# English Version

## Sunflower (*Helianthus annuus* L.) for production of silage of the entire plant

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### Abstract

The objective of the work was to describe the quantitative and qualitative characteristics referring to sunflower cultive (*Helianthus annuus* L.) with the purpose of silage of the entire plant. The providence of conserved roughages is one strategy that can develop the productives and reproductives index of flocks in period of scarcity food, usually determinant by the low availability of pastures. The advantages of sunflower silage in comparison with the maize and sorghum is in the larger tolerance to drought, lower temperatures in the germination period (until 5 °C), smaller vegetative cycle, favoring more than one cultivation in summer with other culture and desired quality of the ensiled product. The lower content of dry matter (20 - 25%) and the high content of ether extract (10 - 18%) had been indicated as the main restrictions for sunflower silage, due to higher storage losses. Concerning the chemical composition of sunflower silage, contrasting with the maize, it is usual to meet larger levels of the crude protein (12% versus 9%), ether extract (14% versus 3%), acid detergent fiber (43 versus 32%) and lesser levels of neutral detergent fiber (47% versus 56%) and dry matter digestibility (49 versus 65%). The sunflower silage must not substitute totally the maize silage in ruminant diet, but it outstands as one forage plant option as source of energy and protein at situations of culture rotation, drought season and in the fall.

**Key-words:** ether extract; neutral detergent fiber, dray matter, crude protein.

### Introduction

The seasonality of production and offer of forage throughout the year is characterized as one of the problems of the Brazilian livestock. In periods of scarcity of forage one should use the methods of conservation, among them the silage of entire plant is the most indicated and used in the South of Brazil, since it represents a strategy that can improve the productive index of the herds.

Several forage species of grass and legume can be used to the production of silage. Among grasses, maize (*Zea mays* L.) produces silage of good storage (EVANGELISTA e LIMA, 2001), being thus, considered standard material, due to the high production of dry matter (> 10 t ha$^{-1}$), the content of soluble carbohydrate present in the plant (> 35% in the DM), which promotes an appropriated fermentation, and contributed to the conservation of a food with high nutritive value.

Among the forages with higher tolerance to the water stress, sunflower (*Helianthus annuus* L.) is noteworthy as appropriated culture to this situation, besides it presents higher tolerance of cultivation to low and high temperatures (between 5 °C and 40 °C), when compared to the other forage species.

Despite being introduced in the country as an oleaginous, studies conducted in the last years show that the sunflower is an alternative forage, either in the form of ensilage or in the form of a monocultive system, when mixed with other cultures (BANYS et al., 1999), mainly with maize. Its production in the form of silage has been improved in several places and periods of planting, since among other characteristics, it has a productive cycle below 90 days and tolerance to water stress (TOMICH et al., 2004a). The use of the silage as a mechanism to reduce costs and guarantee larger benefits to the ruminant feeding has been noteworthy as a new option adopted by farmers, since according to Hill et al. (2003) the most common form of provision of the entire sunflower plant to ruminants is trough silage.

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The cultivation of sunflower worldwide, is an option to the aim of silage (MELLO et al., 2004), due to considerable quantity of dry matter produced by unit of area and silage of good quality. The culture of the sunflower in Brazil occupies an area of approximately 81 thousand hectares in the year 2006, with production of 120 thousand tones in the form of grains, consequently with average yield of 1.5 t $ha^{-1}$.

In this context, this bibliographic review has as objective to describe the main aspects related to the qualitative and quantitative characteristics of the sunflower culture, destined to the use of silage of the entire plant.

## Morphological characteristics of the sunflower

Archeological evidences indicate that the Southwest of the United Stated and the North of the Mexico were the cradle of the domestication of the sunflower (ROSSI, 1998). The name sunflower (*Helianthus annuus* L.) can be explained – either the common name or the botanic name, considering that the genus derives from the Greek *hélios*, which means sun and from *anthus*, which means sun flower. According to Evangelista and Lima (2001) sunflower is an annual dicotiledonea, which belongs to the order *Synandrales* and the family *Compositae* (*Asteraceae*).

