HOT AIR FRYER ON-FARM EASY DRY MATER EVALUATION TOOL FOR FORAGE AS SUPPORT FOR MAKING DECISIONS

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Abstract: *The production of high-quality silage is a major annual challenge that requires storing the forage at optimum dryness under anaerobic conditions to avoid losses of dry matter (DM). Such silage is an important source of digestible nutrients for ruminants in an essentially important voluminous part of the feed ration. Feeding high-quality forage is therefore the basis for optimal management and good health of high-yielding dairy cows. It is an inescapable fact that the decisions we make during forage harvest affect the quality of the forage over a longer period of time. Under practical working conditions, it is often difficult to choose the right time for ensiling. The most important decision is the optimal DM content of the wilted grass with which we will start the forage. Determining the DM of the forage is not a difficult process, but it is necessary to choose an accurate and fast method. In recent years, hot air fryer is increasingly used in farms as a reliable tool for determining DM, instead of other existing methods. Therefore, we methodically reviewed the established protocol for using a hot air fryer as a highly practical and accurate tool for on-farm evaluation of DM. In a simple and practical way, we determined the amount of DM in the grass sample (38% DM) and in the corn mass sample (33% DM). We linked this to the correct assessment of the appropriateness of the timing of forage harvest.*

Key words: *Forage, harvest time, dry matter, hot air fryer*

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1. Introduction

The occurrence of extreme seasonal weather variations during the year greatly affects the amount of forage produced in livestock areas. In the temperate climates of Europe, there is a surplus of forage in the late spring, while in the winter months the opposite is true and there is a shortage of forage (Wilkinson & Rinne, 2017). One of the methods of forage preservation is fermentation, which provides forage for a longer period of time (Muck & Shinners, 2001). Compared to hay, silage production often increases forage quality and reduces yield loss, despite the delicate process of silage fermentation, and increases the potential nutrient yield of available cropland (Jones et al., 2023).

Silage quality depends on forage quality at harvest and ensiling practices (Harris, 1993; Klocker et al., 2019; Kung, 2018). Determining the optimal timing for mowing and forage harvest should become a good farming practice. Timely mowing or harvesting is considered an important step in achieving maximum yield potential, forage quality, digestible nutrient content, and palatability. Determining the optimal harvest time based on dry matter (DM) ensures that forage is not ensiled too wet (leakage of silage juice, low starch content, acidic silage) or too dry (difficult to compress in silo, poor fiber digestibility). Grass is suitable for harvest when it reaches 30–40% DM (Galler, 2011; Harris, 1993; Wallau & Vendramini, 2019). Corn is optimal for harvest when the total corn mass reaches 65% moisture or 35% DM (Jones et al., 2023).

The actual DM content of forage can be easily determined by various laboratory methods. However, the choice of laboratory methods is inadequate to determine the optimum forage harvest time with known dry matter sample results. Most farms do not have laboratory equipment, and at the same time, determining the DM is more time consuming. Moisture content of forage and the right value of DM which are in common practice, carried out on-farms (Jorge et al., 2021) both are important factors in the process of feed rations optimization for dairy cows (Janzekovic et al., 2014). There are some well-known methods that farmers can perform themselves. For practical reasons, farmers have started to look for suitable solutions to quickly determine the DM of forage. In recent years, the use of a hot air fryer for rapid determination of forage DM has been introduced. In this article, a fryer with a grid drum that rotates during drying is presented. The rotation of the drum is an advantage over other methods, such as drying in a microwave oven or a kitchen oven, because there is less risk of spontaneous combustion or scattering of the sample. In addition, drying the sample in the drum is more uniform than drying in a container or on a plate. The drying method is simple and the determination of forage DM is fast, which facilitates the choice of the optimal harvest time for corn. At the same time, it is an important tool to decide when to harvest the grass mass.

2. Importance and effects on DM of plants

The amount of corn produced is affected by the production, loading, and transfer of DM throughout the plant, which is strongly related to the constant loading of DM in the post-flowering stage. Therefore, studies suggest that higher-yielding corn cultivars have higher photosynthetic capacity after the flowering stage (Liu et al., 2017). However, Yang et al. (2021) indicates that DM accumulation at the silking stage is important for higher yield.

