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Producing Silage from Food and Agricultural Waste and Fodder Using Microorganisms: A Review

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Author's contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Water scarcity has led to a decline in agricultural production, and many fertile land is facing a shortage of water for agricultural development. Water shortages and high prices of food and Agricultural inputs in countries are increasing the price of animal feed, poultry and aquatic animals. Therefore, the processing and improvement of the quality of waste and waste of Agricultural and

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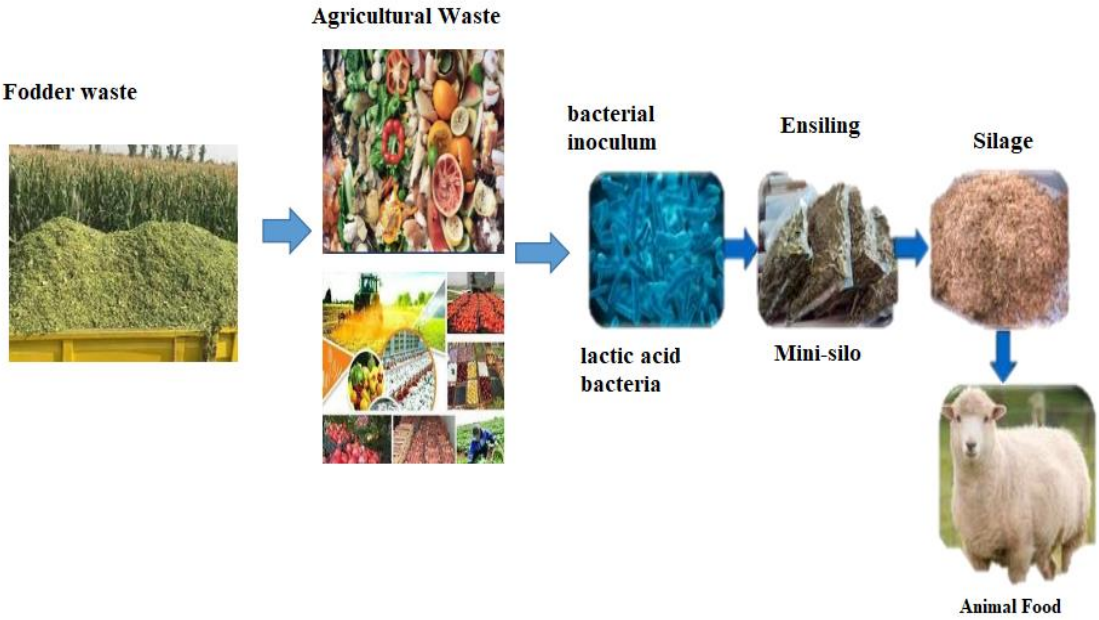
food products will cause these waste materials to be used economically in rations and feeding of various livestock and poultry. The purpose of this research is to investigate the beneficial results of feeding livestock with the fermentation of Agricultural and food wastes in animal feed and economic recycling of these wastes.

Methods: This research was done by studying more than 50 articles published in this field and extracting and integrating the contents.

Results: Animal feed silage is produced by processing essential proteins and vitamins during silage fermentation. This increases the quality of healthy dairy. Usually, livestock food is stored in the spring and summer, and during the cold season of the year, it is not possible to provide fresh fodder and corn, The stored product is used to feed livestock and poultry, It is inexpensive and high nutritional value for milk and meat production and maintaining livestock health.

Conclusion: This method allows us to store a large amount of plants and agricultural waste for animal feed, which today is one of the most basic and important ways to provide food for livestock in the absence of fodder fresh, it is.

GRAPHICAL ABSTRACT



Keywords: Food waste; waste processing; silage; animal food.