Among its morphological characteristics, it can be emphasized the taproot system with a large set of secondary roots, and it may reach until two meters of length, as long as the soil do not present physical or chemical impediments. It has herbaceous stem, which is cylindrical, pubescent, striated longitudinally, fistulated, composed by an aqueous and sponge tissue which disappears in the maturation and making the stem susceptible to lodging (ROSSI, 1998).

The sunflower stem presents vigorous growth, pronounced by the 30 days after emergence; its development is variable among cultivars in function of the environmental conditions, by the arrangement and population of plants (CASTRO e FARIAS, 2005). Leaves are heart-shaped, petiolated, and with high number of trichomes in the abaxial surface and they are compound by a high number of large stomata (CASTRO e FARIAS, 2005). Sunflower plants present a large variation in the number of leaves, from 12 to 40 (ROSSI, 1998). The inflorescence is compound by sessile flowers, condensed in discoid common receptacle and surrounded by a wrapper of bracts, forming in the superior region of the stem, the capitulum, which presents several forms as the concave, convex or plane.

Sunflower also has a dry accessory fruit, know as achene (CASTRO e FARIAS, 2005), which come from an inferior ovary and dicarpelar pistil. The achene is an indehiscent fruit, composed only by one seed, inserted in the fruit wall (pericarp) for only one point, characterized by the Foeniculum. The size, color and content of oil of the grains are variables (30 to 48% of oil) dependent of the cultivar; and the frequent number of achene which may range from 800 to 1700, per capitulum. This species presents cross-pollination, which occurs basically by entomophily, mainly by the action of bees and, in a lesser extent, by other insects and partially anemophilus (ROSSI, 1998).

## Implantation of the sunflower crop

To the sunflower seeding, it is necessary between 3.5 and 4.5 kg $ha^{-1}$ of seeds, aiming population density ranging from 40000 to 55000 plants $ha^{-1}$, spacing between lines ranging from 70 to 90 cm and great depth of seed deposition between 3 and 5 cm (TOMICH et al., 2004a). Concerning seeding period, the sunflower in the South region of Brazil, is planted between August 01 and March 15, with average amplitude of 215 days.

As any other culture, the fertilization of the sunflower crop must be conduced according to the historic of the yield of the anterior cultivation, the soil analysis and the demands of the culture. It is important to emphasize that the areas destined to the production of silage, where it does not occur the return of the plant waste to the soil, the fertilization of reposition is indispensible to maintain the productivity of the area (TOMICH et al., 2004a).

The sunflower is sensitive to the deficiency of boron, which is a micro nutrient, and may be presented in low contents in the Brazilian soil, mainly in soils whish receive high doses of limestone, soils with low content of organic matter and sandy soils.

Boron acts beneficially in the resistance to drought and heat, and it is active in the point of plant growth, favoring the calcium solubility, aiding in the transport of carbohydrate and nitrogen absorption (ROSSI, 1998). Due to this, it presents, with frequency, in the main agricultural regions of the country, symptoms of deficiency, mainly in the stages of flowering and maturation. Small and deformed capitulums and the loss of capitulums are some of the characteristic symptoms of this deficiency (TOMICH et al., 2004a). The lack of boron may be corrected with the application of 10 to 15 kg $ha^{-1}$ of borax in the seeding.

## Sunflower cultivars to silage

Nowadays there are in the market several genotypes of sunflower, among varieties, hybrids and cultivars themselves. However, there is still a lack of studies referent to the genetic breeding of plants and the execution of works that may contribute with materials destined to the production of silage with appropriated bromatological parameters, good production of dry matter per area and good acceptance by the animals. Most of the cultivars used nowadays have confectionary and oil production purposes.

On the other hand, the research has directed researches referent to the genetic breeding directed to obtain sunflower cultivars producers of oil to the production of the biofuel. Gonçalves and Tomich (1999), when evaluating the quality of the silage of confectionary and oil producer sunflower genotypes, emphasize the necessity of the execution of genetic breeding experiments aiming at obtaining sunflower genotypes which are appropriated to the production of silage. Tomichi et al. (2004a) also evidenced the necessity of using genotypes of sunflower plants genetically improved to the ensilage, relating this to the efficiency of fermentation to maintain the nutritive value as close as possible to the original material.