Wei et al. (2019) indicates that seeding density of corn has a significant effect on the distribution of DM between vegetative and reproductive organs. As seeding density increases, the number of vegetative organs increases and the number of reproductive organs decreases (Liu et al., 2017). Solar radiation has a significant effect on the course of photosynthesis, the main physiological process that drives plant growth, and thus affects the development of plant organs and the level of yield (Ding et al., 2005). Plants with higher density and rapid development theoretically maximize leaf area index. As a result, they intercept the most solar radiation, which affects yield and DM content. However, some studies also indicate negative effects of dense seeding (Kolmanič, 2019).

A suitable DM content is reached in corn plants at the wax maturity stage when the grains have 55% DM. In drought-damaged corn, the percentage of grains is much lower (40–45%), so the DM does not increase due to the grains. Therefore, the DM content of the whole plant is lower than expected. In an undamaged plant, the DM content in the grains is 200–300 g/kg. Under drought conditions, the DM content of plant increases to 500 g/kg or more. Therefore, the method of assessing the maturity of drought-damaged plants based on determining the position of the milk line on the grain is not reliable (Kolmanič, 2019).

Each step in the preservation process causes a loss of forage DM. Total losses from cutting to feeding are usually 20–30% of DM. Some of these losses are biological, others are due to mechanical processing (Moore et al., 2020).

3. Optimal time for mowing the green forage

The planning of estimated mowing time is influenced by the appropriate maturity stage of the crop, moisture content (Hernandez, 2020; Jones et al., 2023), and crude fibre content of the green forage (Richardt, 2023). Mowing timing can also be predicted by measuring the height of the green forage. The optimal height of plants for mowing is 25 cm for seeded lawns and a maximum of 40 cm for annual grasses. Harvesting time depends on the content of the forage DM.

Plant development is the passage through life cycle phases, and includes the vegetative stage, the elongation stage, boot stage, the heading stage, and seed ripening. By knowing these stages, farmers can determine maturity and predict quality. The grass must be mowed just before flowering. The DM yield of alfalfa increases with beginning of flowering, so mowing should be done in the early flowering stage. Early mowing usually results in a lower forage yield, but it is very digestible and contains a lot of protein. Mowing later or too late results in a higher forage yield with lower nutritional value and greatly reduced fibre digestibility (increased lignin content). Optimal mowing timing affects, among other things, the appropriate percentage of DM, which is an indicator of potential fermentation and feeding problems. Mowing too fast or too late affects farm income throughout the year by feeding lower quality silage (Bauder, 2022; Hernandez, 2020).

When planning the time of mowing, it is necessary to take a sample at least 14 days before the expected date of grass harvest. On the main part of the mowing area, random samples of the grass are cut at a height of 8 cm above the ground. We take a representative sample and send it for laboratory analysis. Based on the results of the crude fiber content and the daily crude fiber gain (8 g/kg DM per day), the optimal mowing time can be determined. The target of optimal crude fiber content in silage is 230–280 g/kg DM. In the process from harvest to feeding, the crude fiber content increases by 20–40 g/kg DM (Richardt, 2023). In addition to the steps listed for planned mowing, it is necessary to monitor the weather forecast for favorable weather conditions.

3.1 Wilting of green forage

One of the biggest challenges in producing high-quality silage is forage management during the wilting period (Kung & Muck, 2017). Mowed grass contains 70–85% moisture or 20–15% DM and insufficient sugars for normal lactic acid fermentation. For forage that needs to be wilted before harvest, it is necessary to achieve a DM between 35 and 45%. Wilting improves the properties of the forage for the fermentation process. Water activity decreases, which has an inhibitory effect on the development of Clostridia, while the concentration of water-soluble carbohydrates increases (Borreani et al., 2018; Klocker et al., 2019).

Rapid wilting is important to reduce the loss of DM, especially leaves, and nutritional value. Oxygen present in the environment of mowed forage particles allows aerobic microorganisms and plant enzymes to respire. Aerobic microorganisms consume readily available carbohydrates and acids in the silage through the metabolic process of respiration, resulting in a loss of DM. It is necessary to obtain as many fermentable sugars as possible and to achieve an adequate proportion of DM in the forage. In this way, we achieve favorable lactic acid fermentation, optimal pH of silage and increased sugar concentration. A higher proportion of DM in the forage (up to 45% DM) results in sugars in a more concentrated form (Borreani et al., 2018; Galler, 2011; Klocker et al., 2019).

