T.R.
ERCIYES UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF AGRICULTURAL SCIENCES AND TECHNOLOGIES

DETERMINATION OF GAS PRODUCTION KINETICS OF BRASSICA GROUP PLANTS IN GOATS

Prepared by
Zahra OMAR MOHAMUD

Supervisor
Prof. Dr. Yusuf KONCA

M.Sc. Thesis

September 2021
KAYSERİ

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SCIENTIFIC ETHICS SUITABILITY

I'm Zahra Omar Mohamud, hereby declare that this piece of work is the result of my research and that this work has never been submitted anywhere for any degree. All the sources of information used were obtained by academic ethics and have been duly acknowledged.

Zahra Omar Mohamud

This master's thesis was written upon the topic "**Determination of gas production kinetics of brassica group plants in goats**" was prepared accordance with Erciyes University's graduate Thesis Writing Directive.

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Erciyes University, Graduate School of Natural and Applied Science
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ABSTRACT

The nutritional composition, gas production (GP) potentials, and energy values of seeds, tubers, and leaves of Brassica group plants as an alternative animal feed were determined in this study. The chemical composition and 24-hour gas production kinetics of 12 seeds, 7 tubers, and 7 leaves from different brassica plants were determined in the study. In the experiment, weende analyses and acid detergent cellulose (ADF) and neutral detergent cellulose (NDF) contents of seeds, tubers and leaves of brassica group plants were done. The lowest total gas (ml/200 mg) and methane production (%) amounts of brassica group plants determined at the end of 24 hours, in seeds, respectively; radish seed and black sapish turnip seed; in tubers, kohlarabi and daikon; and its leaves have been found in caulifower and broccoli. The highest calculated organic matter digestibility, metabolizable energy (ME, kcal/kg MJ) and lactation net energy (NEL) values in brassica group seeds, respectively; red cabbage, turnip and turnip; in tubers, for three of them were black sapish turnip; and for leaves, three of them were red cabbage. Even though the analyzed brassica plants varied in terms of the features examined, the research findings indicate that the feed quality values are generally adequate. Brassica seeds, tubers and leaves can be classified as feed sources with low methanogenic properties according to their in-vitro methane production rates.

Keywords: Rumen parameters, gas production, brassica plants, nutrient composition

KEÇİLERDE BRASSİCA GRUBU BİTKİLERİN GAZ ÜRETİM KİNETİKLERİNİN BELİRLENMESİ

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ÖZET

Bu çalışmada alternatif hayvan yemi olarak brassica grubu bitkilerin yaprak, yumru ve tohumlarının besin kompozisyonu, gaz üretim (GP) potansiyelleri ve enerji değerleri belirlenmiştir. Çalışmada farklı brassica bitkilerinden 12 tohum, 7 kök ve 7 yaprağın kimyasal bileşimi ve 24 saatlik gaz üretim kinetiği belirlenmiştir. Çalışmada, brassica grubu bitkilerin tohum, kök ve yapraklarının asit deterjan selüloz (ADF) ve nötr deterjan selüloz (NDF) ile weende analizleri yapılmıştır. Brassica grubu bitkilerin 24 saat sonunda tohumlarda belirlenen en düşük toplam gaz (ml/200 mg) ve metan üretim (%) miktarları sırasıyla; turp tohumu ve siyah ispanyol şalgamı; yumrularda, alabaş ve japon turpu; ve yapraklarından karnabahar ve brokolide bulunmuştur. Brassica grubu tohumlarda hesaplanan en yüksek organik madde sindirilebilirliği, metabolik enerji (ME, kcal/kg MJ) ve laktasyon net enerjisi (NEL) değerleri sırasıyla; kırmızı lahana, şalgam ve şalgam; yumru köklerde, her üçüde siyah ispanyol turp; ve yapraklar için her üçüde kırmızı lahana olmuştur. Brassica bitkileri incelenen özellikler açısından farklılık gösterse de araştırma bulguları yem kalite değerlerinin genel olarak yeterli olduğunu göstermektedir. Brassica tohumları, yumrular ve yapraklar *in-vitro* metan üretim oranlarına göre düşük metanojenik özelliklere sahip yem kaynakları olarak sınıflandırılabilir.

Anahtar Kelimeler: Rumen Parametreleri, Gas üretimi, brassica grubu, besin madde içeriği

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CHAPTER 1

INTRODUCTION

Brassicaceae group plants (like brassica Nigra, brassica Juncea, brassica Rapa and brassica Napus cabbages, Dill, fodder kale, Turnip, and Swede) are a genus of the mustard family. Cruciferous vegetables, cabbages, or mustard plants are informally classified as members of this family (https://encyclopedia.pub/808). Turnips, forage brassica hybrids, kale, forage rape, and Swedes are all examples of forage brassica and they differ in terms of their properties and applications (Ayres et al., 2002). In times of seasonal shortages or when pasture is poor, particularly during winter and summer, these crops are used to provide feed (De Ruiter et al., 2009). Brassica plants can produce high dry matter in a short time so they consider as an important subject of scientific interest, especially brassica Carinata, brassica Oleracea, brassica nigra, brassica Juncea, brassica Rapa, and brassica Napus. These species are characterized by their low neutral detection. Brassica forages can increase animal efficiency and decrease the environmental impact via low methane production in ruminant animals (Keim et al., 2019). Brassica forage has high digestibility, caloric, and protein content and can be a rapid and abundant source of feed. The crude protein contents of brassica leave range from 15 to 25%, while turnips and swede bulbs have a crude protein concentration of 9.16 %. Energy values of the change between 11.14MJ ME/kg DM and 11.14MJ ME/kg on a dry matter (DM) basis. Brassicas are also an appealing option for rapid feed due to their inexpensive cost of the establishment (Ayres et al., 2002). However, brassica group plants have some anti-nutritive substances (Bell et al., 2020) and they may limit their use in animal diets.

Many efforts are being made to reduce greenhouse gas emissions and improve the efficiency of digesting energy consumption to reduce methane output. Brassica plants have larger quantities of rapidly fermentable sugars and pectin than other forages. Dairy

and livestock farmers acquire a big part of their animal feed from off-farm sources, Farmers most use well-known feed sources as corn silage and hay; however, there are not use unused feed sources. Alternative feed crops would allow farmers an extended grazing season (Leck, 2011). Brassica crops production for forage may give an opportunity in many fields, even bad soil circumstances (such as low nutrient content, soil acidity, poor drainage, and topographical constraints for forage production) which these conditions there is no possibility to produce like corn and alfalfa. On the other hand, with droughty soils and hill land, the distribution of plants over the growing season is short, and forage supply is very limited especially in the summer and fall seasons (Garg et al., 2012).

The thirty-seventh lower gas yields than pasture resulted from pure forage rape fed as a winter crop. Growing the proportion of forage rape linearly sliced gas yield within the diet of sheep-fed pasture. Additionally, feeding forage rape to Bos taurus resulted in four hundred and forty yards less gas yield than feeding pasture. This meant that reductions in gas emissions were feasible by feeding sheep and Bos taurus with forage brassicas, particularly winter forage rape. To decide their price as a viable mitigation method in pastoral and dairy farming, alternative work aspects of these crops are crucial (Saban and Sanlier, 2018).

Agricultural practices are causing global warming by providing plant and animal production to transmit demand to the world's rising population. The CO_2 is produced by animals, CH_4 is released as a result of fermentation in the rumen and intestines, and CO_2, NH_4, and N_2O from animal fertilizers are generally gases generated in livestock activities within agricultural activities. Reduction of greenhouse gas emissions to the atmosphere by fermentation of the rumen and reduction of ruminant animal manure gasses (Klieve et al., 1999) (Koyuncu et al., 2018). While natural resources produce 30 % of the total CH_4 gas emissions, 70 % of them are generated by human activities. The livestock sector accounts for 25-40 % of the emissions of methane gas resulting from human activities that affect nature (Koyuncu and Akgün, 2018; Campos-Montiel et al., 2018).

However, there are not enough studies to determine the effects of gas production kinetics of brassica group plants in goats. Therefore, this research was aimed to

determine the nutrient content and gas production potential of seeds, leaves, and tubers of some brassica group plants grown in Turkey.

CHAPTER 2

GENERAL INFORMATION AND LITERATURE REVIEW

Brassica crops may grow in the winter and summer seasons. In the plant group including kale (*Brassica oleracea*), forage rape (*Brassica napus*), turnip (*Brassica Campestris*), and swede (*Brassica napus* ssp. *rapifera*) can be grown to provide feed for ruminants worldwide (Barry, 2013). Brassica crops have some advantages to use limited water resources and are suitable to grow in water scarcity (Rawnsley et al., 2013). As they grow in regions where winters are not too harsh and produce roughage at a satisfactory level, it increases the possibility of animals consuming fresh feed in winter and early spring. In the west of Turkey in some locations like Izmir, brassica Rapa has been growing and feeding dairy cows very successfully in the winter season.

Sun (2020) reported that feeding sheep with brassica forages may cause and increase the concentration of free triiodothyronine (FT_3) in blood serum and it can decrease methane production due to the lower retention time of digest in the rumen. Brassica group plants have Glucosinolates (GSLs) as chemical components. After ruminant's intake brassica forages, GSLs are broken down in rumen and after absorption into the blood and then may promote the secretion of FT_3 in and alter may change rumen physiology and decrease in methane emissions. This assumption may explain the brassica plant's potential use to decrease methane emission.

