Harvesting and processing maize silage for dairy cows.

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Maize is a multi-purpose cereal grain that can produce both grain and silage for livestock feeding. In Australia, maize is a minor summer crop with an annual average production of between 350,000 and 450,000 tonnes, with grain yields of about 5-20 tonne/ha. The large majority of maize grown in Australia is sold on the domestic market to the food and stockfeed industries. Maize entering the food market ends up as breakfast cereal, snack foods, corn flour, etc. while the domestic stockfeed feed market includes grain as well as whole plant maize silage. Maize varieties used for stockfeed are chosen mainly for their yield potential rather than grain quality. It is estimated that over the past few years, there has been an increase in the area that has been sown around Australia to produce maize silage, mainly for the dairy industry.

The growing season is generally about 130–150 days, from planting to harvest, with planting often beginning in November/December. The season length will vary with the hybrid/variety selected, seasonal conditions, location and crop management, especially irrigation. A crop is ready to harvest for fodder or silage, theoretically, about 10–14 days before physiological maturity which will be about 3 to 4.5 months after planting.

Expected forage yields observed in commercial crops in Australia are usually up to 25 tonne/ha. Densley et al. (2006) has shown that reliable annual maize silage production of 30 tonne DM/ha was possible using a late maturing maize hybrid combined with a winter forage crop near Hamilton in the north island of New Zealand. Later, Minnee et al. (2009) confirmed that annual yields of forage crops (based upon maize) of around 45 tonne/ha were possible provided that water and nitrogen were plentiful and that the crop rotation was carefully designed to maximise solar radiation capture and utilisation. However, in both these research studies the observed yields were based on 'best' plot yields of crops and pasture.

Composition of Maize Silage

The average composition of maize silage samples analysed by NIR by a US commercial laboratory between 2000- 2018 is shown in Table 1

Table 1 Composition of maize silage (Mike Allen, personal communication).

Nutritive value	No. samples	mean	"normal" range
Dry matter (%)	272,433	33.3	25.5 – 41.1
NDF (% DM)	270,531	43.5	37.6 – 49.5
30 hr *in vitro* NDF digestibility (%)	66,770	52.7	46.7 – 58.6
Starch (% DM)	236,266	31.8	24.4 – 39.2

In vitro starch digestibility (%)	44,721	69.8	47.2 – 92.5

Maize silage provides not only energy and starch, but also fibre in the form of neutral detergent fibre (NDF). As the corn plant matures, starch concentration increases, thereby diluting NDF concentration. Forage NDF is filling compared with starch and maize silage with high NDF and low starch concentration may reduce dry matter intake unless compensated for by adding grain during ration formulation. NDF digestibility affects passage rate and dry matter intake with higher digestibility figures promoting greater voluntary feed intakes. Starch digestibility affects rumen health and may limit dry matter intake under some conditions. The composition of maize silage can be quite variable (Table 1) and will be affected by hybrid, environment and management factors such as population density, maturity at harvest and subsequent processing. In addition, both starch digestibility and NDF digestibility decreases as the plant matures.

Processing effects on the nutritive value of maize silage.

As the costs of growing maize increase, efforts to increase the digestibility of nutrients in maize silage are likely to be cost effective.

Chop height:

Cutting maize silage at higher levels can be a tool for farmers to manage the dry matter of the crop. Since harvesting silage 25 cm higher will generally increase dry matter in the harvested crop by 2% units, farmers could use this to harvest earlier. Because maize silage generally dries down at a rate of about 0.5% units/day, this translates into harvesting approximately four days earlier. The decision to chop maize silage at higher levels is a farm-specific question and is likely influenced by a number of other considerations.

The higher the chop height, the lower the yield but silage produced will be of better quality (Table 2). Conversely the lower chop height will produce more silage, but at a lower quality. The better quality maize silage would be fed to high producing cows to improve dry matter intake and milk yield, while the lower quality silage cut at a lower height could be fed to late lactation cows whose dry matter intake is less limited by gut fill, to promote improved body condition.

Table 2: Effect of chop height on nutritive value of maize silage. Summary of 11 cutting height studies by Wu and Roth, (2016)

Nutritive value	Low chop height (Av. 20 cm)	High chop height (Av. 50 cm)
Dry Matter (%)	38.1	40.3
Crude Protein (%)	7.0	7.1
NDF (%)	41.6	38.6
Starch (%)	30.6	32.4

DM digestibility (%)	78.6	80.6
NDF digestibility (%)	50.6	54.0

Chop length:

The optimum chop length is not constant, but depends upon hybrid, dry matter concentration, processing and other sources of effective NDF in the diet. The typical chop length is about 1-2 cm, but shorter chop length silage can pack better in the silo/pit and can lead to less spoilage and better silage. However shorter chop length may reduce the "effective" nature of the fibre in the rumen.