The wilting of mowed plants proceeds in two phases. In the first phase, the plants lose moisture very quickly. Studies show that during this rapid phase, plants lose up to 75% of the water from the leaf lobes through wilting. Plants also release some moisture through damaged parts of the stem. Young grass loses water very rapidly, 1 g/g DM per hour (Jones, 1979). The immediate scattering of mowed forage immediately after mowing has a significant effect on drying speed because air movement is accelerated over and through the layers of mowed forage (Galler, 2011). For high quality silage, it is necessary to collect the wilted grass mass before the second phase begins, where in less than 24 hours after mowing DM can increase by more than 60%. In the second phase, stomata are closed and water evaporation occurs through the cuticle of the leaves and stems. Compared to the stems, water evaporates faster through the leaf surface even later, when the stomata are closed (Suttie, 2000; Jones, 1979). The DM content increases by about 3–4% per hour under normal wilting conditions.

The optimum wilting level for quality silage can be reached within 5–6 hours after mowing (Galler, 2011). Several factors affect the success of wilting and thus the quality of the forage. One of these factors is mowing with conditioners, which accelerate the wilting of the forage. Conditioners can reduce drying time by up to 30%. Drying is more uniform because a larger surface area of the forage is exposed to drying air. Conditioners compress, crumple, tear, and break the mowed forage and accelerate the evaporation of water from the plants. Plant stems are deformed and leaf epidermis is damaged (Kung & Shaver, 2001). Treatment of forage prior to ensiling not only affects the wilting process, but also significantly affects the availability of nutrients during the fermentation process. Forages that are crushed, kneaded, cut, and ground before ensiling have nutrients more readily available for lactic acid bacteria growth, which significantly affects the amount of lactic acid produced during fermentation (Kung & Muck, 2017; Kung & Shaver, 2001).

Prolonged wilting increases the chances of precipitation, leads to overdrying of forage and sugar losses, and thus lower fermentation substrate content (Borreani et al., 2018; Kung & Muck, 2017). Rainfall during wilting reduces forage quality through nutrient leaching, respiration, and loss of leaf mass. Water soluble nutrients that are leached include readily available carbohydrates, soluble nitrogen, minerals, and lipids. The lower carbohydrate content of the forage provides less substrate for the bacteria that ferment the forage. Respiration resumes when the forage reaches a moisture content of less than 30% and is prolonged each time the forage becomes wet (Rankin & Undersander, 2000).

4. Optimal harvest time for corn

Harvesting corn depends on the moisture content of the whole plant, which changes with maturity. There is a well-known method for determining DM by observing the position of the milk line on the corn grains. This method is often not good or accurate enough to determine the optimum time to harvest. The DM content of the whole plant may be higher than the position of the milk line would suggest. Milk line position and whole plant DM content are influenced by many factors, including hybrid selection, geographic location, planting date, soil type, weather conditions, overall plant health, and stress factors (Lauer, 2016; Peters, 2012). Therefore, corn may dry faster than indicated by the position of the milk line. Hybrids with a pronounced "stay green effect" are also misleading when it comes to estimating maturity by appearance. In fact, they are hybrids with slow drying of the plant mass (Kolmanič, 2019). Nonetheless, assessing the position of the milk line is a useful indicator of when to sample corn for direct measurement of whole plant DM content. When the corn grains have reached ¼ of the milk line, it is time to check the moisture content of the whole plant. To determine the moisture content, random samples must be taken. They are cut at the height intended for harvesting and cut (ground) into the smallest possible pieces. To obtain a representative sample, the whole plant must be ground (Jones et al., 2023). Based on the results of whole plant drying, the harvest time of corn can be determined. The daily increase of DM (0.5–0.6% per day) should be taken into account. Corn harvest is optimal when silage reaches 65% moisture or 35% DM (Jones et al., 2023). Planning the harvest timing corresponds to optimal energy content as a function of starch and fiber maturity. Energy content changes when the whole plant reaches 30% DM. When DM rises above 37%, fiber digestibility begins to decline sharply, resulting in lower levels of usable energy from fiber (Mohar, 2017).