Brassicas are utilized for ruminant feed during the winter months, which is a season with reduced pasture development in humid temperate areas. These forages can provide high DM manufacturing and dietary quality quickly, which relates to high ME, water-soluble carbs, as well as low NDF (Sun et al., 2012). Nevertheless, the high nutrient material of brassicas is not always related to high livestock performance. Barry (2013) recommended that the poor animal-performance feedback to extremely absorbable

brassicas might be a result of detrimental effects of anti-nutritional elements that exist or in higher concentrations than in other various plants.

Agricultural activities are carried out to increase plant and animal production to meet the needs of the increasing population in the world causing global warming. Gases generated in livestock activities included in agricultural activities are generally CO_2 produced by animals, CH_4 released as a result of fermentation in the rumen and intestines, and CO_2, NH_4, and N_2O originating from animal fertilizers (Venkateswarlu et al., 2009). In ruminant animals, it can reduce the emission of greenhouse gases to nature by reducing the gases released by rumen fermentation and manure Köknaroğlu & Akünal (2010) and Moate et al. (1998) reported that the brassicas increased the weight gain of ruminants and enhanced the milk yield of the animals, while it decreased the methane production with no environmental hazards according to the animals fed grasses.

This study focuses on the determination of the amount of gas production in vitro conditions, which is indicative of feed fermentation by microbial digestion; the fermentation residues in the gases include methane (CH_4) and carbon dioxide gas (CO_2). This section will discuss different theories and studies done on the same.

2.1. Characteristics of some brassica plants that are not commonly used as feed

2.1.1. Flaxseed

Flax (*Linum usitatissimum*) is an oilseed produced primarily in Canada and in the northern Great Plains (Berglund et al., 2007). Flax is historically crushed to provide flaxseed oil and the resulting oilseed meal (as well-referred to as linseed) is therefore used in Eutherian feeds as a supper-molecule supplement.

Research suggests several possible benefits to human health related to flax intake. Flax contains approximately 20% of omega-3 fatty acid, as an essential carboxylic acid polyunsaturated fatty acid that is a precursor of omega-3 (EPA), which may be a successive precursor to the production of eicosanoid acids (Lardy et al., 2016).

The flax plant is a source of lignin glycoside precursor, which is born again by tummy microorganisms or hindgut microorganisms in nonruminant animals to distinguish

phytoestrogens. Phytoestrogens may be used to have possible in hormone replacement therapies and cancer prevention (Bauer et al., 2006).

Since flax is high in oil, the supply of fat in farm animal rations is considered(Singh et al., 2011). There was a study that investigated the effects of feeding unheated and micronized flaxseed on milk yield and milk fatty acid composition, nine Holstein cows were used. To fulfill the nutritional requirements of dairy cows in early lactation, three diets have been formulated a control diet, an unheated flaxseed diet, and a micronized flaxseed diet, feeding flaxseed to dairy cows did not affect DM intake or milk yield and the level was 70 g kg-1 of diet dry matter. Flaxseed also decreased the percentage of milk fat without affecting milk protein or milk lactose concentration. The yield of the milk components was not, however, affected by flaxseed feeding (Mustafa et al., 2003).

Picture 2.1. Flax Seed

2.1.2. Cabbage

White cabbage (*Brassica oleraceae* Capitataf. alba) belongs to the genus Brassica and the mustard Brassicaceae family (Cruciferae). White cabbage is among the most widely grown vegetables in the world (Šamec et al., 2017). *Brassica oleracea* is well-known plant species such as broccoli and cauliflower (var. botrytis), kohlrabi (var. acephala), kale (var. capitata), and sprouts from Brussels (var. gongylodes) (var. gemmifera) (Downing et al., 1992).

In a study, the chemical components, in vitro ruminal fermentation, and digestibility of 4 brassica plants were evaluated it was observed that the cabbages have high dry matter and metabolic energy while they had low NDF with quick and increased rumen fermentation. In another study, the dietary supplementation of disposed of cabbage on the feed consumption and growth of lambs were evaluated. From the results, it was observed that the cabbage inclusion decreased the dry matter intake and growth development of young lambs as the level of cabbage supplementation increased. Also, the cabbage inclusion negatively reduced the feed efficiency of lambs (Nkosi et al., 2016).

White cabbage leaves are formed into distinctive cabbage that can vary in leaf color, form, and texture. A large number of cabbage cultivars are under cultivation in different locations and climatic conditions (Al-Shehbaz et al., 2006).

Picture 2.2. White and red cabbages

White cabbage stands out as an important source of phytonutrients in the human diet due to the low prices and abundance in local markets. For long periods, it may be processed raw and will therefore be usable throughout the year. It has also been known to contribute to recovering different inflammations and gastrointestinal disorders and blood purification (Mul et al., 2019).

Red cabbage (*Brassica oleracea* L.var. capitata L. f. Rubra) could be a cool-season vegetable from the Brassicaceae family. This crop has been recognized as a trendy multitasker's dream food for the various edges that it gives us. The crop may be harvested when three months of gathering (Sarkar et al., 2017).

Cabbages have more health benefits, inhibition of in vitro DNA damage in cancer cells (McDougall et al., 2007), inhibition of digestive enzymes, activation of insulin production in isolated pancreatic cells, reduction of inflammatory responses; and defense against age-related declines in brain function (Lee et al., 2002)**.** Effects of feeding dried cabbage leaf residues (DCR) on parameters of development of eggs, components of eggs, and concentrations of egg fatty acid, and apparent total digestibility of the tract. The findings showed that dietary treatments were unaffected by feed consumption, egg development, and feed conversion ratio. However, with increased DCR, the percentage of eggshells decreased. With rising dietary DCR, egg yolk concentrations of alpha-tocopherol, polyunsaturated fatty acids, and linolenic acid have increased. DCR inclusion, however, did not affect the concentration of egg yolk cholesterol. It was concluded that DCR can be supplied on production parameters to layers up to 12 percent without adverse facts and can enhance the overall usage of nutrient and egg quality of the tract (Mustafa et al., 2017).

2.1.3. Mustard seed

Mustard (Brassica species) is produced primarily for seed oil content which is used as an industrial lubricant and an ingredient in condiments. The mustard meal is a by-product of the oil industry containing about 40% crude protein of high quality has the potential of being an economical protein source (Sohail et al., 2017).

The Family Cruciferae, under natural conditions, are commonly cultivated as weeds in Turkey. Mustard is not grown for the production of vegetable oil or the production of biodiesel (Kayaçetin et al., 2018). Two mustard species, Sinapis alba L. together with Sinapis arvensis L.

Picture 2.3 Mustard seed

Research indicates that mustard meals can be fed to sheep and beef cattle. Results have not been as favorable for swine although performance was satisfactory on finishing rations. Processors recently have commenced treating mustard meal with 3% caustic soda (58% Na20 equivalent) during processing, which reduces allyl isothiocyanate (AITC) from 356 ppm to essentially zero (Wims et al., 2010). This has increased palatability for swine. Ellis et al. (2007) reported that satisfactory growth in dairy calves on 8% mustard meal rations, and earlier investigations gave no evidence of detrimental effects when mustard seed rations were fed to lactating dairy cows.

2.1.4. Cress

The cress (*Lepidium sativum* L.) is grown in Western Asia and Egypt and is currently grown worldwide. It has long been using for disease treatment and human diets. The plant seed extract and leaves are also commonly used to treat as anti-asthmatic, antiscorbutic, aperient, poultice, diuretic, stimulant, galactagogue, and regulation of blood pressure (Maghrani et al., 2005). Garden cress seeds are using to promote weight gain because of their high content of essential fatty acids. It has a high concentration of tocopherols, antioxidants, and a good quantity of lignans in its seed oil. It is also known that this herb increases the digestibility of nutrients (Gokavi et al., 2004).

Picture 2.4 Cress

Effect on the efficiency, carcass characteristics, hematology, and serum biochemical parameters of fed ration broilers containing varying levels of feed additive garden cress seed powder. Dry matter consumption improved with an increased amount of garden cress in the ration in the experiment result. However, most parts of the carcass and the weight of the giblet were not affected by its 22.4, 25.7, and 10.5%, addition respectively. Cress, however, increased hemoglobin, the number of packed cells, and red blood cell count. Cress-containing ration consumed by the group showed a

substantial reduction in serum glucose, triglycerides, and cholesterol concentration. The inclusion of up to 2.25% of crass had no adverse impacts on the health of broilers. Cress can be used as a feed additive at a level of 0.75% in the total ratio based on the output parameters used in the study for better and optimistic results on biological efficiency and broiler health status (Shawle et al., 2016).

2.1.5. Dill

Dill, originating in South-East Europe or South-West Asia and is cultivated since historical times. It is a seed spice crop and a major aromatic herb. The extraction of essential oil and the chemical composition of oils from different dill varieties are described, along with culinary, medicinal (both traditional and modern), antimicrobial, insecticidal, and other uses (Karydi et al., 2015).

Dill has beneficial effect some problems in the stomach, digestive, carminative, and tranquilizing fruits properties and has been used to treat colic, stomach disorders, hiccups, flatulence, bad breath, and hemorrhoids (Michalczuk, 2013).

