PART III - NUTRITIVE VALUE ESTIMATION

EFFECT OF DIFFERENT LEVELS OF NITROGEN AND METHODS OF APPLICATION OF UREA ON THE YIELD AND NUTRITIVE VALUE OF GREEN JOWAR (Sorghum vulgare) and Silage
CHAPTER I

1. REVIEW OF LITERATURE

This chapter deals with the review of literature on the nutritive value of sorghum and effect of ensiling on its intake and nutritive value.

1.1 Nutritive value of sorghum

The results on digestibility of green jowar cut at the pre-milk stage and mature stage was studied by Lander and Dharmani (1956) and Schneider (1959) respectively. They reported that certain samples of this fodder have been found to contain insufficient amount of protein even to meet the maintenance requirement of cattle.

Bhatia and Talapatra (1968) conducted metabolic trial on sorghum at pre-flowering stage and reported that the average digestibility coefficients for dry matter, crude protein, ether extract, crude fibre, NFE and total carbohydrate were 57.9, 40.0, 45.7, 58.6, 63.0 and 61.3 per cent, respectively.

The nutritive value of Jowar CV. Nandial in its green stage was studied by Patel et al. (1968). The digestibility co-
efficients of OM, crude protein, EE, CF, NFE and total carbohydrates were found to be 74.3, 58.9, 67.0, 78.6, 68.9 and 75.5 per cent respectively. The digestible nutrients were found to be in order of 3.06 CP; 2.15 EE, 22.15 CF and 37.26 NFE amounting to 68.28 TIN.

Gupta et al. (1967) while making a comparison of the nutritive value of hybrid Napier, Napier and Jowar found that the digestibility coefficients of different nutrients in the case of Jowar were 51.3, 57.8, 60.9, 48.2 and 45.9 for DM, CP, CF, EE and NFE, respectively.

Later Gaffar and Kaduskar (1972) conducted trial to find out the nutritive value of Jowar green, silage and hay. The digestibility coefficients of different nutrients for green Jowar were found to be 52.34, 33.41, 58.29, 64.61, 54.28 and 58.42 for organic matter, crude protein, ether extract, crude fibre, nitrogen free extract and total carbohydrates, respectively. The digestible crude protein and total digestible nutrients were 1.92 and 52.75 per cent, respectively. Ramadan & Robinson (1972) conducted metabolic trial with sorghum containing 89% DM on Najdirams and reported that the feed intake and OM digestibility were 10.6 kg and 62.5% respectively.

In a recent communication, Mathur and Gupta (1971*) reported that the digestibility coefficients of various nutrients
on jowar as CP 42.15 ± 1.72, EE 47.31 ± 2.46, CF 70.37 ± 0.86 and NFE 71.98 ± 0.39. The digestible crude protein and total digestible nutrients worked out to be 0.70 and 24.80 on fresh basis and 1.75 and 62.28 per cent on dry matter basis, respectively.

1.2 Effect of ensilage on intake

Deficiencies in silage as a ruminant feed were often noted in practice, but the first formal definition of the problem appears to have been by Presthegge (1959) and Moore et al. (1960), who showed that the voluntary intake of silage was less than that of hay.

This has been confirmed by many other workers, and Harris and Raymond (1963) have also shown that the intake of silage is generally lower than that of the fresh crop. In all these experiments, products from the same crop were compared; most previous comparisons of hay and silage had been confounded by silage being made at the "Silage" stage of growth and hay at the hay stage that is from a more mature and less digestible crop.

Despite the widespread acceptance of ensiling as an excellent method of forage preservation, the process of ensiling was shown by Moller et al. (1963, 1965) to reduce the feeding value of the corn plant primarily by reducing the voluntary intake of growing dairy heifers.
Temperate experience indicates that the intake of DM by ruminants from silage is generally lower than the intake of the same herbage material fed in a frozen or dried form (Campling, 1966).