As a general rule, according to Gonçalves and Tomich (1999), in the choice of a sunflower cultivar to the production of silage, it must have the characteristics of production of dry matter superior to 8 t ha-1, with contents above 28% of dry matter in the harvest, crude protein superior to 10%, content inferior to 50% of neutral detergent fiber, of 40% in acid detergent fiber and of 7% in ether extract with early cycle (below 100 days), which contributes with one more cultivation in summer crop in crop rotation.

## Forage yield of sunflower

The potential yield of a sunflower crop and consequentially the reduction of costs depend on the technology available for this culture. In certain situations, the water stress is the main cause in the reduction of the forage yield, providing an increase in the cost of the silage, mainly in forage species traditionally cultivated. As a consequence of this fact, there was stimulus of for the cultivation of sunflower aiming at the ensilage, due to its good productive performance under low availability of water 700 mm) (TOMICH et al., 2004a). The advantages of the use of sunflower ensilage, comparing to maize (*Zea mays*) and sorghum (*Sorghum bicolor*) silage, is related to the compatible production of dry matter per area, lower vegetative period, good quality of the final ensiled product and higher tolerance to cold.

Concerning the interference of the temperature over the crop productivity, the sunflower plants may support low temperatures until the appearance of the flower bud (TOMICH et al., 2004a). During the germination, it demands temperatures above 5 °C, as long as there is water availability in the soil. As for the water demand, among the crops used to the production of the silage, sunflower is one of the most tolerant to the scarcity of water in the soil, since it presents a deep and well-developed laterally root system. The necessity of rainfall demanded to a good sunflower yield ranges from 500 to 700 mm well distributed during the production cycle.

The yield of sunflower forage, to Rezende et al. (2003), is influenced by the genotype, seed density and by the interaction between these factors. Evangelista and Lima (2001) added the factor harvest age with the others, emphasizing the seed density as main factor which influences in the production of dry matter per area. Tomich et al. (2004a) emphasized the soil fertility, seeding period, water availability, number of plants per unit of area together with genetic variability and the stage of plant development.

According to Silva et al. (1998), the seed density affects positively the production of dry matter and of the several compounds of the plant, as stem, leaves, receptacles and achenes. Evangelista and Lima (2001) reported values of dry matter productivity from 7.8 to 11.1 t $ha^{-1}$ for the density of 50 and 88 thousand plants $ha^{-1}$, respectively. Rezende et al. (2003), evaluating different sunflower hybrids over the effect of seed density (40 and 60 thousand plants $ha^{-1}$) in the productivity and bromatological composition of silages, verified increase in the average levels of dry matter from 31.2 to 35.6%, for all the evaluated genotypes with the increase of the planting density, as well as observed larger production of dry matter and increase in the participation of stems in the composition of silage comparing to the density 40 thousand plants $ha^{-1}$.

Nogueira (2000), when determined the chemical composition and the nutritive value by the silage with entire plants and with different proportions between the parts that compound the plant, i.e., leaves, stalks and capitulum of different sunflower cultivars, verified that with the increase in the percentage of participation of capitulum in the silages, there was a reduction in the fiber compounds and of the values of pH and an increase in the content of crude protein.

Evangelista and Lima (2001) also verified that the capitulum and the stem are the main constitutes of the silage, which are directly related to the number of plants per area, according to which was observed in comparative experiment among cultivars, on the density of 44 thousand plants $ha^{-1}$, in which, in average, the capitulum contributed with 47.5% and the stem with 30.1% in the silage composition. Tomichi (1999), evaluating thirteen genotypes of sunflower to the silage, verified that the capitulum contributed with the larger proportion (49.7%) in relation to the stem (38.3%) and leaves (12.0%). As a general rule, the participation of capitulum contributed with the largest proportion (approximately 50%) in relation to the other parts of the plant which compound the silage and according to Rezende et al. (2003) the determination of the yield of the sunflower culture is determined by the number of capitulum per hectare, which are directly related to the number of plants per area unit. According to Nogueira (2000), the larger the participation of the capitulum in the silage, the higher the energetic density of it. To the sunflower, it is still necessary studies to define what is the ideal percentage of the several parts of the plant to obtain silage with good quality (EVANGELISTA and LIMA, 2001).