Picture 2.5. Dill leaves and seeds

Flavored oil is active against harmful enteral bacterium together with *Escherichia coli* and against paramecia and helminths (Bean et al., 1981). The leaves may be used for constant functions. Dill oil rubbed onto the skin will stop feelings of nausea. Specific uses area unit for jaundice, fever, and reproductive organ tract infections. It has been utilized in rheumatic affections and alternative swelling of joints as an anti-inflammatory drug and analgesic agent. German commission has accepted the herb's effectiveness in treating loss of appetite, liver and vesical complaints, tubular cavity inflammation, cough, bronchitis, fevers, and colds (Karydi et al., 2015).

Effects of the addition of essential oils of rosemary, dill, and chicory extract to heat-stressed laying hen diets on development, egg quality, and enzyme activity dietary dill had a major impact on the index of eggs under heat stress. The birds supplied rosemary, dill, and chicory alone had lower serum cholesterol and triglyceride concentrations than those fed basal diets under thermoneutral and heat stress conditions. Finally, providing heat-stressed laying hens with a single or combination of rosemary, dill and chicory will increase at least some production efficiency and antioxidant enzyme activity (Torki et al., 2018).

2.1.6. Arugula

Arugula (*Eruca vesicaria*) is a plant that belongs to the Brassicaceae family and native plant of the Mediterranean. It may be a much-appreciated vegetable, its ascorbic acid, potassium, sulfur, and iron, and adult in varied in different regions (da Silva et al., 2019).

Arugula's nutritional value is as essential as its flavor, several studies have shown that eating more plant-based foods reduces the risk of obesity, diabetes, heart disease, and overall mortality, as well as improving skin health, energy, and weight loss. Cancer-fighting compounds are abundant in arugula (Mukherjee et al., 2019).

Picture 2.6 Arugula

2.1.7. Radish

The radish (*Raphanus sativus*), a member of the Brassicaceae family, is a common tuber vegetable. Some cultivars' leaves, siliques, and seed oil are consumed in addition to the

tuber in some areas. Radish tap roots are available in a wide range of colors, shapes, sizes, and flavors. Taproot skin is available in a range of colors, including purple, violet, red, green, white, black, and yellow (Baenas et al., 2015).

Red radish cultivars provide a low-cost source of natural radish. Food coloring is used because it contains a high concentration of red pigments. Furthermore, the anthocyanin and glucosinolate content and stability in the radish cultivars studied are unknown (Jing et al., 2012).

The radish plant is originally from Europe and Asia (Kumar et al., 2020) and it grows in temperate climates at altitudes between and 1240 m. It is 30–90 cm high and its roots square measure thick and of numerous sizes, forms, and colors (Trolove et al., 2018). The preserved radish tubers have a characteristic yellow color, that generates throughout storage (Gutiérrez et al., 2004).

Daikon is regarded as a poor source of ruminal under-grade macromolecules among oilseeds due to its high ruminal degradability. Daikon seed is used as a source of associated energy and macromolecules in ruminant diets (Cardoza et al., 2004). Daikon seed has 210 g/kg crude protein (CP), 430 g/kg oil, and an amino acid composition that is suitable for ruminants. The protein in radish seed is highly degraded by rumen microbes, and high-producing farm cows and rapidly increasing ruminants cannot meet their CP requirements solely from microorganism supermolecules, making it critical that the diet provides slowly degraded proteins with a high potential for rumen escape (Trolove et al., 2018).

Apart from being used as an animal feed and green manure plant cover crop, the seeds of fodder radish (Raphanus sativus var. oleiferusMetzg.) have a high oil content and low viscosity, making them excellent for biodiesel production (Oliveira et al., 2011).

Black radish Daikon Red radish

Picture 2.7. Radish varieties

2.1.8. Hemp

Hemp (*Cannabis sativa* L.) is a cultivated plant that is used for the extraction of fiber and seed oil. Hemp seeds have been shown to have health benefits, including lowering cholesterol and blood pressure (Sacilik et al., 2003). In addition to their nutritional value about 25-35% crude oil, 20-25% crude protein, 20-30% carbohydrates, and 10-15% fiber. With a whole supply of all essential amino and fatty acids, hemp seed may be a completely organic process supply. Moreover, the oil of hemp seed is shown to exhibit pharmacological activity(Oomah et al., 2002). Hemp seed (HS) is usually used for animal nutrition and there is no cannabidiol (THC); however, some studies have according to traces of THC gift within the seed sample most likely as a result of it had been contaminated with plant junk (Vonapartis et al., 2015).

Picture 2.8 Hempseed

A study looked at the production and nutrition of fast-growing broilers fed diets with and without hemp seed cake (HSC) in organic broiler production. Regardless of diet, death was high as a result of the brief heatwave. Hemp seed cake did not affect overall production performance or death. Furthermore, HSC in the feed did not affect the number of perfringens in the caeca. There were differences in litter condition and birdsfoot health, which could be attributed to the high crude fiber (CF) content of the H of C. the diet plan (Eriksson et al., 2012).

2.1.9. Turnip

Turnip (*Brassica rapa*) is cultivated worldwide as a vegetable and fodder. The most edible half could be of the swollen hypocotyl and tuber, though the leaves are typically ingested (Paul et al., 2019). In addition, turnip to providing vital nutrients contains several beneficial components that not only encourage health but also have healing properties. Numerous minerals, such as copper, manganese, and calcium, as well as organic acids, such as sinapic and ferulic acids and their derivatives, are briefly discussed in fresh greens and turnip tubers. Turnip has a protective effect against hepatic damage caused by diabetes and is high in antioxidants (Javed et al., 2019).

Keim et al. (2018) evaluated the fermentation and rumen degradation properties of Brassica rape ssp. (turnips) it was observed that the Turnips had high sugar levels and high dry matter degradation traits with high water solubility. Although, Brassicas did not affect VFA production through in vitro process.

Turnips, on the other hand, are an excellent source of protein for livestock. Turnips have superior forage quality as compared to other widely grown plants. Plant stems, leaves, and tubers are consumed by grazing animals. The tubers contain about 14% crude protein and 80-85% in vitro digestible dry matter, while the stems and leaves contain about 20-25% crude protein, 65-80% in vitro digestible dry matter, 20% neutral detergent fiber, and 23% acid detergent fiber. If an animal is only fed turnips for an extended period, it can develop health problems (Polidoro, 2008).

The addition of antibiotics to animal feed either decreases or raises bacterial counts in the gastrointestinal tract. Turnip has antibacterial properties that have been tested in animal diets. The experiment used different amounts of turnip in chicken water and

compared the growth and bacterial infection of their gut to chickens given a daily antibiotic. Although chickens fed the most turnip grew slowly at first, those fed a medium amount grew faster overall, had stronger feed conversion, and had fewer antibodies in their blood than those fed the antibiotic. This means that putting turnip extract in chickens' diets may be a good alternative to using antibiotics (Eghbaldost-Jadid et al., 2021)

Red turnip White turnip Turnip seed

Picture 2.9. Turnip rood and seed

2.1.10. Kohlrabi

Kohlrabi (Brassica oleraceae var. gongylodes) is a crop that belongs to the Brassicaceae family. Its edible part is the extended stem (Uddin et al., 2009). Kohlrabi is thought to have originated in northwestern Europe, where the Romans cultivated it. It is now grown all over the world, from the tropics to the cold highlands. Kohlrabi is a widely consumed vegetable in Europe, Asia, the northern United States, and Canada (Lim, 2016).

Kohlrabi has tremendous nutritional and medicinal values due to its high content of vitamins (A, B, B, B, B, and E), minerals (Ca, Mg, Zn, and Fe), and antioxidants, which prevent the development of cancer-causing agents (Uddin et al., 2009).

A study compared the quality and production of milk from cattle fed kohlrabi, sugar beet, and maize silage in an experiment that done 23 days in winter and 30 cows were fed maize silage alone or in combination with kohlrabi, sugar beet, or both in varying

quantities, and 22% by clover hay and meadow hay, which supplied 62% of the feed units (FU). As a result, when compared to a diet containing only corn silage, levels of kohlrabi delivering 17 or 18 % feed units boosted milk yield by 5%, and higher amounts raised it, even more, reaching a maximum of 8.6 % when kohlrabi contributed 33 to 36 % feed units. Sugar beet and kohlrabi were both successful at delivering 22% feed units, although 16 kg sugar beet daily caused digestive difficulties whereas 42 kg kohlrabi did not. Both increased milk's fat content but did not affect its protein amount. Feed costs are compared (Gondos et al., 1965).

Picture 2.10. Kohlrabi

2.1.11. Broccoli

Broccoli (also known as broccoli florets or broccoli heads) is a vegetable from the genus Brassica (family Brassicaceae or Cruciferae) that is derived from Brassica oleracea L. and many cultivars were established in Italy, and later in other parts of Europe and America (Latté et al., 2011). It is believed that Italic Plenk originated in the Eastern Mediterranean region and was introduced to Europe, especially Italy, during the Medieval Times (Latté et al., 2011). In recent years, Turkey's broccoli output has increased. According to estimates, Turkey's broccoli production is projected to be about 6500 tons (Yoldas et al., 2008). Broccoli is a nutrient-dense vegetable with a high vitamin and mineral content (Mustafa et al., 2017). It has also been shown to be effective in the prevention of some cancers (Yoldas et al., 2008)

The research looked at the effects of broccoli stems and leaves meal BSLM on the growth and quality of laying hen eggs. The findings revealed that dietary supplementation with BSLM did not affect the efficiency of laying hen production. Supplementing laying hens with BSLM enhances egg production by increasing yolk pigmentation and lowering yolk cholesterol, according to the findings. Changes in cecal

fermentation may have caused a shift in cholesterol synthesis in the egg-fed BSLM, resulting in lower cholesterol (Mustafa et al., 2017).