5. The importance of optimal DM content of forage at the time of harvest

Silage quality depends on the quality of the crop at the time of mowing and harvesting, as well as silage preparation practises (Harris, 1993; Klocker et al., 2019; Kung, 2018). Dry matter content at the time of forage harvest determines potential problems with ensiling and feeding. For optimal ensiling and the best quality of the forage, the DM content of the grass should be between 30 and 40% (Galler, 2011; Harris, 1993; Wallau & Vendramini, 2019). The maximum DM yield of corn is achieved when the plant contains 300–370 g DM /kg (Jones et al., 2023; Slatnar, 2010).

Determining the optimum DM contributes to proper harvest maturity and nutrient content and determines silage digestibility. Fermentation of silage is often an uncontrolled process that is strongly influenced by the DM content of the forage (Jones et al., 2023). At optimum DM content, there are no losses in silage juice, and losses during the fermentation process are also lower. (Harris, 1993; Kung & Muck, 2017; Muck & Shinners, 2001; Wallau & Vendramini, 2019). Undesirable fermentation processes and poor anaerobic stability result in losses of DM, energy, and nutrients, which can negatively impact animal health and the economic justification of forage production (Kung, 2018).

5.1 High moisture content in forage (< 28% DM)

Lower silage DM and relatively low forage carbohydrate contents (less than 8% soluble carbohydrate) increase the potential for undesirable fermentation and increase forage DM losses (Galler, 2011; Harris, 1993; Jones et al., 2023; Muck & Shinners, 2001; Wallau & Vendramini, 2019). Dry matter losses can range from 7 to 12% (even 20–30% or more) (Kung & Muck, 2017). When DM losses are less than 28%, corn silage has lower nutritional value due to poorer forage fermentation (Slatnar, 2010; Jones et al., 2023). Silages are often susceptible to Clostridia occurrence and development, resulting in high energy losses (more than 20%) and deterioration of protein value and silage quality (Galler, 2011; Harris, 1993; Kung, 2018; Muck & Shinners, 2001). Clostridia degrade plant sugars to butyrate and increase the degradation of the protein fraction of the forage (Galler, 2011; Harris, 1993). Silages with higher concentrations of butyric acid (> 0.5% DM) tend to have lower nutritional value and higher levels of acid detergent fiber (ADF)and neutral detergent fiber (NDF). Such silages may also contain amines, which have been shown to negatively affect animal productivity and health (Kung & Shaver, 2001). Fermentation of excessively moist silages is often dominated by enterobacteria, which produce higher levels of acetic acid (Galler, 2011; Kung & Muck, 2017). Animals also reject such forages. Silage pH decreases more slowly in corn mass with less than 30% DM. In addition, such silages often contain a low concentration of starch, which contributes to excessive juicing (Galler, 2011; Harris, 1993; Klocker et al., 2019; Kung, 2018).

Silage juices contain high levels of soluble nutrients, including soluble ammonia-N (35% of total N (Harris, 1993)), soluble minerals, and sugars and pose a potential environmental hazard (Kung & Muck, 2017; Muck & Shinners, 2001).

5.2 Low moisture content in forage (> 45% DM)

The rate and extent of fermentation decrease as the DM content of the forage increases (Galler, 2011; Kung & Muck, 2017). Poor aerobic silage stability is common in forages with high DM content at the time of forage harvest (Kung, 2018). Compaction is difficult in silages with > 45% DM (Galler, 2011; Kung and Muck, 2017), so the silage may be more susceptible to rapid aerobic spoilage (Kung & Muck, 2017). Molds and yeasts may occur and the aerobic phase of fermentation is prolonged, resulting in DM losses (Galler, 2011; Harris, 1993). Nevertheless, Jones et al. (2023) find that as plants mature, the amount of sugar in the stalk and leaves decreases, making silage more durable at a higher DM. At a 70–75% DM of alfalfa hardly grow lactic acid bacteria, so the fermentation of lactic acid bacteria is reduced. At low forage DM and higher sugar content, yeasts can influence fermentation by ethanol formation and reduce the DM of the forage (Kung & Muck, 2017; Galler, 2011). Moisture in the forage is a transport medium for lactic acid bacteria. The intensity of fermentation and lactic acid transport through the forage decrease with increasing DM of the forage (Galler, 2011).