For the effect of the age of cutting over the production of dry matter, Rezende et al. (2007) evaluated the nutritive value of silages of six sunflower cultivars in two cutting ages (95 and 110 days after the emergence) and obtained average production of dry matter of 8 and 9 t $ha^{-1}$ for 95 and 110 days, respectively. Pareira (2003), when evaluating the productivity of four sunflower cultivars, observed that the production of dry matter was not significantly changed by the advance in the stage of maturation, staying between 5.1 and 6.1 t $ha^{-1}$ in conformance with the harvest conducted 30, 37, 44 and 51 days after flowering. Both authors agree that the propitious time to the harvest of the sunflower destined to silage must be focused on the obtaining of concentrations between 30 and 37% of dry matter.

## Quality of the sunflower silage

Researches conducted about the sunflower quality show the potential of the culture, however, there are differences concerning the qualitative parameters of the evaluation of silages when compared to the values indicated to other forage species as maize, because the maize silage is considered pattern among the forage species. According to Fancelli and Dourado Neto (2004), to a good production and quality in the maize silage, it is necessary average values of 35% to DM, 7% to CP, 30% of ADF, 50% to NDS and pH below 4.5 to provide lactic fermentation.

According to Tomich et al. (2003), in order to verify the efficiency of the silage fermentation, it is prior the value of dry matter, the value of pH, the content of ammoniacal nitrogen and organic acid. The content of dry matter is a parameter of importance in the process of silage (TOMICH et al., 2004a) and obtained quality (GONÇALVES et al., 1996; HILL et al., 2003), since it is related to the production of effluents, reduction of the voluntary consumption, observed mainly in silages with low content of dry matter and the action of deletary microorganisms.

Silages with high values of dry matter suffer damages for heating and mold, which come from the difficulty of compaction. Considering this, Leite et al. (2005) recommend to ensile forages that present from 28% to 37% of dry matter. High contents of dry matter are found in sunflower silage when the harvest is performed in the stage of physiological maturation of the achenes, in the stage $R_9$ (GONÇALVE and TOMICH, 1999).

The content of dry matter has extreme importance over the quality of the silage (EVANGELISTA and LIMA, 2001), however, the traditional recommendations used to maize and sorghum are not applicable to sunflower, since the content of dry matter is variable according to the stage of development of the culture and also to the cultivation conditions. The content of dry matter must be associated to the value of pH when evaluating the process of fermentation, since it is requires a value of pH inferior to 4.0 to provide a good conservation of the forage, being this dependent on the content of humidity in the silage, that bust be between 60 and 70%. According to Gonçalves and Tomich (1999), in a study performed about the quality of seeds of different genotypes, it was found that silages with higher content of dry matter presented higher values of pH, since the rate of pH is dependent on the humidity present in the silage.

The conservation of the forage by the method of ensilage is base in the process of conservation in acid pH, in which the decrease of the pH by the action of fermentation controlled to the occurrence of processes that originate deterioration of the forage (McDONALD et al., 1991). Tomichi et al. (2004a) report values of pH between 3.5 and 4.0 as ideal to the conservation of silages. Evangelista and Lima (2001) consider that sunflower silages have high pH when compared to maize and sorghum silages, related to the high protein values, which result in reduction in the relation carbohydrate/proteins, influencing in the pH.

After the cutting and ensilage, it begins the hydrolysis of proteins, resulting in increase of the non-protein nitrogen in the first 24 hours of fermentation (McDONALD et al., 1991), in which the extension of the protein degradation ranges with the plant species, rate and drop of the pH, content of dry matter and temperature, but the content of protein may be reduced in 50-60% even in well preserved silages. It should be noted that the compounds resulting from this degradation of amino acids, besides inhibiting the consumption and presenting low efficiency in the use of nitrogen by the ruminants, change the fermentation, preventing a quick drop of pH.