Picture 2.11. Broccoli

2.1.12. Cauliflower

Cauliflower derives its name from the Latin words caulis and Floris, which mean stem and flower, respectively. Experts believe that cauliflower was domesticated in the Mediterranean region. It started in Cyprus and spread to other countries such as Syria, Turkey, Egypt, and Italy (Kumar, A, 2014).

Cauliflower, also known as Brassica oleracea var. botrytis, has been used for meals as well as traditional and modern medicine. It includes materials with pharmacological activity, such as antimicrobial, antihypertensive, antitumor, antimetastatic, antiangiogenic, antiviral, antioxidant, antidiabetic, and antiallergic properties (Kiyama et al., 2018).

According to one study, leaf waste from commercially grown cauliflower was dehydrated in a pilot-scale alfalfa dehydrator to produce dried food suitable for poultry and cattle feeds. The poultry meal fraction contained 375 to 620 mg/kg of xanthophyll and 26 to 31% protein, while the cattle meal contained 17 to 21% protein, in pigmenting broiler skin, xanthophylls in poultry meal were just as effective as xanthophylls are dehydrated alfalfa meal. Cauliflower meal had no unfavorable flavor in poultry meat. Pressing the cauliflower leaf before dehydration increased its solids content and decreased the amount of water that had to be evaporated per pound of dried product by

nearly 30%. The pressed and dehydrated meals were nearly identical in quality to the unpressed and dehydrated meals (Livingston et al., 1972).

Picture 2.12. Cauliflower

2.2. Gas production kinetics in ruminant animals

Climate change is also affecting agriculture, with extreme weather events, droughts and rising climate variability have global impacts on development and rural livelihoods (Grainger et al., 2007). Agriculture will also be increasingly affected, in addition to the physical effects, by policies aimed at reducing pollution from the land sector. Climate change poses an additional obstacle for farmers and industries to address, alongside resource depletion, intensified competition for agricultural land and water, and declining investments in agricultural research and development. Agriculture must face these challenges while improving production significantly (Navarro-Villa et al., 2011).

Animal manure includes large amounts of organic matter which, if broken down by bacteria in a controlled environment in the absence of oxygen, will considerable quantities of methane (CH_4) gas are produced (Olijhoek et al., 2016). Containment housing systems, where large amounts of waste accumulate easily, increase the capacity for energy recovery from animal waste. A method that recovers energy while reducing

environmental issues and increasing the end-product fertilizer value can be of great value to the agricultural industry and to the community it promotes (Lapp et al., 1975).

In the ruminant digestive system, methane from enteric fermentation is a significant contributor to anthropogenic greenhouse gas emissions worldwide. Methane also reflects a net loss of the animal's nutritional energy (Hristov et al., 2015). To explain the energy of ruminant feed, the systematic use of metabolizable energy (ME) relies either on direct measurements of the production of methane or on appropriate estimates of the production of methane. Since methane is a gaseous loss, specialized equipment is needed for its measurement. The ME of many diets is therefore estimated by the measured methane production, furthermore, a linear relationship between methane production and cattle dry matter intake was discovered (Moe et al., 1979). Accessibility of kinetic data from in vitro gas production curves of ruminant feeds has created a desire for information analysis models to estimate nutritionally necessary variables. Within the analysis of gas production information, several mathematical functions are under use in science (Dillard et al., 2018).

From the above studies, it was hypothesized that brassica plants that are not commonly utilized as animal feed could bring beneficial gains in livestock production by lowering feeding costs, meeting animal nutrient requirements, and enhancing performance and carcass quality.

CHAPTER 3

MATERIALS AND METHODS

3.1. Materials

Brassica group plants have been breeding in Turkey for years and consumed by the people as fresh, include salad and cooked meals. The green fresh tuber and leaf materials are collected from local bazaars and seeds obtained from seed companies. The companies, at the same time, selling to seeds to farmers, and farmers produce green fresh materials. Therefore, these materials same origin in terms of seed, tuber, and leaves. In the experiment 12 seed, 7 tubers, and 7 leaves samples were evaluated.

Twenty-six Brassica group plants were used in this study, they include;

Table 3.1. Plant materials used in thesis study

No	Seeds	Tubers	Leaves
1	Radish seed	Radish	Red cabbage
2	Black spanish radish	Black Spanish radish	White cabbage
3	Daikon	Daikon	Cauliflower
4	Red cabbage	Purple radish	Dill
5	White cabbage	White Turnip	Arugula
6	Turnip	Red Turnip	Crass
7	Dill	Kohlrabi	Broccoli
8	Arugula		
9	Crass		
10	Flax		
11	Mustard		
12	Hemp		

The rumen fluids used in the study were obtained from cannulated goats grown at the Agricultural Research and Application Center of the University of Erciyes. Treatment was formed by adding plant waste materials to the rumen fluid at 0.2 g levels and the treatment doses applied.

3.2. Methods

The experiment was conducted in 3 replications according to the random trial plot order. Treatments included different types of brassica plants and a liquid level of 0,2 g. In addition, the current study; was carried out by using the in vitro gas technique with different incubation time intervals.

Dry matter, crude protein, crude oil, crude ash analyzes of plant materials were performed according to Weende analysis method in the Feed and Animal Nutrition laboratories of Erciyes University, Faculty of Agriculture, Department of Animal Science according to guide of AOAC (AOAC, 2012).

3.2.1. Preparation of samples

After the brassica group plants, samples used in the study were grounded to 1mm in diameter, 0.2 g (200 mg) of each sample in three replicates for each treatment group were weighed with 0.001 precision scales, then placed at the bottom of the measuring cylinder with the help of a long spoon and made ready for incubation.

3.2.2. Chemical analysis

Dry matter: Samples were subjected to a drying process in the oven at 105 $^{\circ}C$ for 18 hours to make dry matter analysis.

Crude ash: The feed samples were burned at 550 $^{\circ}C$ for 5 hours and the amount of ash formed from the remaining inorganic materials was expressed in%.

Crude oil: ratios of the feed samples were determined by extraction with the XT 15 ANKOM device.

Crude protein: The protein was detected using the Dumas nitrogen analyzer (NDA 701, VELP Scientifica Ltd. Co. Italia), where samples were produced with an average weight of 0.400 mg and placed in a specific aluminum sheet before being placed in the device assigned location.

Picture 3.1. Preparation of samples and chemical analysis

3.2.3. Conducting the in vitro trial

The pistons of the measuring cylinder (Picture 3.2) were lubricated with silicone and placed in the cylinder; 30 samples were created. In determining the gas production amounts, 5 blind groups that do not contain any Brassica group plants were added and the gas readings were corrected in this direction.

The rumen fluids obtained from the rumen of the animals that came to a commercial slaughterhouse operating in the region, whose feeding and disease history are known and was sent to slaughter, were brought to the laboratory quickly with a thermos, filtered through a 4-fold strainer, and mixed with artificial saliva in a 2: 1 ratio and fermentation liquid were prepared. The mixture obtained was taken into 30 ml syringes preheated at 39°C and kept in a 39°C water bath during the incubation period. The liquids prepared for all treatments were subjected to 24-hour incubation and the gas production amounts were recorded. In the results obtained, the groups were not analyzed again, since there were not many differences between repetitions in the groups.

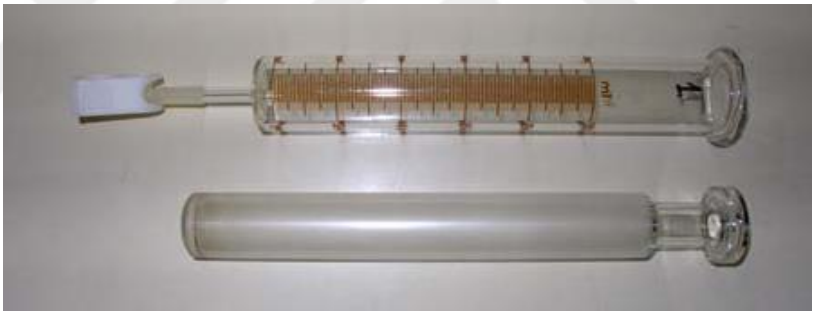
3.2.4. Gas generation technique

In the determination of in vitro gas production, the method developed at Hohenheim University in Germany and named HohenheimerFutterwert Test (HFT) or Hohenheim

feed test was used (DLG., 1981). The basis of this method is based on the measurement of gas (CO_2 and CH_4) production that occurs as a result of 24-hour incubation of feeds with rumen fluid in the incubator. The results obtained are used to calculate the digestibility of organic matter and the net energy lactation (NEL) content of feedstuffs. In addition, the relationship between gas production and in vivo digestibility is determined.