6. Fermentation process

Silage is defined as moist forage that is preserved by fermentation and stored in the absence of oxygen for an extended period of time (Galler, 2011; Harris, 1993). The fermentation process of forages involves various technological and scientific approaches that enable successful silage production. To obtain high quality silage, it is necessary to rapidly deoxidize the silage mass and rapidly reduce the pH of the forage to 3.8–5.0. This depends on the DM and the forage crop (Moore et al., 2020). Fermentation helps to preserve the original nutrients in the forage plant for later feeding (Jones et al., 2023; Kung, 2018) by converting plant sugars into organic acids (Galler, 2011; Jones al., 2023). The success of fermentation depends on DM and sugar content, low pH, which inhibits the growth of Clostridia, and anaerobic conditions, which prevent the growth of molds and yeasts. (Klocker et al., 2019; Muck & Shinners, 2001). Fermentation of silage occurs in four phases usually completed after 21 days. If improperly forced, a fifth, undesirable phase occurs (Jones et al., 2023).

Phase 1 – Respiration within the plant continues for several hours or even several days after mowing if oxygen is not removed from the silage mass (Kung, 2018; Jones et al., 2023). Plant cells inside the mowed forage continue to consume oxygen, and plant enzymes continue to operate. Aerobic bacteria are naturally present on leaves and stems and begin to grow. These processes consume readily available carbohydrates and produce carbon dioxide, water, and heat (Jones et al., 2023). Rapid removal of oxygen in the silage mass is necessary because it is the only way to prevent the growth of undesirable aerobic bacteria, molds, and yeasts that compete with beneficial bacteria for fermentation substrates (Kung, 2018; Kung and Muck, 2017). If the oxygen is not removed quickly enough, heating of the silage mass will occur. This increases the energy and feed losses in the DM (Galler, 2011; Kung, 2018).

Phase 2 – The plant carbohydrates are converted to acetic acid. As a result, the silage mass acidifies and the pH decreases from 6 to 5. Thus, phase 2 transitions to phase 3, where lactic acid formation begins (Harris, 1993; Jones et al., 2023).

Phase 3 – The number of acetic acid-producing bacteria begins to decline (Harris, 1993; Jones et al., 2023). During ensiling, anaerobic fermentation of the forage occurs using the lactic acid bacteria present in the forage. The decreased pH of the silage mass initiates the development of lactic acid bacteria, which usually represent a small proportion (< 0.1%) of the natural population of microorganisms in the forage (Klocker et al., 2019). A decrease in silage pH leads to the action of homofermentative lactic acid bacteria (Ishler et al., 2023), which convert plant sugars to lactic acid under anaerobic conditions. This inhibits the growth of enterobacteria, and homofermentative species are preferred in silage (Klocker et al., 2019). Normally, enterobacteria are active before the pH drops below 5.0. During this time, they ferment sugars to acetic acid and produce nitric oxide (Kung & Muck, 2017) and ethanol (Klocker et al., 2019). Heterofermentative lactic acid bacteria produce acetic acid, ethanol, mannitol, and carbon dioxide, with acetic acid maintaining aerobic stability of the silage and preventing heating and growth of undesirable microorganisms (Galler, 2011; Jones et al., 2023). Lactic acid should be the primary acid of good silages (at least 65–70% of all silage acids) because it causes the least loss of DM and energy during forage storage (Kung & Shaver, 2001). Klocker et al. (2019) assume an optimal lactic acid content (> 75%) in a sample of fermented forage.

Phase 4 – Lactic acid production continues for about two weeks until the pH of the silage is low enough to limit all bacterial growth. Rapidly lowered pH limits protein degradation by inactivating plant proteases (Kung, 2018). Depending on the plant material and DM, silage has a pH between 5 and 6, but it can also be lower, between 3.5 and 4.8 (Kung, 2018; Harris, 1993; Galler, 2011; Klocker et al., 2019). Corn mass with > 42% DM has a pH higher than 4.2 (Kung & Shaver, 2001) or reaches up to 4.4 (Galler, 2011). Fermentation stops at pH 3.8–4.2 (Harris, 1993) and when silage is not exposed to oxygen. Otherwise, undesirable fermentation processes continue (Jones et al., 2023).