1. INTRODUCTION

The supply of livestock food and the production of silage has always been of great importance to humanity. Many of our foods depend on livestock and we will have many problems if we cannot provide livestock food. In many cases, such as cold and snowy winters, it is very difficult to provide fresh livestock food. So over the years we have used methods to store livestock food. One of the most important forms of livestock food storage is to do it in silage [1]. This method allows us to store a large amount of plants for animal feed. Agricultural wastes are materials that are mostly edible or can be consumed or consumed before harvest, during harvest or after harvest from farm, garden, Local livestock farming, in which agriculture and animal husbandry activities are ongoing, is acquired. In some cases, by harvesting the product and performing preparation operations on it to market the consumption, remains or wastes are created. Also, some agricultural products are damaged due to lack of timely consumption by consumers or during maintenance or transportation and due to changes in quality or corruption, They become unusable and turned into waste. The beneficial result of feeding livestock with agricultural waste should be such that this feed is produced from both high quality materials and can be maintained for a long time. Animal feed silage is produced by processing essential proteins and vitamins during fermentation. This increases the quality of healthy dairy [2]. Usually, livestock food is stored in the spring and summer, and during the cold season of the year, it is not possible to

provide fresh fodder and corn, the stored product is used to feed livestock and poultry, so the ultimate goal in using silage is to achieve healthy feed, It is inexpensive and high nutritional value for milk and meat production and maintaining livestock health. The production of a fermented substance with a controlled fermentation of a plant or high-moisture fodder in a closed space and relatively anaerobic conditions is called silage. With the help of forage fermentation, it is kept for a longer period of time and contains energy-efficient substances to strengthen livestock. Fermentation in silage allows for long-term preservation of the fodder [3,4].

2. SILAGE

silage is processed from the fermentation of stems and leaves of fodder such as corn, oats or other farm additions, which is an unmatched food for livestock. With the help of forage fermentation, it is kept for a longer period of time and contains energy-efficient substances to strengthen livestock. The key factor in the preparation of suitable silage is the high production of laconic acid in low time and the rapid reduction of pH in silage fodder. Research results suggest that lactobacillus are the dominant microorganisms in growing fodder and play a major role in silo fermentation. Fermentation in silage makes it possible to use silage fodder for a long time, without reducing the nutritional value of fodder. In Iran, silages are usually made with chopped corn (including stems, Corn and leaves), but in countries where alfalfa production is high and drying is difficult, Silage alfalfa is also produced. Silage production by fermentation of plant residues and agricultural products such as corn stalks, wheat, fruit wastes and. it's done. In the months of the year when natural animal feed is not found, the use of fermented silage in livestock farming is done. The method of silage production is done so that waste is collected, then fermented in such a way that most of the nutrients, including sugar and protein, remain within it. Fermentation is essentially a microscopic process. The use of appropriate acid content in the process of silage production causes nutrients to remain in fodder [5,6].

3. STEPS FOR SILAGE PRODUCTION

- **Combining forage with agricultural waste for preparation silage:** Plants are harvested for silage production, as they contain the highest amount of nutrients. Typically, plants contain the highest amount of nutrients before reaching full maturity. This is important because stored fodder species contain less nutrients than fresh animal feed. Therefore, maximizing the nutrient content is crucial in silage production to ensure the health of livestock during consumption. Insufficient nutrient intake during feeding can lead to health problems for livestock and affect the quality of animal products. After harvesting, the plants are left in the farm for several hours to partially dry and reduce the moisture content to around 60 to 65 percent, which is optimal for the silage production process and facilitates fermentation. If the plants are left in the environment for too long, they will lose more moisture and become too dry for fermentation. Additionally, delaying the collection of plants will result in a decrease in their nutrient content. Over-drying the plants makes the packaging process more difficult, as overly dried plants trap more air and hinder the fermentation process [7].

- **Crushing of waste materials:** One of the most important parts of preparing high quality silage is crushing. This is usually done by a device called Chagher. Care must be taken in the size of the products. Lesions should be crushed enough to increase the level of contact with bacteria, leaving less oxygen in the particle cell. On the other hand, they should not be very small and crushed because the silages are essentially forage applications and with the shrinking of the parts, Chewing has also decreased, so we will not have good fermentation in the rumen. The best size for fodder and waste is three-quarters of an inch to one-and-a-half inches [8].

- **Fermentable:** The process of crushing plants into smaller pieces and then compressing and condensing them to produce silage is essential for removing oxygen from the plants. This reduction of oxygen is crucial for the fermentation process, as lactic acid bacteria require an oxygen-free environment to carry out fermentation. The degree of plant compression varies depending on the method of silage production, but in all cases, it is important to ensure that the plants are sufficiently compressed and that

an oxygen-free environment is provided for the activity of lactic acid bacteria [8].