3.2.5. Tools and materials

Measuring cylinder (36 mm diameter, 200 mm long) with a 100 ml volume marked and a 50 mm long and 5 mm diameter silicone tube attached to the thin end, a clamp that closes the measuring cylinder on the tube, device for taking rumen fluid. Dispenser (50 ml piston and adjustable to 30 ml volume), it woulfbottle. Magnetic stirrer, water bath (set at $39^{\circ}C$), and carbon dioxide tube.



Picture 3.2. Measuring Cylinder

3.2.6. Preparation of solutions

Macro mineral solution: 5.7 g Na_2HPO_4 + 6.2 g KH_2PO_4 + 0.6 g $MgSO_4$ $7H_2O$ + It is dissolved in pure waterand complete to 1000 ml.

Micro mineral solution: 13.2 g $CaCl_2$ $2H_2O$ + 10 g $MnCl_2$ $4H_2O$ + 1.0 g $CoCl_2$ $6H_2O$ + 8.0 g $FeCl_3$ 6 H_2O + It is dissolved in pure waterand complete to 1000 ml.

Buffer solution: 39 g Na HCO_3 + 4 g (NH_4) HCO_3 + It is dissolved in pure water and completed to 1000 ml.

Resazurin solution: 100 mg dissolve resazurin in pure water and makeup to 100 ml.

Reduction solution: It is prepared fresh in every work. First 1.99 ml of 1 N NaOH solution is put into 47.45 ml of distilled water, 285 mg of Na2S 7HO is added.

3.2.7. Method application

The solutions prepared as described above were put into the woulf bottle in the amount and order given below.

474.50 ml distilled water + 0.12 ml micro mineral solution + 237.23 ml buffer solution + 237.23 ml macro mineral solution + 1.22 ml resazurin solution + 49.44 ml reduction solution.

This mixture was prepared just before the rumen fluid was taken (DLG., 1981), mixed with a magnetic stirrer in a 39$^{\circ C}$ water bath under CO_2 gas, and kept until rumen fluid was added.

3.2.8. Intake and incubation of rumen fluid

On the morning of the analysis, rumen fluid was obtained from the rumen of one of the animals whose feeding and disease history is known and sent to slaughter, by going to one of the slaughterhouses operating in the region. The rumen fluid was immediately taken to the laboratory after it was placed in a thermos to maintain its temperature and the mouth was tightly closed. In the laboratory, 500 ml of rumen fluid (1/2 ratio of the mixture) was added to the mixture that we prepared in the woulf bottle. CO_2 gas was continuously injected into this mixture with a tube, while the color change was checked for about 15 minutes. After putting 30 ml of rumen liquid mixture with the dispenser into the measuring cylinders where the Brassica group plants have been previously placed and kept at 39$^{\circ C}$ in the incubation cabinet, the air bubbles in it are removed from the environment, the clamp on the tip is compressed and the measuring cylinder is placed in the incubation cabinet as shown in Picture 3.3.

It is arranged these processes were repeated until the samples we put in the incubation cabinet are finished. Incubation took place at 39$^{\circ C}$ for 24-hours. Each example was studied in 3 repetitions. The liquids prepared for all treatments were subjected to 24-hour incubation time and gas production amounts were recorded period.

Picture 3.3. Incubation of prepared rumen fluids

3.2.9. Determination of methane gas percentage of brassica seeds

The percentage amount of methane (CH_4) gas formed as a result of fermentation in vitro in the total gas produced was determined using the methane detector (Picture 3.4).

Picture 3.4. Methane detector

3.2.10. Calculation of OMD and ME content of brassica seeds and leaves

After the gas production amounts of plant by-products were determined, OMD (%), ME (MJ / kg), and NEL (MJ / kg) values were calculated using the equations reported by (Menke and Steingass, 1988) and shown below using the equations below.

For forage feeds, ME (MJ/kg DM) = 2.20 + 0.136GP + 0.057CP + 0.0029CF2

For concentrate feeds, ME (MJ/kg DM) = 1.06 + 0.157GP + 0.084CP + 0.22CF − 0.081CA

NEL(MJ/kg KM) = 0.115×GP+0.0054×HP+0.014×HY −0.0054×HK−0.36

OMD (% KM) = 0.9991×GP+0.0595×HP+0.0181×HK+9.00

3.2.11. Evaluation of data

In the analysis, each sample was analyzed in three repetitions and the averages of these data were written in the tables. Since there was no group comparison, they were not subjected to any statistical analysis.

CHAPTER 4

RESULTS

The dry matter, crude protein, crude oil, crude ash, and crude cellulose analyzes of brassica plants used in the study were carried out according to the Weende analysis method in Erciyes University, Faculty of Agriculture, Department of Animal Science, Feeds and Animal Nutrition laboratories. Then gas production kinetics were determined. The brassica plants' leaves, seed and tubers' nutrient contents are given in the tables below.

The dry matter, crude ash, crude oil, and crude protein contents of brassica seeds are given in Table 4.1. There was statistical significance between the seeds' nutrient compositions ($P< 0.01$). The dry matter content of dill and flaxseed was lower than the others. There were big differences between the plant seed crude ash content and mustard was the highest and flaxseed the lowest. Similarly, crude protein, crude oil, and acid detergent cellulose, and neutral detergent fiber contents were statistically very different. The crude protein content of arugula and white cabbage was higher than others and the lowest one was determined in dill seed. The crude oil content of radish and flaxseed was higher than the others and also was lowest in mustard seeds. The ADF content in dill was higher than others and in black spanish radish, ADF content was lower than the others. The hemp seed's NDF content was higher than others and the mustard seed was lower than others.

Table 4.1. Dry matter, crude ash, crude oil, and crude protein contents of brassica seeds

Sample Name	Dry matter	Crude ash	Crude protein	Crude oil	ADF*	NDF*
Radish seed	94±0.05a	4.7±0.10g	28.7±0.00c	40.0±0.15a	45.3±0.18d	22.8±0.14f
Black spanish radish	93.7±0.05a	3.6±0.06h	28.4±0.12c	38.2±0.20b	27.5±0.06j	33.4±0.21b
Daikon	93.3±0.03a	3.6±0.04h	26.4±0.07e	37.8±0.10b	33.9±0.50h	22.5±0.16f
Red cabbage	93.3±0.16a	5.6±0.07e	34.7±0.13b	27.2±0.00f	33.8±0.69h	29.6±0.23d
White cabbage	94±0.05a	6.8±0.06c	35.7±0.17a	27.4±0.07f	35.5±0.47g	29.4±0.02d
Turnip	93.9±0.11a	4.7±0.00g	27.3±0.38d	35.2±0.05c	38.6±0.55f	25.4±0.53e
Dill	88.7±4.72b	8.6±0.06b	17.9±0.23g	8.5±0.04h	62.1±0.13a	31.8±0.62c
Arugula	94.8±0.02a	4.9±0.08fg	35.6±0.25a	28.5±0.20e	39.9±0.30e	22.1±0.78f
Crass	93.3±0.01a	5.9±0.06d	27.4±0.46d	28.5±0.20e	49.6±0.11c	29.85±0.69d
Flax	82.4±0.11b	3.1±0.05i	24.9±0.12f	40.1±0.35a	40.1±0.06e	32.7±0.03bc
Mustard	94.1±0.02a	11.4±0.03a	34.2±0.31b	23.2±0.24g	32.6±0.18i	11.0±0.30g
Hemp	94.1±0.01a	4.9±0.04f	26.5±0.19e	32.0±0.30d	58.7±0.17b	49.7±0.01a
SEM	0.75	0.47	1.05	1.78	2.12	1.83
P	0.001**	0.000**	0.000**	0.000**	0.000**	0.000**

[a, b]: Differences between the averages are significant in the same column with different letter, *ADF: acid detergent fiber, NDF: neutral detergent fiber, **:P<0.01

The nutrient contents of the brassica tuber used in the study are examined are given in Table 4.2. There were strongly positive statistically significant differences between the treatments. The differences between the groups in terms of DM tuber were found statistically significant (P<0.001). The highest value was obtained from the black Spanish radish tuber and the lowest value was in white turnip and radish tubers. The differences between the groups in terms of crude ash were found statistically significant

(P<0.001) and the highest value was in kohlrabi tuber and the lowest value was in daikon tuber. The differences between the groups in terms of crude protein were found statistically significant (P<0.001). The highest value was obtained from the red turnip tuber. The lowest value was obtained from the purple radish tuber. The differences between the groups in terms of crude oil were found statistically significant (P<0.001) The highest value was obtained from the white turnip tuber, red turnip tuber, and kohlrabi tuber. The lowest value was obtained from the black spanish radish tuber. The differences between the groups in terms of ADF were found statistically significant (P<0.001) The highest value was obtained from the kohlrabi tuber. The lowest value was obtained from the radish tuber. The differences between the groups in terms of NDF were found statistically significant (P<0.001) The highest value was obtained from the purple radish tuber. The lowest value was obtained from the daikon tuber.