7. Known methods for determining DM on-farm

Proper wilting of green forage, and thus the optimal harvest time, is determined by drying the forage. Drying the entire plant can also determine the optimal time to harvest corn. Determining forage DM is not considered a sophisticated procedure, but it is necessary to choose an accurate and fast method that is useful under practical production conditions. Most farms do not have laboratory equipment for the determination of DM, so it is necessary to use methods that farmers can perform themselves. Several methods are known to dry the forage sample and determine the DM. The use of a **microwave oven** is suitable for rapid determination of DM content in forage (DLG, 2002). The fresh sample should not weigh more than 50 g before drying.

Before drying, the sample must be spread evenly on the plate to allow uniform evaporation of water. The sample is dried for such a long time that the final weight of the sample remains unchanged. Drying time varies and depends on the moisture content of the sample. Typically, a corn sample with about 35% DM is dried in less than 12–15 minutes (Kung & Muck, 2017). When drying in a microwave oven, there is a possibility that the sample could ignite. Therefore, short intervals are used during drying (Cherney et al., 2021; Jorge et al., 2021). Microwave drying is not suitable for laboratory analysis of feed quality. Temperatures above 70 °C (Griggs, 2005) alter the chemical composition of the sample in terms of digestibility and quality of nutrients and proteins (Wallau & Vendramini, 2019).

Drying forage in a **kitchen oven** is a simple method that can be carried out at different temperatures and with different drying times. According to the literature available to us, we can summarize that different ovens (gas heated, electrically heated, vacuum ovens, ovens with steam) have been used to determine the DM, with temperatures between 65 and 135 °C and drying times of 2–20 hours (Novotny et al., 2018). Samples dried by this method are not suitable for subsequent analysis of fibers, lignin, or insoluble nitrogen from acid detergents. Volatile acids and alcohols can be lost from fermented samples. The forage sample is placed in a covered container before drying, as the velocity of the air flow may cause the material to blow around in the oven, and weighed along with the sample. Before starting to dry the sample, the oven must be preheated to the required temperature. Any change in the conditions (drying time, drying temperature, type of drying container, type of oven) may give different results for the same sample material. The temperature in the oven must remain constant during drying, as most methods require temperature control with a tolerance of ± 1 °C. A shortened drying time will result in incomplete removal of water from the sample. A longer drying time may lead to loss of volatiles or decomposition of substances (Novotny et al., 2018).

The **Koster tester** is a method commonly used on-farms to determine the DM of forage. We use an electric device equipped with a heater and a fen, as well as the appropriate technology. For drying fresh forage, it is recommended to follow the drying guidelines given by the manufacturer. The drying time should be between 20 and 50 minutes, but depends on the size of the sample and the material of forage. The device accurately determines the DM in the forage, but there is a possibility that the results will not be completely accurate if the measurement is performed by an inadequately trained person. In addition, the cost of the Koster tester method can be high (Jones et al., 2023; Jorge et al., 2021; Wallau and Vendramini, 2019).

Electronic meters are less accurate compared to Koster testers and microwave ovens and can only be used when forage is compacted (Wallau & Vendramini, 2019). Moisture content is determined by measuring the electrical conductivity of the silage mass. It is usually necessary to calibrate these meters or convert the obtained measurements (Jones et al., 2023).

In the field, we can perform the so-called **wrapping test of green forage**. In this method, DM is determined by shaping a bunch of forage with the palms of the hands and rolling it into a roll. If drops can be seen on the palms, it can be concluded that the DM of such fodder is between 20–25%.

If the palms remain moist after rolling the feed, the DM is 30%. However, if only a touch of moisture remains on the palms, the DM is slightly higher than 35%. However, if the palms remain dry, the DM is > 45% (DLG, 2002). In this method, the DM value of the forage is evaluated subjectively, which means that the wrapping test is not suitable for an accurate evaluation of DM. The method requires some practice and is often only an initial indication of the DM content of the forage. However, it can provide a rough estimate to approximate the target moisture content (Galler, 2011; Fodjan, 2019).