Venkatakri shnan (1967) found that the average daily intake of Brachiaria mutica silage by bullocks was 1.68 and 1.62 kg DM and that of comparable hay was 2.85 and 2.67 kg DM/100 kg body weight. For Pennisetum purpureum, the intake of silage and green forage by dairy cows in West Indies were both low at 1.2 kg DM/100 kg body weight per day (Duckworth, 1969); but these two forages did not come from the same harvest.

Patel et al. (1968) while working on the comparative study on the nutritive value of jowar green, silage and hay reported that the dry matter intake was maximum from jowar green which was 1.7 kg per 100 kg body weight and was quite close to the intake of 1.6 kg from silage indicating that silage was as good as green fodder in palatability, while the intake from hay was only 1.03 kg per 100 kg body weight showing its less palatability.

Balwani et al. (1969) reported that there were some obvious relationship between dry matter digestibility and digestible dry matter intake in forages but the two figures were not highly correlated, suggesting that factors other than
apparent digestibility are controlling intake. These workers further reported that among the grain and forage sorghum silages, both had similar nutritive values although crude protein and intake were higher in grain sorghum.

There have been a number of other reports that the voluntary intake of DM by dairy cows fed silage made from tropical pasture grass was relatively low (Catchpoole and Henzell, 1971). The average daily intake of Cynodon dactylon ensiled with 41 crushed grain/t was between 1.5 and 1.6 kg/100 kg live weight (Clifton et al., 1963); it was a little better at 1.8 kg when 23 days old regrowth was ensiled with 50 kg grain/t (Clifton et al., 1967). The grain itself may have increased the intake of these silages.

In South Carolina the intake of unamended C. dactylon silage was 1.2 kg/100 kg live weight; but was up to 1.5 kg for equivalent silage made with maize meal (King et al., 1964). In comparison, dairy cows given silage made from temperate herbage consumed up to 2.2 kg DM/100 kg live weight per day (Murdoch, 1960).

Lucci et al. (1968) reported that in a trial in September-December, 1968, 12 dairy cows were fed on silage of (a) Napier grass (b) Maize (c) Sorghum in a switch back design. Milk production was maximum with (b) 10.3 kg FCM per day, and was
9.3 kg in (a) and 3.4 kg in (c). On a fresh matter basis, significantly more maize silage (34.3 kg/cow/day) was consumed than sorghum silage (30.4 kg). Consumption of Napier was intermediate but the differences were not significant. On a DM basis, significantly more maize silage was consumed (9.5 kg/cow/day) than either sorghum or Napier silage. Intake of TDN was 5.9 kg/cow per day for maize silage, 4.8 kg for sorghum and 3.8 kg for Napier grass.

Gill (1970) while studying the response of dairy cows to maize and grain sorghum fed as silage reported total DM intake of 19.8 and 21.3 lb per head per day and DM intake 14.3 lb and 13.2 lb/head per day for maize and jowar silage, respectively.

Jackson and Forbes (1970) ensiled the herbage from same timothy/meadow fescue/white clover swards immediately after cutting or wilting. The resulting silages had DM content of (a) 19.0 (b) 27.3 (c) 32.3 and (d) 33.2% respectively. Each silage was fed individually to 7 beef cattle (Mean live weight 334 kg). Although the silages from wilted herbage had lower digestibility than that from un wilted herbage, wilting increased DM intake as well as the metabolizable energy (ME) intake. The mean daily intakes of DOM were (a) 53.0 (b) 58.1 (c) 59.6 and (d) 59.6 g/ W 0.75 . The corresponding ME intakes, expressed as multiple of the ME requirement for maintenance, were 1.17,
1.29, 1.30 and 1.28, respectively. The percentage of acetic acid in the silage DM was significantly (r = -0.56) and linearly related to voluntary intake. The relationship between lactic acid concentration and voluntary intake was significantly curvilinear (r = 0.48).

Bhatia and Talapatra (1968) reported that the dry matter consumption in case of green jowar and silage prepared out of it was 2.2 ± 0.01 and 1.9 ± 0.05 per 100 kg body weight respectively.

Gaffar and Kaduskar (1972) reported that the dry matter consumption in case of green jowar and silage was 1.86 and 1.80 per 100 kg body weight, respectively. Preshegge (1959) and Moore et al. (1960) showed that intake of silage was increased if the crop was wilted before ensiling.