4. DIFFERENT FERMENTATION METHODS USED IN THE PRODUCTION OF SILAGE

4.1 Aerobec Fermentation

The aerobic stage is mainly referred to as the initial siloing and as the breathing process. This step is at a time when fodder and waste are cut and placed inside the silo building until oxygen is depleted from the inside of the plant material ‹it continues. oxygen must beremoved from the silo as quickly as possible due to inhibiting the growth of undesirable aerobic microorganisms. Aerobic microorganisms consume sugars in the plant, which were originally intended to be consumed by lactic acid bacteria or rumen Microorganisms [9].

4.2 Anaerobic Fermentation

The anaerobic phase commences once waste and stored fodder materials are devoid of oxygen. During this phase, anaerobic bacteria initiate the fermentation process, converting water-soluble carbohydrates into acetic acid, some lactic acid, alcohol, and carbon dioxide. While acetic acid is less potent than lactic acid, it contributes to a decrease in pH within the silo materials. Sustained pH reduction inhibits the growth of acetic acid bacteria and promotes the growth of desirable lactic acid bacteria. The pH of siloed materials should drop to below 5 within 24 hours for whole corn plants and within 72 to 96 hours for alfalfa. Failure to achieve this pH level can lead to increased dry matter loss, reduced availability of water-soluble carbohydrates for lactic acid production, and greater opportunities for the growth of undesirable microorganisms [10].

4.3 Production of Silage Using Agricultural Waste

Water scarcity and high prices of food and Agricultural inputs in the country increase the price of animal feed, poultry and aquatic animals. Therefore, the processing and improvement of the quality of waste and waste of Agricultural products will cause these waste materials to be used economically in rations and feeding of various livestock and poultry. Most types of by-products and Agricultural waste will be of good quality and can be used in livestock and poultry rations.Silage production by fermentation of plant residues and Agricultural products such as corn stalks, wheat, fruit wastes and.. it's done. In the months of the year when natural animal feed is not found, the use of fermented silage in livestock farming is done. The method of silage production is done so that waste is collected, then fermented in such a way that most of the nutrients, including sugar and protein, remain within it. Fermentation is essentially a microscopic process. The use of appropriate acid content in the process of silage production causes nutrients to remain in fodder [11,12].

4.4 Different Categories of Agricultural Waste

Agronomic wastes and food conversion industries:

1. Remains of crops left on the farm
2. Remains of grain production, including cereals, legumes and edible items
3. Remain of flour making industry
4. Remain of rice cubes industries
5. Remains of Tomato and Composting Industries
6. Remains of food products packaging industry, such as chips, puffs, snacks, pasta, cakes and cookies, flour and rice, pickles, jam and other edible products
7. Remains of oilseed industries and corn production

Wastes of garden crops:

1. The result of packing garden products and fresh fruits
2. Dates, olives, pistachios and nuts
3. Remains of dried products, such as grapes, figs and similar fruits

5. KEY FACTORS IN THE PRODUCTION OF SILAGE FROM AGRICULTURAL WASTE

Product moisture: If the moisture level of the waste is high, the fermentation process will face challenges. The high humidity level in silage causes freezing during the cold season. Usually, in order for Silo to remain at the level of Bakievite, the humidity level should be between 5to 50 percent. The humidity suitable for ground silos is 65 to 72% and for vertical silos is 62 to 65. High humidity will cause chloridic acid fermentation and low humidity will cause silage-producing silage. To reduce silo moisture, waste

can be removed before the storage stage for fermentation in order to wither ‹Spread in the sun for 3-4 hours, grains like corn can also be used in layer [13].

Particle size: The more and more accurate the amount of fodder crushing, the higher the quality of the final silo product. The reason for the crushing process is better air discharge in the silage process. In this way, the growth of acid-lactic-producing bacteria is increased and fermentation is easier to do [13].

Water-soluble carbohydrate content: The greater the quantity of carbohydrates in the forage, the more favorable the silage fermentation process, and the greater the preservation of the product's nutritional value [14].

The available capacity: The pH level needs to be rapidly decreased. This reduction process should occur as quickly as possible to ensure proper silage preservation. Some plants are resistant to significant changes in pH levels [15].