Santos and Zanine (2006) emphasize that the pH of the sunflower silages is variable in conformance with the cultivar used, the age of harvesting and the practice of ensilage. The preservation of the food trough the method of ensilage occurs due to the production of organic acids, as lactic acid, coming from soluble sugars, which causes reduction of pH and later, the inhibition of undesirable deletary microorganisms.

Concerning the organic acids, the values of the lactic acid are used as indicators of fermentative quality. The needed quantity of the lactic acid to reduce the pH in a way that is fast and that difficult processes that consequently induce the deterioration of the ensiled material changes according to the capacity of buffering of the forage and the content of humidity of the silage. Tomich et al. (2004b) showed that sunflower silages present high proportions of lactic acid, 7% in relation to the dry matter, however the capacity of buffering of the plant does not enable reduction of the value of pH to the verified for the silages of maize and sorghum.

Few works were conduced about the acetic acid in silages of sunflower (PEREIRA, 2003), which is related to lower rates of decrease and higher final values of pH in the silages. According to Tomich et al. (2004b), in well conserved sunflower silages, it was found low concentration of acetic acid (2.0% of acetic acid in the dry matter). Concerning butyric acid, several studies notified low content in sunflower silages. Tomich et al. (2004b) studied several sunflower cultivars and found average value of 0.1% to butyric acid. The butyric acid indicates the clostridial activity over the forage and it is also related to lower rated of decrease and higher final values of pH in the silages. According to Leite et al. (2005), present contents of butyric acid is considered one of the main negative parameters of the silage quality, which generates significant losses of dry matter and energy of the original material in the fermentative process, consequently, reducing the palatability and the consumption of the roughage.

The content of ammoniacal nitrogen of the silage reveals the deletary action of enzymes of the plants and microorganisms over the protein part of the forage. In the green forage, approximately 75 to 90% of the total nitrogen is in the protein form, and the rest is characterized as non-protein nitrogen, referent to the free amino acids and amines. In a general way, it is considered maximum values of ammoniacal nitrogen approximately 10% (LEITE et al., 2005; TOMICH et al., 2004a), which is considered ideal in well conserved silages. Values that are inferior to 10% of ammoniacal nitrogen in relation to the total nitrogen indicate that the process of fermentation did not result in excessive break down of protein in ammonia and the amino acids constitute most part of the non-protein nitrogen.

In sunflower silages, the highest content of protein in relation to the maize and sorghum silages, according to Tomich (1999) and Hill et al. (2003), is one of the positive factors, resulting in the conservation of the quality of the protein, and may be benefited during the storage. Mello et al. (2004) evaluated the productive and qualitative potential of hybrids of maize, sorghum, and sunflower for the ensilage and found higher values of ammoniacal nitrogen in sunflower silages (7%) than maize (3%) and sorghum (5.3%) silages, due to its low content of dry matter (20% of the sunflower against 42% for the maize and 39% for the sorghum) and highest index of pH (3.9 to sunflower against 3.7 to maize and sorghum)..

In relation to the soluble carbohydrates present in the sunflower silage, researches reveal appropriated levels of soluble carbohydrate to the conservation of the silage during the fermentative process, causing a reduction in the content of carbohydrates of the original material, being sufficient to the production of lactic acid, providing a good fermentation. The soluble carbohydrates (sugars, polysaccharides and starch) are the main substrates so that there is a forage fermentation of quality, showing thus that it is a parameter which indicates quality. The forage needs to have alt least 25% of them in the dry matter (EVANGELISTA e LIMA, 2001).

It still should be emphasized that the content of oil present in the sunflower silage must be considered as a risk factor to the development of processes of rancidification and limitation of acceptance by animals.

