
Almond Hull control	Peanut shell 10%	2.19	0.715
Almond Hull control	Peanut shell control	2.19	0.715
Peanut Shell 5%	Peanut Skin	-2.19	0.715
Peanut Shell 5%	Peanut shell 10%	-1.10	0.987
Peanut Shell 5%	Peanut shell control	2.19	0.715
Peanut Skin	Peanut shell 10%	2.19	0.715
Peanut Skin	Peanut shell control	2.19	0.715
Peanut shell 10%	Peanut shell control	2.19	0.715

Statistical analysis for DM, ASH and Crude protein using ONE-WAY ANOVA (Non-parametric)

Descriptives				
	SAMPLE	DM	ASH	CP
N	Almond Hull 5%	3	3	3
	Almond Hull c	3	3	3
	Almond H 10%	3	3	3
	Peanut Shell 5%	3	3	3
	Peanut Skin	3	3	3
	Peanut shell 10%	3	3	3
	Peanut shell c	3	3	3
Mean	Almond Hull 5%	90.7	3.46	10.8
	Almond Hull c	95.1	5.15	2.67
	Almond H 10%	89.0	4.94	14.3
	Peanut Shell 5%	90.7	4.26	8.03
	Peanut Skin	96.9	4.27	15.2
	Peanut shell 10%	90.1	4.81	10.9
	Peanut shell c	95.7	5.43	7.61
Std. error mean	Almond Hull 5%	0.176	0.199	0.157
	Almond Hull c	0.115	0.00626	0.0223
	Almond H 10%	0.0577	0.112	0.417
	Peanut Shell 5%	0.176	0.0890	0.128
	Peanut Skin	0.233	0.0973	0.0378
	Peanut shell 10%	0.608	0.0651	0.175
	Peanut shell c	0.529	0.0300	0.0340
Standard deviation	Almond Hull 5%	0.306	0.346	0.272
	Almond Hull c	0.200	0.0108	0.0386
	Almond H 10%	0.1000	0.195	0.723
	Peanut Shell 5%	0.306	0.154	0.222
	Peanut Skin	0.404	0.168	0.0655
	Peanut shell 10%	1.05	0.113	0.302
	Peanut shell c	0.917	0.0519	0.0588

ONE-WAY ANOVA (NON-PARAMETRIC)

Kruskal-Wallis				
	χ^2	df	p	ε^2
DM	17.6	6	0.007	0.879
ASH	19.0	6	0.004	0.951
CP	19.3	6	0.004	0.965

Dwass-Steel-Critch low-fligner pairwise Comparisons

Pairwise comparisons – DM			
		W	p
Almond Hull 5%	Almond Hull c	2.777	0.438
Almond Hull 5%	Almond H 10%	-2.777	0.438
Almond Hull 5%	Peanut Shell 5%	0.318	1.000
Almond Hull 5%	Peanut Skin	2.777	0.438
Almond Hull 5%	Peanut shell 10%	-0.926	0.995
Almond Hull 5%	Peanut shell c	2.777	0.438
Almond Hull c	Almond H 10%	-2.777	0.438
Almond Hull c	Peanut Shell 5%	-2.777	0.438
Almond Hull c	Peanut Skin	2.777	0.438
Almond Hull c	Peanut shell 10%	-2.777	0.438
Almond Hull c	Peanut shell c	1.252	0.975
Almond H 10%	Peanut Shell 5%	2.777	0.438
Almond H 10%	Peanut Skin	2.777	0.438
Almond H 10%	Peanut shell 10%	1.879	0.839
Almond H 10%	Peanut shell c	2.777	0.438
Peanut Shell 5%	Peanut Skin	2.777	0.438
Peanut Shell 5%	Peanut shell 10%	-0.926	0.995
Peanut Shell 5%	Peanut shell c	2.777	0.438
Peanut Skin	Peanut shell 10%	-2.777	0.438
Peanut Skin	Peanut shell c	-2.160	0.729
Peanut shell 10%	Peanut shell c	2.777	0.438