Owens (1968) reported the data from trials in 1965 and 1966 wherein, maize was ensiled at high DM (>42%) and medium DM (32-42%). The DM intake, milk production and body weight gains were greater from high DM silage, but differences were significant in 1966 only. The silages were nearly equal in feeding value.

As with forage intake, it is clear that there is no single factor causing the intake of unwilted silage to be lower than that of the equivalent fresh or dried forage. It is not
due to the high moisture content per cent in the silage, for addition of water to hay or wilted forage does not decrease voluntary intake (Thomas et al., 1961).

Moore et al. (1960) and McCullough (1961) showed that possibly some undesirable products which reduce animal intake are produced during certain type of silage fermentation.

Campling (1964) has suggested that silage within the rumen forms a fibrous dough from which "digested" feed particles can pass only with difficulty to the hind tract, so that the rate of passage and as a result level of feed intake is restricted. Most workers, however, have considered that during the ensilage process chemical compounds are produced which limit intake (Raymond, 1969).

Lucci et al. (1969) conducted experiment with 4 steers fed ad lib. on silage of sorghum CV. Saga Eliza and made observations on intake and rumination time. The amount of kg of feed consumed per animal/day for silage was 16.1 kg fresh material and 3.9 kg of dry matter. The total water intake was 19.7 litres out of which 12.2 was from silage and 7.5 was from drinking.

Recently, Verma (1974) determined the intake of silage prepared from Vidisha 60-1 variety of jowar and reported that the dry matter and digestible dry matter intake were found to be
46.5 and 21.4 g/.. W0.75 and the relative intake of digestible dry matter was 100. The digestible energy of the silage was found to be 2828 Kcal/kg and its intake as 131 Kcal/.. W0.75.

More serious is the problem of low intake with the low pH silage which the efficient preservation process aims to make, and in which there is minimal degradation of the protein fraction. There is now some evidence that this is at least partly due to high content of free organic acid in such silage (Harris et al., 1966; McCullough, 1966).

It has been found that a number of silage constituents including lactic, acetic and propionic acid and longer chain fatty acids may lead to reduced feed intake when they are added to silage before feeding or infused directly into the rumen (Thomas et al., 1961; Hock et al., 1963; Wittyatt, 1965).

There is evidence that the voluntary intake of silage is restricted either by the products of protein degradation in silage which has undergone a clostridial fermentation or by high concentration of free acids in well preserved silage (Wilkins et al., 1971).

Kirchgesner et al. (1972) studied the influence of fermentation in grass silage on fodder intake by dairy cows and reported that DM intake increased significantly with increasing DM and lactic acid content and decreased with increasing butyric
acid content in the silage. Multiple regression analysis showed that DM intake was significantly correlated with silage dry matter content only.

A further interesting development has been the addition of urea to the crop before ensiling, with the aim of increasing the crude protein content of silage made from low protein crops, in particular corn silage (reviewed by Briggs, 1967; Essig, 1968). An addition of 0.5 to 1.0 per cent urea appears to increase dry matter loss slightly, and markedly to increase the free ammonia content in the silage; a perhaps unexpected observation is that simultaneous addition of 0.5 per cent ground lime stone improved silage fermentation. Essig (1968) reported a 5 per cent increase in gains when treated corn silage was fed to cattle.

McLeod et al. (1970) reported that free acid content of grass silage was reduced by the addition of sodium bicarbonate to the silage and increased by the addition of lactic acid. The addition of sodium bicarbonate to increase pH from about 4.0 to about 5.4 resulted in insignificant increase in DM intake ranging from 9.7 to 20.7 per cent. Intake of OM was consistently increased by this partial neutralisation, but the increase was not significant in all trials. The addition of sodium as sodium chloride rather than sodium bicarbonate did not alter the intake of a higher acid silage. Addition of
lactic acid to reduce the pH of a silage from 5.4 to 3.8 resulted in a 22% decrease in DM intake. The correlations between DM intake and the silage characteristics: titrable acidity, total organic acid content, lactic acid content and pH were significant. It was concluded that the acids produced during normal silage fermentation can limit silage intake and it is suggested that chemical treatments which will preserve wet grass without the presence or formation of large quantities of acids be investigated.