## Nutritive value of the sunflower silage

The sunflower silage, according to Mello et al. (2004), contain superior contents of protein (11.4%), ether extract (17.4%) and minerals (3.5%) compared to the maize silages (5.7% of protein, 4.2% of ether extract, 2.5% of minerals) and sorghum (4.9% of protein, 3.6% of ether extract and 1.7% of minerals).

The protein value of the sunflower silage, when compared to maize, according to several studies, has superior values (EVANGELISTA e LIMA, 2001). Rezende et al. (2007), when evaluating the nutritive value of six sunflower cultivars, obtained average values of 11.2% and 12.4% to crude protein 95 and 110 days after seeding. Jayme et al. (2007) obtained average values of 9% of crude protein when studying the quality of silages of different sunflower genotypes, while Rezende et al. (2002), comparing ensiled sunflower genotypes with 95, 110 and 125 days of age found average crude protein values of 9.3, 10.5 and 10.5%, respectively, according to the advance of the period of cutting to ensilage.

The value of the ether extract in the sunflower silage is three to four times superior to the maize silage, since according to Tomich et al. (2003), when evaluating silages of different sunflower hybrids, it was observed average content of 13.7% of ether extract. Similar results to ether extract were found by Mello et al. (2004), when studying the productive and qualitative potential of maize, sorghum and sunflower hybrids to silage of the entire plant, who found values of ether extract of 3.9 to 4.2% to maize, 3.4 to 3.8% to sorghum and 14.1 to 20.6% to sunflower silage.

The ether extract present in the silage of the entire plant of sunflower, in most of the researches, according to Hill et al. (2003) presented values of approximately 10% in the stage of physiological maturation. In the same work, Hill et al. (2003) evaluated the nutritional value of the sunflower and concluded that the level of ether extract is higher in the phenological stage $R_9$ (14.3%) when compared to the stages $R_7$ (12.1%) and $R_8$ (11.2%). Rezende et al. (2007) observed decreases in the contents of ether extracts according to the advance of the age, 14.6% for 95% days and 14.2% for 110 days. Rezende et al. (2003) verified effect of the seeding density over the productivity and bromatological composition of sunflower silages, founding higher values of ether extract in plants coming from a stand of 60 thousand plants $ha^{-1}$ compared to the stand of 40 thopusand plants $ha^{-1}$.

A good part of the sunflower cultivars present in the market aim at the production of oil. When used with the aim at silage, sunflower has presented high content of ether extract. These high contents signify a limiting factor as the only source of roughage, thus, there is the necessity of association with other roughages. According to Tomich et al. (2004a), roughages with more than 7% of ether extract are related to reduction in the ruminal fermentation, in the fiber digestibility and in the rate of motility in the ruminal threat. According to Silva et al. (2004), the sunflower silage must not be offered as the only source of roughage to cows in milk, since it may occur reductions in the ingestion and digestibility in diet which contains more than 8% of ether extract. Still in the same work, Silva et al. (2004) observed reduction in the milk production, in the content of protein and in the total dry extract of the milk.

According to Mello et al. (2004), the sunflower silage, when used in balanced diets, presenting protein doses of 11.4% of CP and minerals of 3.5%, may present an economic advantage in relation to the others, since nutrients are supplied to the animals by the roughage, reducing thus the supply of nutrient trough roughage or mineral mixture. On the other side, the utilization of the energy available in the fiber fraction may be restricted, since the sunflower silage presents lower content of NDF (42.4%) than maize (51.5%) and sorghum (60.1%) silages and it contains high proportions of ADF (34.8% for sunflower against 27.4% to maize and 33.8% to sorghum).

According to Mello et al. (2004), in an evaluation of the productive and qualitative potential of hybrids of maize, sorghum and sunflower to the ensilage, the compounds of the cellular wall of the silages (NDF, ADF, hemicellulose, cellulose and lignin in acid detergent) presented significant differences between cultures, but the sunflower silage presented lower content of NFD and hemicellulose compared to maize and sorghum. Values found by Rezende et al. (2002) indicated differences in the levels of NDF in sunflower cultivars in relation to three cutting periods, due to the increase of participation of the dry matter, tissue lignification and advance in the physiologic maturity.