Table 4.2. Dry matter, crude ash, crude oil, and crude protein contents of brassica tubers

Sample Name	Dry matter	Crude ash	Crude protein	Crude oil	ADF*	NDF*
Radish	4.6±0.66c	12.7±0.01c	16.2±0.16d	1.4±0.01c	22.1±0.78d	18.6±0.07f
Black Spanish radish	10.5±0.22a	8.0±0.05f	18.5±0.05c	0.6±0.01d	17.8±0.07e	21.5±0.15e
Daikon	7.0±0.28b	7.8±0.06f	15.4±0.24d	1.3±0.05c	14.4±0.34f	8.6±0.04g
Purple radish	7.5±0.06b	11.3±0.09e	1.4±0.52f	2.3±0.05b	28.1±0.77b	33.0±0.32a
White Turnip	4.6±0.45c	17.7±0.00b	13.3±0.05e	3.5±0.30a	26.4±0.25c	25.8±0.07b
Red Turnip	6.5±0.23b	12.3±0.04d	21.4±0.05a	3.34±0.13a	21.8±0.04d	22.7±0.15d
Kohlrabi	6.4±0.42b	20.5±0.17a	19.8±0.05b	3.6±0.20a	32.8±0.52a	23.6±0.21c
SEM	0.52	1.21	1.71	0.31	1.61	1.9
P	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

[a, b]: Differences between the averages are significant in the same column with different letter.
*:ADF: acid detergent fiber, NDF: neutral detergent fiber, **:P<0.01.

When the nutrient contents of the brassica leaves used in the study are examined are given in Table 4.3. There were strongly positive statistically significant differences between the treatments. The differences between the groups in terms of DM leave were found statistically significant (P<0.001). The highest value was obtained from the broccoli leaves. The lowest value was obtained from the crass and arugula leave. The differences between the groups in terms of crude ash leave were found statistically significant (P<0.001). The highest value was obtained from the dill, arugula leaves, and crass, the lowest value was obtained from the red cabbage leave. The differences between the groups in terms of crude protein were found statistically significant (P<0.001). The highest value was obtained from the arugula leaves, and crass the lowest value was obtained from the red cabbage and white cabbage leaves. The differences between the groups in terms of crude oil were found statistically significant (P<0.001). The highest value was obtained from the dill leaves, and lowest in red cabbage leaves. The differences between the groups in terms of ADF were found statistically significant (P<0.001).

Table 4.3. Dry matter, crude ash, crude oil, and crude protein contents of brassica leaves

Sample Name	Dry matter	Crude ash	Crude protein	Crude oil	ADF*	NDF*
Red cabbage	11.0±0.42b	6.4±0.05c	14.67±0.26e	1.1±0.06f	18.4±0.54e	9.8±0.10g
White cabbage	7.6±0.14c	7.9±0.08b	15.50±0.09e	4.8±0.06b	19.5±0.57e	11.4±0.60f
Cauliflower	8.1±0.30c	8.4±0.19b	18.78±0.41d	2.3±0.12e	25.1±0.27d	32.5±0.32a
Dill	7.4±0.16c	20.4±0.32a	29.21±0.15b	6.2±0.05a	43.7±0.04a	23.6±0.31d
Arugula	5.7±0.20d	20.8±0.01a	37.13±0.42a	4.7±0.06b	35.2±0.59b	29.8±0.34b
Crass	5.5±0.04d	20.4±0.04a	37.51±0.04a	3.9±0.08c	42.7±0.29a	17.3±0.40e
Broccoli	14.5±0.23a	8.3±0.15b	24.96±0.42c	2.8±0.04d	27.4±0.10c	26.3±0.00c
SEM	0.82	1.77	2.47	0.44	2.67	2.28
P	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

[a, b]: Differences between the averages are significant in the same column with different letter. OMD: Organic matter digestibility, ME: Metabolic energy, NEL: Net energy lactation, MJ: Megajoule, **:P<0.01.

The highest value were obtained from the dill and crass leaves and the lowest were in red cabbage and white cabbage leaves. The differences between the groups in terms of NDF were found statistically significant (P<0.001) and the highest value was obtained from the cauliflower leaves and the lowest value was in red cabbage leaves.

The average brassica seeds of 24-hour gas (ml / 0.2 g) production where 49% red cabbage seed had the highest value. The lowest value was obtained from radish seed 30%. Methane production sample the highest value was obtained was 11.50% the hemp seed. The lowest value was obtained from the radish seed 10.1%. The highest OMD values were found in the red cabbage with 59.25% and the lowest value was obtained from radish seed 42.77%. ME (MJ / kg DM), turnip seeds with 18.26, and the lowest value was in dill seed with 10.19. Also, NEL, MJ/Kg DM the highest value in red cabbage with an average of 5.81, and the lowest value was in mustard seed with 3.77.

Table 4.4. Average of 24th-hour gas production potential, CH_4 gas ratio, organic matter digestibility, and metabolic energy values of brassica seeds

Sample name seed	24-hour gas, ml /200 mg	Methane (CH_4) %	OMD, %	ME, MJ/kg DM	NEL, MJ/kg DM
Radish seed	30,50+,50f	10,30+,30a	43.1±0.41g	16.6±0.12	3.84±0.06f
Black spanish radish seed	37,50+,50d	10,40+,20ab	49.0±0.41eg	17.4±0.10	4.62±0.06cd
Daikon seed	34,00+,00ef	10,00+,00b	45.9±0.01f	16.6±0.02	4.20±0.00df
Red cabbage seed	50,00+1,00a	11,70+,70a	60.0±0.85a	17.3±0.17	5.92±0.11a
White cabbage seed	33,00+1,00ef	9,65+,15b	45.8±0.83f	14.7±0.16	3.97±0.11f
Turnip seeds	47,00+1,00b	10,45+,45ab	57.0±0.82b	18.1±0.11	5.66±0.11b
Dill seed	40,50+,50c	10,00+,10b	51.2±0.41de	10.1±0.04	4.46±0.05cd
Arugula seed	43,00+,00c	10,70+,00ab	54.1±0.02c	16.7±0.06	5.15±0.00b
Crass seed	41,00+1,00c	9,95+,15b	52.0±0.82cd	15.6±0.07	4.87±0.11bc
Flaxseed	31,00+1,00ef	10,50+,50ab	43.2±0.85	16.5±0.24	3.88±0.12f
Mustard seed	33,00+1,00ef	10,00+,10b	46.0±0.82f	13.3±0.19	3.88±0.11f
Hemp seed	42,00+2,00c	11,00+1,00ab	52.7±0.70cd	16.5±0.26	5.03±0.22b
SEM	1,29	1,14	1,10	0,44	0,14
P	0,000**	0,178	0,000*	0,000*	0,000*

[a, b]: Differences between the averages are significant in the same column with different letter. OMD: Organic matter digestibility, ME: Metabolic energy, NEL: Net energy lactation, MJ: Megajoule, **:P<0.01

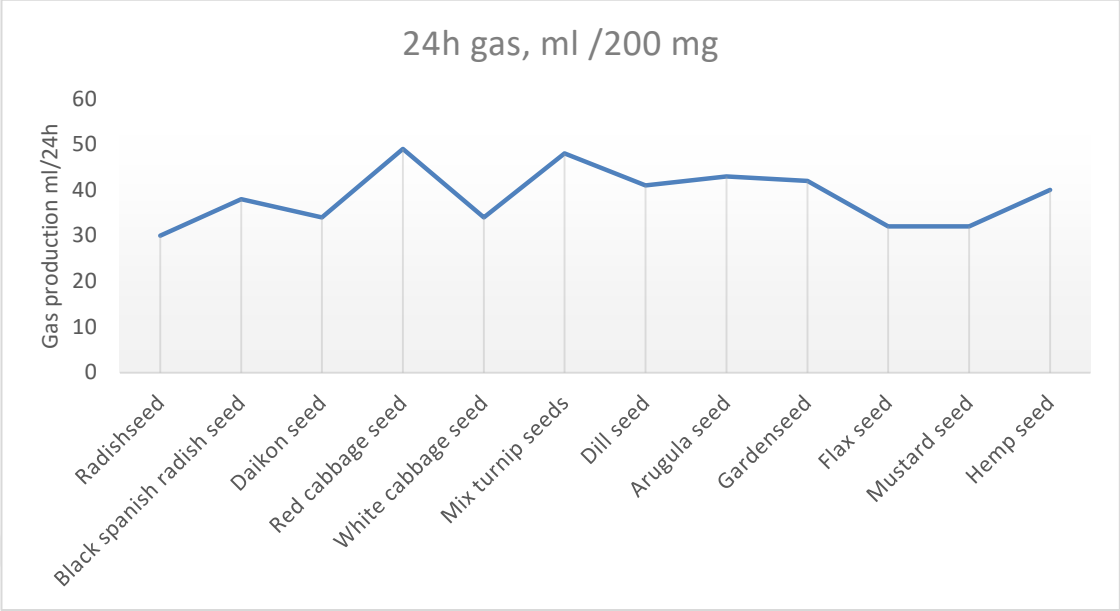


Figure 4.1 Gas Production of Seeds

The average brassica tubers of 24-hour gas (ml / 0.2 g) production were 85% black spanish radish tuber had the highest value and the lowest value was obtained from kohlrabi 35%. In terms of methane production was 9.8% the White Turnip and the lowest value was obtained from daikon 7.9%. The highest OMD values were found in the black spanish radish tuber with 88.88% and the lowest value was obtained from kohlrabi 47.32%. ME (MJ / kg DM) mean black spanish radish tuber with 14.82 and the lowest value was obtained from purple radish tuber 10.45. also NEL, MJ/Kg DM the highest value in black spanish radish tuber with an average of 9.48, and the lowest value was obtained from kohlrabi 3.69.