Pairwise comparisons – ASH			
		W	p
Almond Hull 5%	Almond Hull c	2.777	0.438
Almond Hull 5%	Almond H 10%	2.777	0.438
Almond Hull 5%	Peanut Shell 5%	2.777	0.438
Almond Hull 5%	Peanut Skin	2.777	0.438
Almond Hull 5%	Peanut shell 10%	2.777	0.438
Almond Hull 5%	Peanut shell c	2.777	0.438
Almond Hull c	Almond H 10%	-2.777	0.438
Almond Hull c	Peanut Shell 5%	-2.777	0.438
Almond Hull c	Peanut Skin	-2.777	0.438
Almond Hull c	Peanut shell 10%	-2.777	0.438
Almond Hull c	Peanut shell c	2.777	0.438
Almond H 10%	Peanut Shell 5%	-2.777	0.438
Almond H 10%	Peanut Skin	-2.777	0.438
Almond H 10%	Peanut shell 10%	-1.252	0.975
Almond H 10%	Peanut shell c	2.777	0.438
Peanut Shell 5%	Peanut Skin	0.309	1.000
Peanut Shell 5%	Peanut shell 10%	2.777	0.438

Peanut Shell 5%		Peanut shell c		2.777		0.438	
Peanut Skin		Peanut shell 10%		2.777		0.438	
Peanut Skin		Peanut shell c		2.777		0.438	
Peanut shell 10%		Peanut shell c		2.777		0.438	

Pairwise comparisons – CP							
				W		**p**	
Almond Hull 5%		Almond Hull c		-2.777		0.438	
Almond Hull 5%		Almond H 10%		2.777		0.438	
Almond Hull 5%		Peanut Shell 5%		-2.777		0.438	
Almond Hull 5%		Peanut Skin		2.777		0.438	
Almond Hull 5%		Peanut shell 10%		0.309		1.000	
Almond Hull 5%		Peanut shell c		-2.777		0.438	
Almond Hull c		Almond H 10%		2.777		0.438	
Almond Hull c		Peanut Shell 5%		2.777		0.438	
Almond Hull c		Peanut Skin		2.777		0.438	
Almond Hull c		Peanut shell 10%		2.777		0.438	
Almond Hull c		Peanut shell c		2.777		0.438	
Almond H 10%		Peanut Shell 5%		-2.777		0.438	
Almond H 10%		Peanut Skin		2.777		0.438	
Almond H 10%		Peanut shell 10%		-2.777		0.438	
Almond H 10%		Peanut shell c		-2.777		0.438	
Peanut Shell 5%		Peanut Skin		2.777		0.438	
Peanut Shell 5%		Peanut shell 10%		2.777		0.438	
Peanut Shell 5%		Peanut shell c		-2.777		0.438	
Peanut Skin		Peanut shell 10%		-2.777		0.438	
Peanut Skin		Peanut shell c		-2.777		0.438	
Peanut shell 10%		Peanut shell c		-2.777		0.438	

Appendix II: Comprehensive Results Of Statistical Analysis For In-Vitro Digestibility Of Groups Of Skins, Shells And Hulls

Descriptive

	Sample	Treatment	IVTD (As Fed)	IVTD (DM)	NDF	NDFD%
N	Almond Hull	10%Urea	4	4	4	4
		5%Urea	3	3	3	3
		Control	5	5	5	5
	Peanut Shell	10%Urea	4	4	4	4
		5%Urea	4	4	4	4
		Control	5	5	5	5
	Peanut Skin	10%Urea	0	0	0	0
		5%Urea	0	0	0	0
		Control	5	5	5	5
Mean	Almond Hull	10%Urea	85.2	85.2	16.6	49.5
		5%Urea	90.0	90.0	11.0	64.5
		Control	81.1	81.1	19.8	43.4
	Peanut Shell	10%Urea	55.1	55.0	49.7	14.1
		5%Urea	58.1	58.1	46.1	17.1
		Control	43.6	43.5	62.2	6.40
	Peanut Skin	10%Urea	NaN	NaN	NaN	NaN
		5%Urea	NaN	NaN	NaN	NaN
		Control	66.9	67.1	34.1	17.0
Std. error mean	Almond Hull	10%Urea	0.568	0.569	0.637	1.47
		5%Urea	0.559	0.560	0.617	1.98
		Control	0.417	0.417	0.437	1.25
	Peanut Shell	10%Urea	0.431	0.432	0.478	0.825
		5%Urea	0.609	0.610	0.670	1.14
		Control	0.224	0.225	0.248	0.372
	Peanut Skin	10%Urea	NaN	NaN	NaN	NaN
		5%Urea	NaN	NaN	NaN	NaN
		Control	0.0896	0.168	0.0924	0.225

e-Way ANOVA

One-Way ANOVA (Welch's)