Roller clearance:

The typical maize forage harvester has both choppers and rollers to crack any grain. The rollers will increases total tract starch digestibility, decrease sorting and cob refusal. Roller clearance can vary between 1 and 3 mm and is dependent upon the vitreousness and moisture content of the kernel. The roller clearance should be tightened until all kernels are broken and there are no cob pieces greater than a finger tip. However fine processing lowers machine output and increases power requirement and fuel consumption.

***Relationships between nutritive value of maize silage and dairy cow performance*.**

NDF digestibility:

NDF digestibility of maize silage may range from 30% to 60%, but the majority of samples are likely to be between 40% and 50%. Higher NDF digestibility of NDF in maize silage leads to improved animal performance and Oba and Allen (1999a) have estimated that each unit increase of NDF digestibility results in an increase of 0.17 kg/day dry matter intake and an increase of 0.25 kg/day in milk yield. Note that there appears to be no relationship between the *in vitro* NDF digestibility and total NDF content for corn silage.

Starch digestibility:

Maize is an advantageous source of starch for lactating dairy cows because the ruminal digestion of starch in maize is slower than starch digestion in some other cereal grains such as wheat and barley. The slower digestion of starch in maize helps cows maintain a more stable rumen pH and avoid the milk fat depression often seen when diets high in other forages are fed. This slower digestion of starch in maize is often very complementary to winter cereal grain digestion.

The kernel moisture content and whether the endosperm is a floury or vitreous type will affect the digestibility of starch in maize silage. Starch digestibility decreases as vitreousness increases and high moisture maize and floury endosperm will have higher fermentability in the rumen of cows. Maize silage that is more fermentable will have higher starch digestibility.

Ensiling increases the *in vitro* digestibility of starch in maize silage. As the silage process progresses, *in vitro* starch digestion in maize silage increases, particularly over the first 3-4 weeks (Figure 1)