1.3 Effect of ensilage on digestibility and nutritive value of sorghum

Watson and Ferguson (1937) could not find any difference in the digestibility of herbage ensiled without additive or with molasses or mineral acids. The same workers also reported no significant difference in the digestibility of the original herbage and the silage prepared from the same.

Sears et al. (1942) found that the herbage of different digestibilities gave ensiled products which also differed in digestibility.

An effect of herbage digestibility was reported by Dodsworth and Cambell (1953) who found that delay in the date of cutting of herbage led to lowered digestibility of silage. They also suggested that there exists the overall relationship
between the digestibility of herbage and that of resulting silage and methods of ensiling also affected the digestibility.

Bratager (1959) measured the energy contents of dried herbage samples and faeces. The digestibility and gross energy of the silages could then be calculated and compared with the original herbagess.

Newlander and Riddell (1957) reported a slight increase in digestibility of silage after wilting, whereas Murdeeh et al. (1955) did not find any effect on dry matter digestibility, but found a depression in crude protein digestibility.

Earlier studies (Watson and Nesh, 1960) had indicated a rather lower digestibility of the silage than the crop ensiled. In some cases, however, this may have been because of the intake of silage was based on dry matter determinations made at 100°C.

Poor conditions at the time of ensilage can lead to depressed digestibility for instance, when there are high losses of soluble constituents in effluent or when over heating and caramelization occur (Watson and Nesh, 1960; Wieringa et al., 1961).

Hay, Haylage and fresh cut silage was made at the same time from the same sward of lucerne (1957 - 1959) and the digestibility of 3 feeds was determined each year using dairy
Animal acceptance, milk production and live weight gains tended to be highest with hay and lowest with fresh cut silage. Milk production, however, was similar for both silages. The digestibility of various components of these forages was in general highest for the hay and lowest for the haylage (Gordon et al., 1961).

Owen et al. (1962) reported that a disadvantage of sorghum for silage is the low digestibility of its seed. Sterile varieties might therefore be preferable. Silages made from 2 male sterile hybrids (Rs. 303 F and Rs. 301 F) were compared in 2 feeding trials with lactating cows with silages made from Axtell sorghum, Tracysorghum and maize, and latter found to be superior in milk production.

The values for silages made from tropical grasses are often less than 60% (Miller, 1969; Miller et al., 1963). Harris and Raymond (1963) showed that the silage may suffer from considerable losses of volatile constituents during oven drying. This leads to an underestimate in the amount eaten and in the measured digestibility. These authors measured the free dry matter content of silage by toluene distillation and showed almost identical digestibilities for the silage and the original crop. In the same year Harris (1963) also found that the digestibility of maize silage was very similar to that of the fresh crop and Johnson and McClune (1968) found that
digestibility of maize silage cut at increasing stages of maturity to be 65.3 per cent, 71.9 per cent and 69.8 per cent in line with the expected change in crop digestibility.

In this experiment voluntary intake was closely related to silage digestibility (h2.9, 58.9 and 54.0 g/ w0.75 kg, respectively), but this has not been found with unwilted grass silage (Harris and Raymond, 1963).

Verma (1971) determined the digestibility coefficients of dry matter energy and ADF of the silage prepared from Vidisha 60-1 variety of jowar and found the values as h6.2; 72.9 and 45.0 per cent, respectively.

In two instances ensiling considerably reduced digestibility percentage. In northern New South Wales, IM digestibility fall from 64% to 6% during ensiling of Pennisetum clandestinum (Holder and L., 1964). Corresponding figures before and after ensiling for Paspalum dilatatum were 60 and 51 per cent in Queensland (Levitt and O'Bryan, 1965). The fall in digestibility for P. clandestinum might have been over estimated as no correlation was made for losses of IM during oven drying of the silage, however, this correction was made for P. dilatatum. The above reductions are apparently much larger than would be expected with temperate herbage (Raymond, 1969).
Tocchini (1966) reported that maize ensiled with urea increased the CP content of silage and improved CP digestibility.