Table 4.5. Average of 24th-hour gas production potential, CH_4 gas ratio, organic matter digestibility, and metabolic energy values of brassica tubers

Sample name	24-hour gas, ml /200 mg	Methane (CH_4) %	OMD, %	ME, MJ/kg DM	NEL, MJ/kg DM
Radish	70,50+,5b	11,00+,0a	76.7±0.43c	12.7±0.09c	7.79±0.06c
Black Spanish radish	84,00+,0a	8,95+,9a	88.0±0.84a	15.2±0.16a	9.36±0.11a
Daikon	78,00+,0b	4,45+,4b	82.7±0.02b	14.2±0.00b	8.67±0.00b
Purple radish tuber	61,00+,0d	8,00+,0a	67.8±0.82d	10.3±0.11e	6.63±0.11d
White Turnip	57,50+,5e	10,20+,2a	65.9±0.43d	10.5±0.15e	6.28±0.06e
Red Turnip	57,50+,5e	10,15+,1a	66.0±0.43d	11.6±0.11d	6.35±0.06e
Kohlrabi	39,50+,5f	10,20+,2a	51.3±0.44e	8.06±0.02f	4.23±0.05f
SEM	3,83	0,64	3.16	0.63	0.44
P	0,000**	0,034*	0.000**	0.000**	0.000**

[a, b]: Differences between the averages are significant in the same column with different letter. OMD: Organic matter digestibility, ME: Metabolic energy, NEL: Net energy lactation, MJ: Megajoule, *P<0,05, **P<0,01

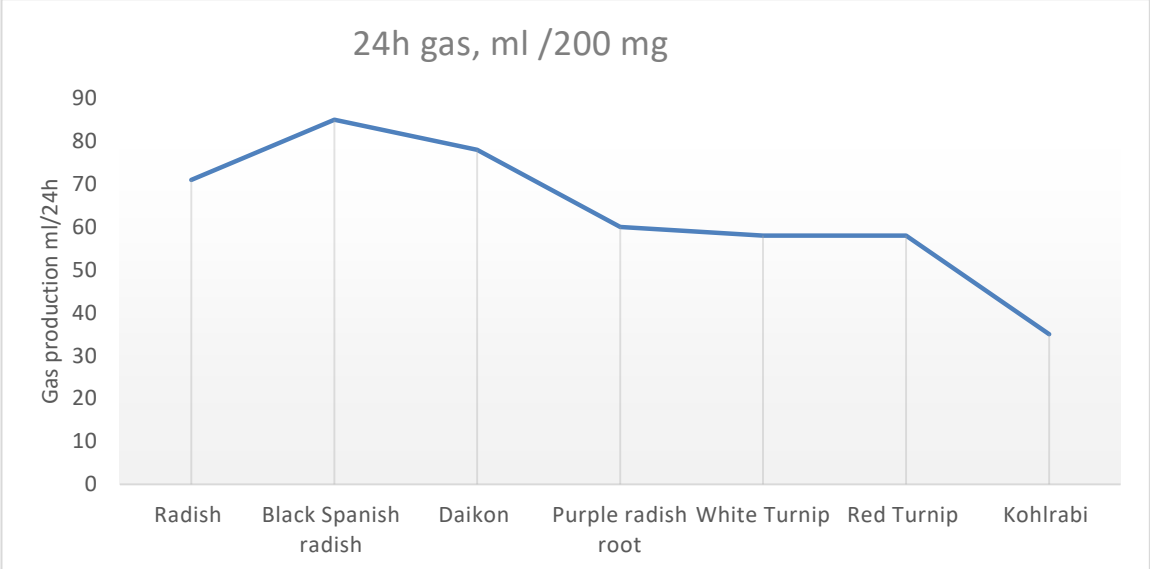


Figure 4.2 Gas Production of Tubers

The average brassica leaves of 24-hour gas (ml / 0.2 g) production were 73 red cabbage had the highest value and the lowest value was obtained from cauliflower 30%. In terms of methane production was 10.1% the dill and the lowest value was obtained from broccoli 7.85%. The highest OMD values were found in the red cabbage with 78.48% and the lowest value was obtained from cauliflower 42.41%. ME (MJ / kg DM) mean red cabbage with 13.05 and the lowest value was obtained from cauliflower 7.85. Also NEL, MJ/Kg DM the highest value in Red cabbage with an average of 8.1 and the lowest value was obtained from cauliflower 3.18.

Table 4.6. Average of 24th-hour gas production potential, ch_4 gas ratio, organic matter digestibility, and metabolic energy values of brassica leaves

Sample name leave	24-hour gas, ml /200 mg	Methane (CH_4) %	OMD, %	ME, MJ/kg DM	NEL, MJ/kg DM
Red cabbage	72,50+,50a	7,95+,05b	77.9±0.41a	13.4±0.04a	8.03±0.05a
White cabbage	65,00+4,00b	9,30+,40ab	71.7±0.39b	12.9±0.61a	7.22±0.46b
Cauliflower	42,00+,00c	9,85+,05a	52.5±0.01c	9.07±0.07cd	4.55±0.00c
Dill	34,00+1,00d	9,10+,10ab	47.2±0.81d	8.57±0.16df	3.68±0.11d
Arugula	29,50+,50d	5,75+,85c	43.9±0.39d	8.17±0.03f	3.18±0.05d
Crass	41,00+1,00c	9,35+,15ab	53.6±0.84c	9.85±0.16bc	4.50±0.11c
Broccoli	46,50+,50c	8,95+,55ab	56.7±0.43c	10.4±0.12b	5.12±0.06c
SEM	15,34	1,40	3.25	0.54	0.46
P	0,000**	0,003**	0.000**	0.000**	0.000**

[a, b]: Differences between the averages are significant in the same column with different letter. OMD: Organic matter digestibility, ME: Metabolic energy, NEL: Net energy lactation, MJ: Megajoule, **:P<0.01.

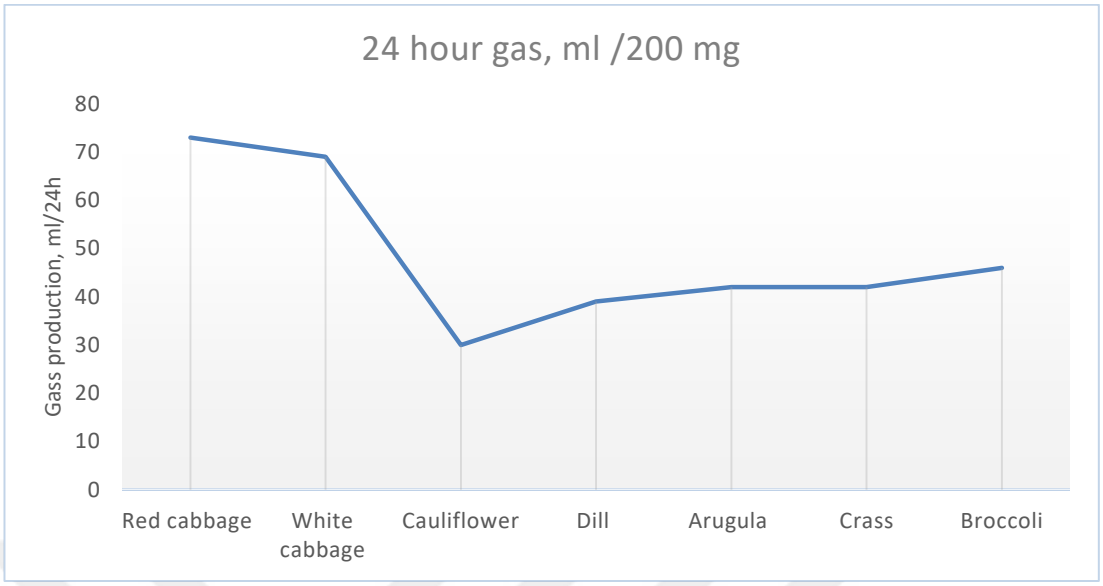


Figure 4.3 Gas Production of Leaves

CHAPTER 5

DISCUSSION

Until now, the brassica plants well known in grower country. However, there is limited research results compared to other plant sources on their chemical components and use for different kind animal groups. So, these data in this thesis my helpful for next experiments. This study were focused on the determination of nutrient composition and amount of gas production in vitro condition of some brassica group plants. Gas production is an indicative of feed fermentation by microbial digestion. The fermentation residues in the gases include methane (CH_4) and carbon dioxide gas (CO_2) of the plants. When plant residues are left to decay in nature, carbon dioxide and methane will be released while the nutrients they contain are dissolved in nature. If it is possible to use plants as animal feed, economic feed resources will also be obtained from these and nutrients will be provided to animals.

5.1. Evaluation of nutrient content of seed leaves and tubers

The nutrient contents of the feeds used in the present study were examined and found that within the brassica plant kind there were huge variations between the plants contents. In terms of DM ratio, the highest average value was found in arugula seed with 94.86%, while the lowest average value was obtained from flaxseed with 82.46%. Sheikh et al. (2018) reported that white and red turnip containing respectively, 88.51 and 88.20 DM%, 0.13 and 0.20 % crude oil, 1 and 0.90% crude protein and 0.15 and 0.85 crude ash in fresh forms.