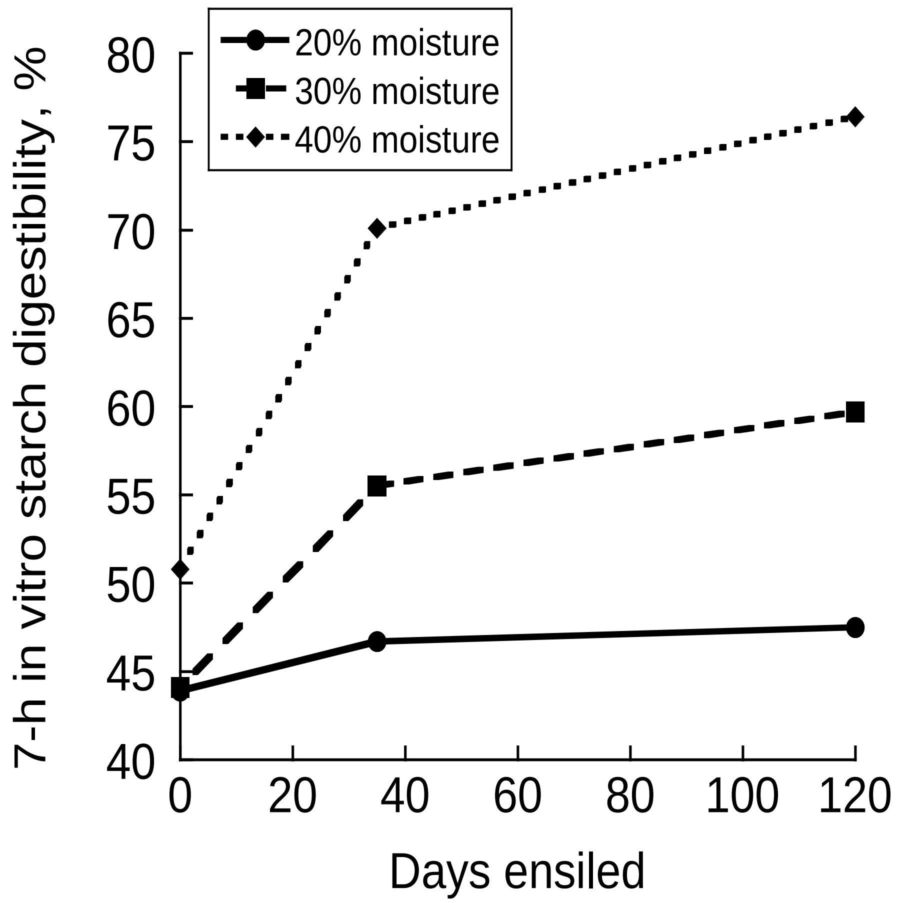

Figure 1: Effect of the moisture content of the grain in maize silage on the digestibility of starch after ensiling (Allen et al. 2003)

When should maize be harvested?

Maize must be ensiled at the proper moisture content to get fermentation for preservation. But, determining when to harvest maize at the right whole plant moisture is difficult. The dilemma is finding an easily measured indicator that accurately correlates with moisture.

Kernel milkline has been the most widely used indicator for determining when to harvest maize for silage, as it indicates the rate at which the crop is drying down. However, the development of the milkline in the kernel is not the preferred method of identifying optimum time for harvesting maize. It is much better to directly measure dry matter of the whole plant to identify the right time (about 30% to 32% DM) to harvest maize for silage. To do this you should sample each paddock by harvesting 15-20 plants and chopping them up, subsample and determine DM% by oven drying at 100°C for 24 hours or drying in a microwave for up to about 15 minutes.

Specialty Hybrids for Silage: Brown midrib maize

Brown midrib maize was first discovered in USA in Minnesota in 1924 as a natural mutation of regular dent maize. Brown midrib maize plants exhibit a reddish-brown pigmentation of the leaf midrib. The brown midrib phenomenon is also found in sorghum and pearl millet. About 40 years after the initial discovery, brown midrib mutations were found to have a significant reduction in lignin content (Lechtenberg et al., 1972), and that digestibility of brown midrib varieties of maize silage was improved in ruminants. Although brown midrib varieties of maize have been used in USA for the past 30 years or so, they are not yet present in Australia but are likely to be introduced in the next couple of years

The lower lignin content of brown midrib maize leads to greater NDF digestibility, dry matter intake and milk yield (Table 3). Furthermore, feed intake and production responses to brown midrib maize silage increases with the milk yield of cows. The small reduction in the yields of BMR varieties that have been observed in USA are often more than compensated for by the greater nutrient digestibility in dairy cows, particularly in the first part of lactation.

Table 3: The effect of brown midrib maize silage on the performance of high producing lactating dairy cows when included at 45% of the diet (Oba and Allen, 1999b).

Nutritive value	Brown midrib maize silage	Normal maize silage
Dry Matter (%)	31.7	32.6
NDF (%)	38.3	40.1
Lignin (%)	1.7	2.5
Crude Protein (%)	8.7	8.4
In vitro NDF digestibility (%)	49.1	39.4
Dry Matter intake (kg/day)	25.5	23.5
Milk Yield (kg/day)	41.7	38.9

Conclusions:

Maize silage is a high quality forage supplement that is increasingly being successfully incorporated into dairy rations in Australia. The average composition of good quality maize silage is about 40% NDF with an *in vitro* NDF digestibility of about 55%. In addition, it may contain between 30% and 35% starch. The composition of maize silage can be quite variable and will be affected by hybrid, environment and management factors such as maturity and dry matter at harvest, chop height, chop length and subsequent processing. Good quality maize silage should be fed to cows during early lactation where it is most effective, improving dry matter intake and milk yield. Poorer quality maize silage could be restricted to feeding cows in later lactation where it may improve body condition without any major effect on milk yield.

References:

Densely, Austin, Williams, Tsimba and Edmeades (2007). Proceedings of New Zealand Grassland Association 68:193-197

Lechtenberg, Muller, Bauman, Rhykerd, and Barnes (1972). Agronomy Journal 64:657-660.

Minee, Fletcher, De Ruiter and Clark (2009). Proceedings of New Zealand Grassland Association. 71: 93-100.

Oba and Allen, (1999a). Journal of Dairy Science. 82:589.

Oba and Allen, (1999b). Journal of Dairy Science. 83:135.

Wu and Roth (2016). https://extension.psu.edu/considerations-in-managing-cutting-height-of-corn-silage

Figure 2: Harvesting Maize Silage

Figure 1: Maize growing during the season