A small decrease in dry matter digestibility might also occur when forage is wilted before ensiling. Thus Harris et al. (1966) found a mean dry matter digestibility of 63.9 per cent for a number of wilted silage samples (26 to 54 per cent dry matter) compared with 66.3 per cent for the unwilted silage from the same crop (16 to 23 per cent dry matter); Schulz and Osalage (1967) found a similar fall in digestibility with some silage samples, but concluded that this did not necessarily result from wilting.

Dijkstra (1966) reported that the nutritive value of silage of early cut oat fodder was similar to that of green but the nutritive value of the silage of late cut oats was very low representing average loss of 44% DCP and 24% SE.

Patel et al. (1968) compared the nutritive value of jowar green, silage and hay and reported that protein from jowar green was digested to the extent of 58.9 per cent, while from silage it was only 33.6 per cent and from hay it was further low as 28.3 per cent. The ether extract was digested to the maximum extent from silage, the digestibility coefficient being 69.2 as against 67.0 and only 51.6 per cent in jowar green and hay, respectively. Crude fibre was digested to an equal
extent of about 80 per cent in all the three forms, but the digestibility of nitrogen free extract decreased gradually from jowar green to silage and hay having minimum digestibility of only 32.5 per cent. Thus it was concluded that digestible crude protein was maximum in jowar green providing as high as 3.06 kg digestible protein as compared to 1.14 kg and 0.88 kg supplied by silage and hay respectively. Silage with 3.12 kg digestible fat was found to be rich in digestible ether extract as compared to green and dry forms of the fodder with 2.45 and 1.26 kg respectively. The only constituent which was digested to a large extent from hay was crude fibre and hence it provided maximum digestible fibre as compared to other two forms. Digestible NFE and carbohydrates provided by jowar green, silage and hay were in decreasing order as observed in case of crude protein. The TDN supplied by jowar green silage and hay were 68.3, 62.2 and 49.1% respectively. They concluded that preference should be given for feeding of the animals in order of jowar green, silage and hay.

In another communication, these workers further reported (Patel et al., 1968) that silage prepared by the addition of 0.4 kg urea per 100 kg sorghum herbage (25.2% DM) contained 57.6% TDN and 5.7% DCP compared with 62.2% and 1.1% respectively for silage made without urea. The coefficient of digestibility of all nutrients except for CP were slightly lower in the urea treated than in the untreated silage.
Miaki (1968) applied 0, 0.6 and 1 kg N (as ammonium sulphate) 1.2 kg P2O5 and 1 kg K2O per 100 m² of hybrid sorghum. Digestion trial with 2 sheep showed that digestibility of CP and to a lesser extent that of crude fat increased with increasing rates of N. Variation in applied nitrogen did not effect the digestibility of DM, NFE, or CF. TDN content was 55.5, 54.3 and 57.1% and that of DCP 2.4, 3.3 and 6.3% for 0.06 and 1 kg N/100 m², respectively. N application therefore had a greater effect on DCP than on TDN in sorghum silage.

Boin et al. (1968) studied the digestibility of the proximate constituents of maize, sorghum and Napier grass silage using the total collection method. TDN in the original material were 17.9, 15.4 and 11.4% for maize sorghum and Napier grass respectively. TDN in maize silage was significantly higher than in the other two silages. DM content was 28.3, 25.5 and 20.4% respectively. On dry matter basis there were no statistical differences in TDN among the silages being 63.0, 60.2 and 55.7% respectively. DCP contents were 3.0, 1.0 and 3.7% respectively.

Balwani et al. (1969) evaluated green chop and ensiled sorghum along with other forages, using digestion trials in sheep and reported that the digestibility of corn silage dry matter or organic matter was higher than the digestibilities of these components in either of the sorghum silages (grain type or forage type). In fact, the sorghum silages tested in
these trials resembled corn stover silage more closely and it was interesting that the digestibility of dry matter for the forage type sorghum silage was actually higher than that for the grain type sorghum silages. The dry matter, organic matter, cellulose and crude protein content of the grain type sorghum was found to be 24.5, 94.8, 26.6 and 10.1 per cent respectively, as compared to 31.9, 95.9, 3.4 and 7.6 in the case of forage type sorghum. The digestibility of DM, OM, cellulose and CP were 51, 53, 46 and 36 per cent for grain type and 55, 56, 53 and 55 for forage type respectively.