Packing promptly: Silage quickly spoils when exposed to air, so it is crucial to pack silage rapidly and keep it away from oxygen. Silage should be packed in a convenient and swift manner to prevent oxygen from entering easily. In silages that are promptly filled and properly sealed, the risk of spoilage is very low [16].

6. TYPES OF MICROORGANISMS IN SILAGE PRODUCTION

Lactic acid bacteria: Bi-hydration is the authority to ferment water-soluble carbohydrates and produce organic acids, especially lactic acid [17].

Clostridiums species: The source of the soil and spores is completely anaerobic, which produces lactic acid by breaking down sugars and then converts it into butyric acid. break down proteins into amino acids and then release amino acids into acetic acids, butyric acids, Amines and ammonia convert their optimal growth occurs at pH 7.4-7 [18].

Enterobacteria: Bi-Havazzi was discretionary pH desirable 7. The soluble carbohydrates are converted into watanol and hydrogen acetic acid [18].

Fungi: They're absolutely airy. Mycoxins are a group of fungi whose high levels in silo cause complications for consumer livestock [18].

Silo material segmentation in terms of fermentation rate of the material in silo:

Fast fermentation silage: Fodder corn, sugar beet leaves and crowns, sunflower plants, fodder cabbage, garden products such as apples.

Siloba medium fermentation: Pasture fodder, grass mix with clover, fodder beans.

Silage with slow fermentation: Clover fodder, young pasture grass, mandab, mustard, types of chickpeas, leguminous fodder

Additives in silage production from agricultural waste:

Stimulants: further irritate the bacteria that produce lactic acid.
inhibitors: such as formic acid, which by raising the acidity of silo, prevents the activity of bacteria that produce buteric acid.

Nutrients: such as molasses, which are better used to improve the nutritional value of silage and fermentation.

Absorbers: Used in high-water silos to compensate for the lack of dry matter. such as wheat bran and citrus fruits.

Antibacterial: such as formaldehyde (formalin) to prevent the growth of undesirable organisms.

Buffers: such as sodium bicarbonate, which is used to modulate the acidity of silages [19].

The efficacy of additives: In nature, in the field of fodder, a high number of different bacteria, fungi, and pouches are on the plant, which immediately after the forage is cut and crushed, They begin to grow with dry materials. It is evident that a group of these same bacteria, (homofermentative lactobacillus) combined with an excellent management, can achieve a good silage, but since the number of efficient lactobacillus plantarum ‹In the field, it is small and weak, both the fermentation process takes longer and the dry substance and the taste and digestibility of silage do not reach the best. To compensate for this, biological additives have come to the market. In fact, a good add-on along with a good management, many times its cost, benefits livestock [20].

mildew prevention: Air is the main enemy of Silage. Air contact with silage occurs in any condition, causing the activation of molds, fungi, and aerobic bacteria that consume fodder dry materials. Preventing mold in the silo's surface and sides is a management task, and whenever it is not well covered and heavy on the silo, and the air comes into contact with flooded fodder ، No additive can prevent mold and fodder corruption. Claims that are made in efficiency to prevent mold and mushroom growth in silo procedure do not have a proper basis.The efficacy of additives in the prevention of corruption and mildew within the silage mass can also be true if the biological additive has a strong and efficient strain of lactobacillus plantarum, which has been active since The added silage begins [21].

Prevention of waste when harvested from silo: Some add-ons can compensate for the weakness of harvest management to some extent when harvested from silo. The main bacteria of these additives is a heterolactic bacterium that produces a large amount of acetic acid. astringent prevents the activation of fungi and molds for a while when silage comes back into contact with air. In this regard, two points should be noted that the fermentation of silage with heterolytic lactobacilli is very slow and in some cases very late and may never reach the stabilization stage, which is why ،A significant amount of fodder dry matter is lost in the fermentation process. As a result, the nutritional value of silage is greatly reduced. This amount of nutritional devaluation is much greater than it may be due to poor management of the silo harvest. The number of livestock that manage their harvesting from Silage is so weak that they take Silage from Silo, for example, 48 hours later to the manger is very small. It should be emphasized that, however, ranchers should take the silage harvested from the silo to the manger in the shortest time and harvest it at a thickness of 15 to 30 cm from the entire silo forehead every day [22].