	F	df1	df2	p
IVTD (As Fed)	1797	6	8.52	< .001
IVTD (DM)	1730	6	8.98	< .001
NDF	1985	6	8.48	< .001
NDFD%	275	6	8.65	< .001

Group Descriptives

	Samples	N	Mean	SD	SE
IVTD (As Fed)	Ahu	5	81.14	0.932	0.4167
	Ahu10	4	85.24	1.136	0.5678
	Ahu5	3	89.98	0.967	0.5586
	PSh5	4	58.13	1.218	0.6089
	PSk	5	66.93	0.200	0.0896
	Psh	5	43.58	0.502	0.2244
	Psh10	4	55.12	0.862	0.4311
IVTD (DM)	Ahu	5	81.11	0.933	0.4174
	Ahu10	4	85.22	1.138	0.5688
	Ahu5	3	89.97	0.970	0.5601
	PSh5	4	58.05	1.220	0.6100
	PSk	5	67.07	0.376	0.1683
	Psh	5	43.49	0.503	0.2248
	Psh10	4	55.04	0.864	0.4319
NDF	Ahu	5	19.80	0.978	0.4374
	Ahu10	4	16.56	1.274	0.6370
	Ahu5	3	11.03	1.069	0.6170
	PSh5	4	46.09	1.340	0.6702
	PSk	5	34.11	0.207	0.0924

	Psh	5	62.24	0.554	0.2475
	Psh10	4	49.73	0.955	0.4777
NDFD%	Ahu	5	43.37	2.798	1.2512
	Ahu10	4	49.53	2.949	1.4744
	Ahu5	3	64.55	3.427	1.9788
	PSh5	4	17.10	2.274	1.1370
	PSk	5	16.98	0.503	0.2249
	Psh	5	6.40	0.832	0.3722
	Psh10	4	14.11	1.650	0.8249

Post Hoc Test

Tukey Post-Hoc Test – IVTD (As Fed)

		Ahu	**Ahu10**	**Ahu5**	**PSh5**	**PSk**	**Psh**	**Psh10**
Ahu	Mean difference	—	-4.10 ***	-8.84 ***	23.0 ***	14.21 ***	37.6 ***	26.02 ***
	p-value	—	<.001	<.001	<.001	<.001	<.001	<.001
Ahu10	Mean difference		—	-4.74 ***	27.1 ***	18.31 ***	41.7 ***	30.12 ***
	p-value		—	<.001	<.001	<.001	<.001	<.001
Ahu5	Mean difference			—	31.9 ***	23.05 ***	46.4 ***	34.87 ***
	p-value			—	<.001	<.001	<.001	<.001
PSh5	Mean difference				—	-8.80 ***	14.5 ***	3.01 ***
	p-value				—	<.001	<.001	<.001
PSk	Mean difference					—	23.3 ***	11.81 ***
	p-value					—	<.001	<.001

Psh		Mean difference												—		-11.54	***
		p-value												—		< .001	
Psh10		Mean difference														—	
		p-value														—	

Note. * p < .05, ** p < .01, *** p < .001

Tukey Post-Hoc Test – IVTD (DM)

				Ahu		Ahu10		Ahu5		PSh5		PSk		Psh		Psh10	
Ahu		Mean difference		—		-4.11	***	-8.86	***	23.1	***	14.03	***	37.6	***	26.07	***
		p-value		—		< .001		< .001		< .001		< .001		< .001		< .001	
Ahu10		Mean difference				—		-4.75	***	27.2	***	18.14	***	41.7	***	30.17	***
		p-value				—		< .001		< .001		< .001		< .001		< .001	
Ahu5		Mean difference						—		31.9	***	22.89	***	46.5	***	34.93	***
		p-value						—		< .001		< .001		< .001		< .001	
PSh5		Mean difference								—		-9.02	***	14.6	***	3.01	**
		p-value								—		< .001		< .001		0.001	
PSk		Mean difference										—		23.6	***	12.03	***
		p-value										—		< .001		< .001	
Psh		Mean difference												—		-11.56	***
		p-value												—		< .001	
Psh10		Mean difference														—	
		p-value														—	