In trials 1967, 8 lactating cows were fed with fresh herbage or silage from maize or sorghum, each with supplements, and digestibility trials were carried out. Mean digestibility values of maize and sorghum were 70.2 and 61.6%; total DM intake 19.8 and 21.3 lb/head per day and DDM intake 14.3 lb and 13.2 lb/head per day respectively. Cows fed on maize tended to produce more milk than did those fed sorghum, but the effect of the low digestibility could be overcome by feeding 21 lb concentrate/day per 1000 lb body weight (Gill et al., 1970).

Melotti and Boin (1969) determined the nutritive value of the silage of sorghum (S. vulgare) CV. Santa Eliza in a trial on digestibility (apparent) with cattle. pH value of the silage was 3.8. The silage contained 22.9% DM and 5,573 Kcal gross energy/g DM. Average digestibility coefficients were: DM 57.2%;
GP 13.5%; CP 66.6%. The TIN values were 62.9% on DM basis and 11.4% for the fresh material.

A trial was carried out to study the digestibility of the silage from sorghum CV Santa Elisa harvested at (a) 15 (b) 17 (c) 19 (d) 21 or (e) 23 weeks after sowing. DM content of the silage increased with age of the harvest material being (a) 26.3% (b) 31.6% (c) 32.1% (d) 36% and (e) 41.1%. The CP content decreased from 8.1% in (a) to 5.5% in (d) whereas the CF content varied little. TIN values of the DM were (a) 52% (b) 60.4% (c) 52.9% (d) 52.8% and (e) 52.2%. Contents of DCP were (a) 2.2% (b) 2.3% (c) 1.5% (d) 1.1% and (e) 1.1%. Results indicated that the (b) was the optimum cutting date (Helotti et al., 1969).

Patel and Dave (1972) reported that ensiling of sorghum forage cut at the flag leaf stage resulted in loss of 4.86% of the DM; 37.64% CP, 11.31% NFE and 52.13% of the carotene.

Bhatia and Talapatra (1968) determined the digestibility of green jowar, silage and hay made out of it. The digestibility coefficients of different nutrients for the green jowar were 57.9 ± 1.4; 40.0 ± 3.1; 15.7 ± 3.1; 58.6 ± 1.9, 63.0 ± 0.6 and 61.3 ± 0.6 per cent respectively for dry matter, crude protein, ether extract, crude fibre, nitrogen free extract and total carbohydrates. The corresponding digestibility coefficients of these nutrients in the case of silage were 46.5 ± 0.9;
26.8 ± 0.6; 36.0 ± 1.8; 60.0 ± 1.8; 50.0 ± 3.0 and 53.8 ± 0.6 per cent, respectively. Silage showed least dry matter and crude protein digestibility than the green jowar. The crude protein digestibility of silage was found to be as low as 54% than the green jowar. The DCP, SE and TDN were 0.47 ± 0.0; 9.89 ± 0.5 and 15.56 ± 0.5 per cent for the silage as compared to 0.87 ± 0.1; 15.75 ± 0.1 and 23.82 ± 0.5 per cent for DCP, SE and TDN in the green forage.

Gaffar and Kaduskar (1972) reported that the digestibility coefficient of crude protein in green jowar was 33.4% while the figure for the silage was 25.1%. Crude fibre digestibility in green jowar and silage was 64.6 and 67.0%, respectively. NFE digestibility decreased from green jowar (54.28) to silage (53.32) as was observed by Patel et al. (1968). Digestible crude protein in green jowar was maximum providing 1.92 kg as compared to 1.17 kg by silage. The TDN supplied by green jowar and silage were 52.75 and 52.47 kg respectively, on dry matter basis.