A **hot air fryer** is a small convection oven for frying food without oil (Jorge et al., 2021). There are many different models of the device on the market, but generally the cooking process is based on a mechanism called fast air technology. The heating mechanism, located in the upper part of the unit, radiates heat downward, while the fan circulates hot air around the food, ensuring that the food is heated from all sides. Air fryers are built to be airtight and compact so that all the air in the chamber is actively moving and the food loses moisture (Fig. 1.) (Simarmata, 2023). The air fryer consists of an opening at the top, through which air is drawn in, and an opening at the back, through which the temperature is controlled by releasing excess hot air. The drying system is very similar to the convection oven used in laboratories to determine forage DM (Jorge et al., 2021). When using a hot air fryer, it is not necessary to monitor the drying process because it is unlikely that a fire will accidentally start in the room (Wallau & Vendramini, 2019).

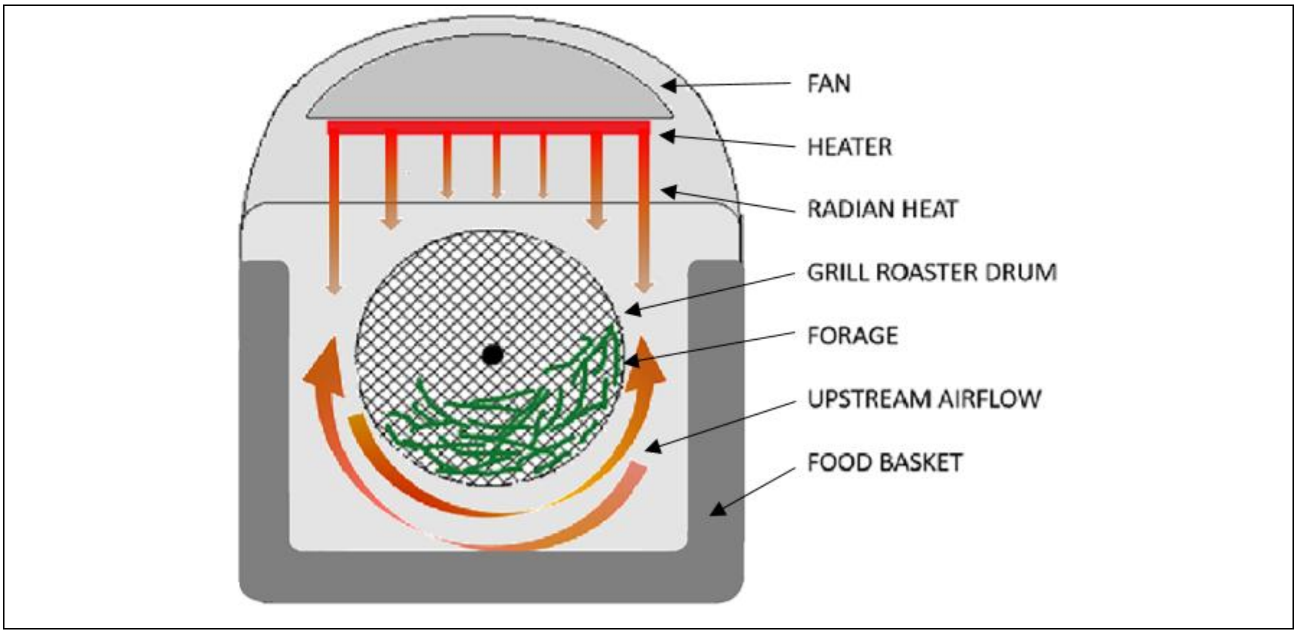

Fig. 1. Schematic of forage drying in a hot air fryer

8. Practically useful results of using hot air fryers on-farms

The operation of the fryer requires an electrical supply to the device, so it is more difficult to determine the forage DM directly in the field. It is necessary to take a representative sample of the grass mass or corn mass. The amount of partial samples taken must be adjusted to the size of the field (Wallau & Vendramini, 2019). Sampling locations in the field must be random.