The average crude ash rate was detected in the samples and the highest one is mustard seed with 11.45% and the lowest in flaxseed with 3.50%. It was seen that the highest crude oil rate belongs to flaxseed with 40.15%, and the lowest HY rate belongs to dill seed with 8.54%. The average NDF rate detected in the samples was in the highest

hemp seed with 48.24% and the lowest in a mustard seed with 11.09%. The average ADF rate detected in the samples was in the highest dill seed with 61.14% and the lowest in black spanish radish seed with 27.57%. Among the feeds used in this study, white cabbage seed was the feed rich in crude protein (35.76%) and the lowest average value was found in dill with 17.95%. In the current study, the average chemical composition of red and white cabbage seeds was 91.32 DM, 5.63% CA, 27.20 % CP, 33.90 % ADF, and 26.14 % NDF. Similarly Evan et al. (2019) analyzed the chemical contents, in vitro ruminal fermentation, and intestinal digestibility of discarded samples of four Brassica vegetables: Brussels sprouts (BS), white cabbage, Savoy cabbage, and red cabbage. The researchers reported that all the cabbages have low DM 16.50 % and but their DM has high crude protein contents 19.5–24.8% with low NDF of 17.5–28%. Also, in the same study, it was reported that all cabbages have high protein digestibility above 91.5%. As it increased digestibility of dry matter and protein, while it decreased in vitro CH4/total volatile fatty acid production. Ngu and Ledin (2005) reported similar findings. However, in contrast to that, another study (Mekasha et al., 2002) noted that cabbages had lower crude protein composition. The differences found in chemical contents according to results reported in the literature may be due to the difference of stage of growth, season, species and variety, soil types, and growth environment. When it comes to the radish seed has an average 94.08 of DM, 4.71 of CA, 28.76 of CP, 45.39 of ADF, and 22.82 of NDF. Similar to that it was reported by Trolove *et al.* (2018) that the protein in radish seed is highly degraded by rumen microbes, and high-producing farm cows and rapidly increasing ruminants cannot meet their CP requirements solely from microorganism super molecules, making it critical that the diet provides slowly degraded proteins with a high potential for rumen escape. Manivannan et al. (2019) as added that those reddish seeds have nutritive and bioactive chemical contents which provide antimicrobial and antioxidant to both animals and humans. So as the previous studies reported radish seeds and leaves are sources of nutrients and phytochemicals which are good for the health status of the animals. Radish leaves chemical contents had highly nutritional and medical value. The chemical composition of radish leaves is comparable to the findings noted (Gupta et al., 2005). Similar findings were observed that the radish leaves had higher protein percentage, crude ash, and dietary crude fiber than those of the reddish tubers. The total energy contents of radish leaves were lower than the other vegetables as reported (Raimi et al., 2014). Turnips are used to feed

animals when there is low pasture and shortage times especially during the cold and hot seasons because they contain high dry matter and there are easily digestible. In the present study, it was noted that the turnip seeds had DM of 90.91, 4.72 of CA, 27.31 of CP, 38.68 of ADF, and 25.46 of NDF. Similar findings have been reported by Westwood (2012). Furthermore, same as that Moate et al. (1998) mentioned that the supplementation of 5 kg DM turnips enhanced the milk production (±2.5 kg milk) of mid-lactation dairy cows. Also Keim et al. (2018), investigated summer brassica turnips, with their high degradability, which was an attractive alternative for farmers to increase the energy supply in the rumen of dairy cows has increased their milk yield. Also Keim et al. (2018) examined the fermentation and rumen degradation properties of Brassica rape ssp. (turnips) then it was observed that the turnips had high sugar levels and high dry matter degradation traits with high water solubility. Although, brassicas did not affect VFA production through in vitro process. Flaxseeds are famous for their rich dietary fiber, as well as high-quality protein contents. In this present study, it was noted that the turnip seeds had DM of 82.46, 3.50 of CA 40.15 of CP, 40.14 of ADF, and 32.73 of NDF. Bernacchia *et al.* (2014) explained that the flaxseed contain 41% fat, 20% CP, 28% TDF, 7.7% moisture and 3.4% CA. Also, the researchers (Hussain et al., 2008; Menteş et al., 2008) found out similar results. In addition to that some researchers (Bozan et al., 2008) reported similar findings. In the current study, crude oil findings agree with the previous studies. However, they reported less crude protein compared to the present study. The differences found in chemical contents according to results reported in the literature may be due to the difference of stage of growth, season, species and variety, soil types, and growth environment. Mustard seed contains about 40% crude protein of high quality has the potential of being an economical protein source (Sohail et al., 2017). In this current study, mustard seeds had DM of 94.17, 11.45 of CA, 34.20 of CP, 23.29 of ADF, and 32.68 of NDF. Same as that Abul-Fadl et al. (2011) noted high crude protein and high crude oil. Similar findings were published (Cserhalmi et al., 2000; Ildikó et al., 2006; Sen and Bhattacharyya, 2003). Hempseeds are a good source of oil, protein, and carbohydrates (Callaway, 2004; Konca et al., 2014). In the present study, hempseeds had DM of 94.17, 4.94 of CA, 32.00 of CP, 58.71 of ADF, and 48.24 of NDF. With a whole supply of all essential amino and fatty acids, hemp seed may be a completely organic process supply (Eriksson et al., 2012). Moreover, the oil of hemp seed is shown to exhibit pharmacological activity (Oomah et

al., 2002). Also, Borhade (2013) reported that hempseed contains 32.21% of crude oil, 23.90 % of crude protein, 4.32% of ash 17.30% of fiber, and 28.50 % of carbohydrates. Hempseed protein has been noted to possess equivalent dietary value to egg white and soybean proteins as a result of its outstanding digestibility and competence in essential amino acids (Yin et al., 2008). The differences found in chemical contents according to results reported in the literature may be due to the difference of stage of growth, season, species and variety, soil types, and growth environment. Parameters of the fundamental chemical structure of broccoli leaves are shown in table 4.2. Broccoli leaves had a higher crude protein, crude fiber, and crude ash, but a low amount of crude oil. The chemical structure revealed minimum inconsistencies with the values noted by other researchers (Barth et al., 1992). However, the differences can be credited to the variety, maturation state, and environmental conditions of broccoli, as well as the method of sampling.

In this current study, the gas production was the highest value in red cabbage seed with an average of 49%; In terms of the average percentage methane (CH_4) 11.50% hemp seed, OMS (DM%) the highest value in red cabbage within 59.25%, and ME (MJ / kg DM) mean black Spanish radish seed with 17.53, also NEL, MJ/Kg DM the highest value in red cabbage with an average of 5.81%. Among the brassica leaves used in the present study, while the average of 24-hour gas (ml / 0.2 g) production was 85, black Spanish radish leave had the highest value; In terms of average% methane (CH4), dill leaves with 10.10%, Also black Spanish radish leave with 88.88%, 14, 84% and 9.48% respectively in terms of OMD (% DM), ME (MJ / kg DM) and NEL, MJ/Kg DM. Stefanski *et al.* (Stefanski et al., 2010) reported that supplementation of Brassica plants to dairy cows reduced the dry matter intake of animals due to the high water content of summer turnip that increased the feed simplicity and lives weight as it reduced the methane production of animals. Similar findings were observed by Moate et al. (1998). Also Oba (2011) reported that supplementation of Brassicas plants were higher acetate and fewer propionate proportions were observed in the rumen fluid. The average dry matter ratio of leave was changed between 14.56% (broccoli) and 4.20% (white turnip); dry matter values and the nutrient content of some feeds used in ruminant animal nutrition (Barry, 2013). Evan *et al.* (2019) that mentioned brassica leaves are rich in energy because they have a high content of dry matter like white cabbage (8.64) The CP

value of black radish leaves is generally higher than the CP value of all the other samples obtained in this study. However, the HP ratios of brassica leave feed and some other feeds on a dry matter basis (radish leaves 16.20%; daikon 15.44%; purple leaves 16.30%). From these findings, it can be said that trial feeds can be considered as a good source of protein. Concerning the oil contents, the crude fat contents of the trial feeds were determined as 6.26%, for the highest dill leave and 0.63% for the lowest black spanish leave; Some brassica leaves such as radish (1.46), daikon (2.38), purple leave (2.38), red cabbage (1.16), white cabbage leave (4.80) are generally higher than the CO values stated in the study of (Barry, 2013) it was found to be high. The main reason for this height is to obtain the oils in medicinal plants by pressing and the temperature is desired not to increase during the extraction of the oils. Otherwise, it is thought that squeezing oil at high temperatures will cause deterioration in the quality of the oils and may not have a positive effect on health.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

According to the research results, although the studied brassica plants differ from each other in terms of the characteristics examined, it has been observed that the feed quality values are generally sufficient. However, it can be said that brassica seed and leaves are classified as low anti-methanogenic based on their in-vitro methane production percentage.

Brassica plants that are not commonly used as animal feed. As these are obtained as a supplement to the main product, they can provide positive improvements in livestock farming in reducing feeding costs and meeting the protein and energy needs of animals, improving economic benefits.

Animals can be supplied with nutrients by the use of these feeds in animal feeding, but they have been successful in reducing methane gas production. However, this study is thought to be a reference for other researchers.

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