Note. * p < .05, ** p < .01, *** p < .001

Tukey Post-Hoc Test – NDF

				Ahu		Ahu10		Ahu5		PSh5		PSk		Psh		Psh10	
Ahu		Mean difference		—		3.24	***	8.76	***	-26.3	***	-14.3	***	-42.4	***	-29.93	***
		p-value		—		< .001		< .001		< .001		< .001		< .001		< .001	
Ahu10		Mean difference				—		5.52	***	-29.5	***	-17.6	***	-45.7	***	-33.17	***
		p-				—		< .0		< .00		< .00		< .00		< .	

		value						01		1		1		1		001	
Ahu5		Mean difference						—		-35.1	***	-23.1	***	-51.2	***	-38.69	***
		p-value						—		< .001		< .001		< .001		< .001	
PSh5		Mean difference								—		12.0	***	-16.1	***	-3.64	***
		p-value								—		< .001		< .001		< .001	
PSk		Mean difference										—		-28.1	***	-15.62	***
		p-value										—		< .001		< .001	
Psh		Mean difference												—		12.51	***
		p-value												—		< .001	
Psh10		Mean difference														—	
		p-value														—	

Note. * p < .05, ** p < .01, *** p < .001

Tukey Post-Hoc Test – NDFD%

				Ahu		**Ahu10**		**Ahu5**		**PSh5**		**PSk**		**Psh**		**Psh10**	
Ahu		Mean difference		—		-6.16	**	-21.2	***	26.3	***	26.392	***	37.0	***	29.26	***
		p-value		—		0.005		< .001		< .001		< .001		< .001		< .001	
Ahu10		Mean difference				—		-15.0	***	32.4	***	32.552	***	43.1	***	35.42	***
		p-value				—		< .001		< .001		< .001		< .001		< .001	
Ahu5		Mean difference						—		47.4	***	47.571	***	58.2	***	50.44	***
		p-value						—		< .001		< .001		< .001		< .001	
PSh5		Mean difference								—		0.126		10.7	***	2.99	
		p-value								—		1.000		< .001		0.470	
PSk		Mean difference										—		10.6	***	2.87	
		p-value										—		< .001		0.459	
Psh		Mean difference												—		-7.71	***
		p-value												—		< .001	
Psh10		Mean difference														—	

		p-value														—	

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

CURRICULUM VITAE

I am Nida Irshad, born on ****', P****. I have acquired a bachelor's degree (Doctor of Veterinary Medicine, DVM) from the University of Veterinary and Animal Sciences Pakistan. My MPhil is in Animal Nutrition from Niğde Ömer Halisdemir University Turkey. I have two years of working experience in animal nutrition and molecular biological techniques mentioned in my CV including international study programme in Turkey at well-renowned university under competent researchers.

My great experience in MPhil is related to animal nutrition. My thesis research title is "Determination of in vitro digestibility and nutrient composition of peanuts shells, peanut skins, and almond hulls as ruminant feed.". I have also worked on animal nutrition in different projects entitled "The use of agriculture fruit waste as animal feed". Along with ruminant nutrition, I have experience in monogastric nutrition as well. I worked on a project "Role of Aloe vera as a natural feed additive in poultry production". In these projects, I examined chemical composition, plant secondary metabolites and nutritional values of experimental diets. In-vivo and in-vitro digestibility trials were conducted using total collection method and Daisy incubator, TPC, Batch Culturing and Hohenheim gas production system techniques respectively. Moreover, I examined microbial diversity using milk composition, and rumen fermentation parameters such as pH, volatile fatty acids, ammonia-nitrogen, and gas production. In terms of performance parameters, animal weight gain, feed intake, feed efficiency and biochemical parameters were examined.

Considering postgraduate degree and research in Animal Nutrition and Biotechnology, I have gained ample knowledge of animal nutrition, modulation of gut ecosystem and environmental impact of livestock production. My research experience in animal nutrition and molecular biology makes me an appropriate person for further research in this field.