A Z-shaped walk-through has been shown to be an effective method for random sampling of green forage (Richardt, 2023). For corn, partial samples for DM determination are taken in a slightly different manner because the DM of the entire plant must be determined. For a representative sample, it is important to select plants in the centre of the field (3–5 plants). This avoids edge effects or measurements that do not indicate the correct DM content of the corn. The content can be affected by the fineness of the chop, as studies have shown that the finer the material is chopped, the more accurately the moisture content can be measured. Therefore, it is necessary to chop the entire plant sufficiently fine (Peters, 2012).

The hot air fryer is a more modern, accessible and safer alternative that provides results within 30 minutes. Drying is performed at 121 °C with a sample weight of 120–130 g (Wallau & Vendramini, 2019). The determination of the mass of the sample dried in the fryer depends mainly on the material. Due to the action of conditioners during mowing, the grass is compressed and crumpled (Kung & Shaver, 2001). In practice, despite the use of mowing conditioners, the length of wilted green forage is not suitable for optimal drying in the fryer. The long fibers often wrap around the axis of the drum, and in this case the green forage is not dried evenly. Therefore, it is necessary to cut the forage into fibers about 10 cm long before drying. At this length, the grass does not wrap around the axis of the drum. If the dried forage is not cut before drying, the weight of the grass sample must be reduced to less than 120 g.

$$\% \text{ DM} = ((\text{Final Weight}) / (\text{Initial Weight})) \times 100 \quad (1)$$

Sampling	Grass mass	Corn mass
	Z-shaped walk-through the field	Sampling of random plants in the middle of the field
Number of random partial samples taken	5–10	3–5
The height above the ground of the samples taken	Minimum 8 cm (estimated cutting height)	Between 15–20 cm (estimated harvest height)
Treatment of sample before drying	Cut grass fibers to 10 cm	Whole plant grind
Weight of representative sample	0,5–1,0 kg	0,5–1,0 kg
Weight of drying sample	120–130 g	170–180 g
Drying time	30 min (+ 5 min)	30 min (+ 5 min)
Drying temperature	120 °C	120 °C

Tab. 1. Protocol for sample preparation, drying of green mass and corn mass using a hot air fryer on-farm

The optimal drying time can be determined by weighing the sample again and observing when the mass does not change after drying. We also know from practice that the drying time should not be too long. This is due to the fact that there may be combustion of the forage particles, which are on the edge of the grid drum. As a result, there is a loss of substance, which is not only moisture. Therefore, the calculated value of the DM can be inaccurate and thus wrong. A similar thing can happen if the drying temperature is increased. Again, the temperature must not be too high, as this can also lead to a loss of substances that are not moisture. Drying at low temperatures requires a little more time to prepare the sample to a constant dry mass (Mertens et al. 2006).

Grass mass and corn mass were sampled and dried according to the protocol (Tab. 1). In our case, we did not perform drying at 121 °C because we could change the temperature on the device by 5 °C. Therefore, all drying was performed at 120 °C. Drying was continued until the sample reached a constant mass. After drying, we cooled the sample to room temperature, weighed the dried sample with a scale and used formula (1) to calculate the percentage of DM (Tab. 2) (DLG, 2002; Fodjan, 2019; Jones et al., 2023; Saverson, 2019).

Weight of fresh sample of green forage:	128 g
Weight of sample after drying:	49 g
Calculation: % DM = (49 / 128) x 100 ≈ 38 % DM	

Tab. 2. Example of calculation % DM of a grass mass sample

9. Conclusion

The production of high-quality silage is associated with risks that arise when an operation is carried out at a less than optimal time or with non- optimal ensiling methods. Ensiling forage crops with high or low moisture content can cause problems. Determining the optimal harvest time based on DM will ensure that the forage is not ensiled too wet or too dry. Using a hot air fryer is a simple and quick method to determine DM in a forage sample. Depending on the sample material (grass or corn mass), the required number of samples should be taken and the weight of the drying sample should be adjusted. In the future, it would be useful to analyse several farms to plan mowing or harvesting operations. In this way, we would gain insight into how farmers actually decide on the optimal timing for these operations. Based on the results obtained, more accurate recommendations could be made for determining the forage DM.

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