Prevention of dry forage waste: Immediately after the forage is cut and crushed, various bacteria, Mushrooms and molds that are on the fodder plant are activated and the consumption of dry fodder and its nutritional value begins. Self-fodder enzymes also break down proteins. This process begins in the field and continues in silo until the air inside the silage has ended, usually 48 hours for the silage that has been well beaten. But the activity of some microorganisms and molds, which do not require much air, and tolerate weak acidic environments, continues. It is at this stage that some molds produce harmful mycotoxins. The only way to reduce the loss of dry matter and prevent corruption within the siloed forage mass is to speed up the fermentation process and shorten the period of aerobic activity, fungi and molds. This can only be done by using a powerful homolytic bacterial additive that does not require any auxiliary bacteria [22].

7. THE MOST IMPORTANT BIOLOGICAL ADDITIVE IN SILAGE PRODUCTION

Ecosyl: It is a biological additive in the preparation of quality silages. It has a very strong strain of Lactobacillus plantarum Ecosyl prevents the conversion of fodder sugar into weaker acids such as butyric acid and acetic acid, water and carbon dioxide, thus preventing energy loss. Ikosyl produces delicious silage due to its abundant lactic acid. Ecosyl leads to a higher production of milk and meat due to the improvement of silage digestion and preservation of dry matter of fodder. The fermentation of silage is associated with biochemical changes, bacteria and fungi break down the sugar in the forage and turn it into acids, water and carbon dioxide. The most important goal in using biological additives is to shorten the fermentation period and achieve complete fermentation in the shortest possible time. Molding of silage causes: disrupting the digestive system and production and abortion, and even reduces the occurrence of estrous symptoms in dairy cows. Lactobacillus plantarum icosyl bacteria has the ability to destroy fungi, molds and spoilage microbes as soon as possible [23,24].

Biomin biostable mayes: The Bayomin Bio-Stabil Mayes additive is used as an increase in the population of beneficial bacteria in the process of forage corn siloing. Increasing the population of beneficial bacteria in corn silage reduces the duration of aerobic fermentation and accelerates the development of anaerobic conditions. This product contains enterococcal microorganisms of fascium, lactobacillus bervis, lactobacillus plantarvium. The product also contains the inulin compound, which is considered as a nutrient for the bacteria to start growing. The mechanism of action of the byomine byostabil mayes is a combination of fermentation-identical and non-fermentation-identical bacteria used to optimize aerobic and

non-aerobic stability of fodder silage. This process is done through rapid and complete acidification of silage. Also, the use of this product maintains the quality of the silo after its opening, which is due to the production of acetic acid by non-fermented bacteria in it. Three bacterial species used in this product after distribution on corn silage use the carbohydrates in this forage source and give them acetic acid and acid Lactic transform. The presence of beneficial bacteria and lack of access to raw nutrients reduce the chances of the presence of butyric acid-producing bacteria, fungi and molds in corn silage. On the other hand, increasing the ratio of lactic acid to acetic acid and reducing the amount of undesirable metabolites such as ethanol, ammonia and butyric acid improve the quality indicators of corn silage.The optimal formulation of bivastabil mayes not only makes fermentation better and more desirable stability, but also maintains the energy content of corn silage. The number and ratio between the same fermentation bacteria to non-fermentation bacteria in the bio-stabil mayes minimizes the energy and protein loss in corn silage. This has a favorable effect on the quality of the silage produced [25,26].

Advantages of Bayomin Bayou Stabil Mayes:

Effective use in corn silages with different dry matter content

rapid acidification and prevention of energy loss

Increased aerobic stability (up to 7 days)

Decrease in the drop in dry matter and energy after silo opening.

8. CONCLUSIONS

The supply of livestock food and the production of silage has always been of great importance to humanity. Many of our foods depend on livestock and we will have many problems if we cannot provide livestock food. In many cases, such as cold and snowy winters, it is very difficult to provide fresh livestock food. So over the years we have used methods to store livestock food. One of the most important forms of livestock food storage is to do it in silage. This method allows us to store a large amount of plants and agricultural waste for animal feed, which today is one of the most basic and important ways to provide food for livestock in the absence of fodder fresh, it is.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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