According to data referent to the research conducted by Rezende et al. (2007) about the evaluation of different sunflower cultivars in two cutting ages, it was verified values of NDF of 54.6% for the cutting performed 95 days after the seeding and 55.0% for 110 days. Silages with high content of dry matter have as a trend to have higher content of ADF and NDF, according to the description of Jayme et al. (2007), since the sunflower has content of ADF close to the NDF, due to the low content of hemicellulose. Tomich et al. (2004b), when evaluating the chemical characteristics and digestibility in vitro from thirteen sunflower cultivars, found average values of 45.8% to NDF, 35.7% to ADF and 6.5% to lignin, and concluded that high values of ADF and of lignin may restrict the quality of the fiber fraction and the use to more exigent categories.

In the compounds of the cellular wall, according to Evagelista and Lima (2001), the lignin present in the sunflower silage in a percentage of NDF represents twice the value when compared to the maize silage. By contrast, the contents of NDF and ADF in the sunflower silage are inferior to NDF and superior to SDF when compared to the maize silage.

The in vitro dry matter digestibility (INDMD) together with the chemical composition and the consumption of the dry matter, are parameters considered to define the nutritive value of the forage. Besides presenting low content of dry matter in the ensilage, the sunflower also presents low digestibility (EVARISTA and LIMA, 2001), and makes in a disadvantage to use sunflower in the ruminant diet. Comparing the sunflower silage with the maize silage, it can be seen that the content of lignin can be the main limiting factor of the digestibility. Silages with higher content of NDF and ADF, according to Jaime et al. (2007), have a trend of lower values of INDMD which was compared with the values of 48.7% to NDF and 38.5% to ADF, according to an evaluation performed in six sunflower genotypes confectioner and oil producers and noticed that there was a tendency of the genotypes with higher content of dry matter to present higher content of NDF.

Rezende et al. (2007) found average values to INDMD of 56.2% in cutting performed 95 days and 48.1% to 110 days, indicating also that the content of INDMD is related to the phenological stage of the sunflower plant. Researches conduced in the last years, as described by Evangelista and Lima (2001), revealed in averages ranges of 46.9% to 56.7% for in vitro dry matter digestibility of the sunflower silage.

## Point of ensilage of the sunflower

The definition of the ideal moment to the sunflower harvest for the confection of the silage is of major importance to the production of roughage with appropriated nutritive values. However, the recommendations of the ensilage point are controversial. According to Leite et al. (2005), one of the disadvantages of the sunflower is the low content of dry matter, which is a limiting parameter to the production of silage. According to Rossi (1998) several times are indicated to start the silage, including the period in which half of the plants present flowering, the stage $R_{5\ 1}$, in which 10% of the flowers of the capitulum are flowering. The cutting age is defined according to the cycle of production of the sunflower which ranges from 90 days to early cultivars to 130 to late cultivars (LEITE et al., 1996), associated to the climate conditions of the cultivation period (REZENDE et al., 2007).

Castro et al. (1996) conduced cutting from the 96 to 110 days after seeding, with plants presenting 50 to 75% of mature grains and obtained silages with 21 to 25% of dry matter, in which the plant was close to the physiological maturity. Rezende et al. (2002), evaluating the potential of three sunflower cultivars for ensilage in three cutting periods, observed increase in percentage of the dry matter (22.9, 24.8 to 28.1%), pH (3.8, 4.0 and 4.0), crude protein (9.3, 10.4 to 10.5%), NDF (34.2, 39.7 to 46.0%) and ether extract (9.3, 12.7 to 13.9), throughout the advance of the cutting period 95, 110 and 125 days after seeding, respectively.

Rezende et al. (2007) determined the sunflower plant cut to ensilage in the $R_9$ stage, since plants are in complete maturation, with dry leaves and stalks and hard grains. In the $R_9$ reproductive stage, sunflower plants present brown coloration in the back of the capitulum, the bracts are brownish yellow and a large part of the remaining leaves in the stem are senescent. This occur between 85 and 105 days after seeding to genotypes of early to late cycle.

There is also de idea of ensiling the sunflower plant in the phase of physiological maturation of the achenes, since several researches point that in the $R_9$ reproductive stage, plants present appropriated content of dry matter to provide a fermentation which enables good forage conservation. According to Tomich et al. (2004a), the sunflower ensilage conducted in the $R_9$ stage has presented content of dry matter between 26 and 30% of crude protein in the band of 10% and coefficient of IVDMD of approximately 50%. Evangelista and Lima (2001) emphasize that when the sunflower silage is performed with 90% of the mature grains in several cultivars, it has provided silages with content of dry matter of approximately 25%.

Based on the information described about the point of ensilage, the recommendation of the best ensilage point is the stage $R_9$, since the sunflower plant has content of dry matter between 26 and 30% and crude protein of approximately 10% (TOMICH et al., 2004a). However, it is still important to emphasize that in the R9 stage the stem of the sunflower plants is susceptible to lodging and the achenes to the attack of birds, and this may cause losses superior to 15% in the harvest (TOMICH et al., 2004a). There is a necessity of conduct new works which evaluate the characteristics of different sunflower cultivars traded in order to define the appropriated point of ensilage.

## Performance of animals fed with sunflower silage

The animal performance is related with the consumption of the dry matter and most of the studied showed that the consumption of diets containing sunflower silages was lower than the maize silage with the reduction of 10 to 15% (RIBEIRO et al., 2002).

Leite (2002) studied the performance of Holstein cows fed with sunflower and maize silages, in which the sunflower silage promoted significant reduction of 17% in the ingestion of dry matter, however in combined use (partial substitution of 34% or 66%) it was not observed reduction in the consumption of dry matter. Silva et al. (2004) do not recommend the total substitution of the maize silage for sunflower silage, due to reductions in the milk production (from 27.5 to 24.0 kg day$^{-1}$), in the protein (from 0.84 to 0.70%) and in the total dry extract (from 3.0 to 2.6%) in dairy cow diet.

The development of sheep fed with sunflower silage was researched by Bianchini et al. (2002?), who evaluated the development of lambs in finishing stage fed with sunflower silage, presented worse yield of the carcass then lambs feed with maize silage, since the sunflower silage presented worse yield, which is caused by the lower ingestion of dry matter. On the other side, Bueno et al. (2004) evaluated lambs fed with maize and sunflower silages and concluded that the animals fed with sunflower silage had inferior performance than those fed with maize silage (daily gain of live weight of 181.8 against 108.2 g and food conversion of 3.8 against 5.3 kg of dry matter for each kg of gain of live weight).

Not only the performance of animals fed with sunflower silage must be monitored, but also the cost of production. The productivity per area is one of the determining factors of the cost of silage (FERNANDES e AMABILE, 2003).

When comparing the cost of production of the sunflower silage with the maize silage, containing 26% of dry matter, with the cost of the maize silage with content of 34% of dry matter, the cost of implantation of the sunflower crop was approximately 1042.00 R$ ha$^{-1}$ (AGRIANUAL, 2007) against 1625.00 R$ ha$^{-1}$ for the maize (PEREIRA, 2007). Considering the same operational cost of ensilage for both cultures, it must be added more 410.00 R$ ha$^{-1}$. Consequently, the sunflower silage present cost per ton of ensiled dry matter of R$ 170.00 against R$ 120.00 for the ensiled ton of maize dry matter.

According to the data referent to the cost of sunflower production, it is evidenced that the higher the index of productivity per area of the sunflower forage dry matter, the lower are the costs per ensiled ton.

## Final considerations

The development of appropriate cultivars of sunflower to the practice of ensilage, trough plant genetic breeding, may contribute with the parameters referent to nutritional and productive values of the sunflower forage, and may be an alternative to the ruminant feeding. There are some cautions that must be considering when using this roughage, when provided as only source in the ruminant diet, according to parameter as the high content of ether extract (above 10%) and low content of dry matter (below 25%). The main determining factor in the economic viability to the production of sunflower silage is the production of dry matter per unit of area.

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