THE NUTRITIVE VALUE
OF SOME AGRICULTURAL
BY-PRODUCTS

S. ECONOMIDES AND D. HADJIDEMETRIOU

AGRICULTURAL RESEARCH INSTITUTE
MINISTRY OF AGRICULTURE AND NATURAL RESOURCES

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ABSTRACT

The chemical composition, the in vivo and in vitro digestibility for dry matter, organic matter and crude protein of citrus peels, citrus pulp, grape marc, vine canes, acacia leaves (Acacia cyanophylla), carob meal and barley straw were determined. The in vivo digestibility coefficients were measured using vasectomized rams and the in vitro with the method proposed by Tilley and Terry (1963). From the digestible organic matter energy values were calculated for each feedingstuff.

Generally all tested feedingstuffs were poor in protein and phosphorus and high in calcium content. The fat content of grape marc and certain minerals in acacia leaves were particularly high. The in vivo and in vitro methods gave results which were in close agreement.

The in vivo digestibility coefficients for dry matter were 67, 92, 28, 20, 32, 56 and 48% for citrus peels, citrus pulp, grape marc, vine canes, acacia leaves, carob meal and barley straw, respectively. Corresponding in vitro DMD values were 91, 91, 22, 28, 49, 60 and 46%. Values for the in vivo digestibility of crude protein were 15, 65 and 19% for citrus peels, citrus pulp and grape marc respectively and none for vine canes, acacia leaves, carob meal and barley straw.

The metabolizable energy in Kcal/kg dry matter of the feedingstuffs tested were: 2,350, 3200, 1,030, 750, 1,090, 2,050, 1,800 for fresh citrus peels, citrus pulp, grape marc, vine canes, acacia leaves, carob meal and barley straw respectively.

INTRODUCTION

The necessity of increasing livestock production is of paramount importance to the economy of Cyprus. Many problems confront the development of livestock, one of which is shortage of roughage and the high cost of imported feed.

The potential value of a food for supplying a particular nutrient can be determined by chemical analysis, but its actual nutritive value to the animal can be arrived at only after making allowances for the inevitable losses that occur during digestion, absorption and metabolism. From these three losses, those occurring during digestion are the main determinants of the nutritive value of the food.

Ruminants can utilize a wide range of feedingstuffs including agricultural by-products like cereal straw, citrus pulp and grape marc. Extensive work has been published on the use of some by-products particularly dried citrus pulp (Cunha, 1973; Sanchez, 1969; Cottyn and Boucque, 1969; Maymone and Datillo, 1958; Garcia et al., 1953) and cereal straw (Morrison, 1959; McDonald et al., 1969;)

(*) Assistant Agricultural Research Officers.
N.R.C., 1971) which is used widely either for bedding or feeding in various forms (long, chopped and ground). To our knowledge no work has been published on the feeding value of vine canes and Acacia cyanophylla leaves.

The objective of this work was to determine the chemical composition, the in vivo and in vitro digestibility of citrus peels, dried citrus pulp, grape marc, carob meal, vine canes, acacia leaves and barley straw.

**MATERIALS AND METHODS**

**In vivo experiment**

Six Chios and two Chios x Awassi vasectomized rams between 1½ and 2½ years old and weighing 70—75 kg were used.

The animals were found to be free from gastrointestinal parasites. They were housed individually in metabolic crates designed for the separate collection of urine and faeces. All animals were given a basic ration consisting of 50% chopped straw, 37% crushed barley, 11% soybean meal and 2% dicalcium phosphate, at a rate calculated to provide approximately 90% of the energy requirements for maintenance for each individual animal. The protein content of the basic ration as fed was 10.8%.

The digestibility of the basic ration was determined first with eight animals. Subsequently each feedingstuff under test was given to four animals together with the basic ration, but in a different feeding trough at quantities between 20—27% of the total dry matter of the mixed ration. The basic ration was offered in two meals and the feedingstuff under test was given with the morning meal. Water was given three times daily.

For each digestibility trial there was a preliminary period of eight days followed by a six day collection period.

Sub-samples from the ingredients of the basic ration were taken at the first and the sixth day of the collection period and representative samples were prepared and analysed for dry matter, nitrogen, crude fibre, crude fat, ash and mineral elements. The same procedure was followed for four of the tested feedingstuffs. For citrus peels, acacia leaves and vine canes, representative samples were taken on the first, third and sixth day of the collection period. Faeces were collected twice daily and kept in a deep freeze at −20° C until the end of each collection period. The daily faecal output of each animal was bulked and a representative sample from the six day collections for each animal was prepared and mixed thoroughly. Three samples for each animal were analysed for dry matter and ash after drying at 100° C. Nitrogen was determined in fresh faeces.

For the estimation of the apparent digestibility the calculation by difference of the digestion coefficients of the particular feed as a part of the mixed ration was used (McDonald et al., 1969). The calculation is as follows: A known quantity of a ration is given in a first trial for which the digestibility is determined i.e. feed intake and faecal output are measured accurately. In a second trial a known quantity of the feedingstuff under test is given in combination with the ration of the first trial. If the daily dry matter intake would increase by 300 g and if the output of faecal dry matter increased by 90 g, the digestibility of the dry matter in the tested material could be calculated as:

\[
\frac{300 - 90}{300} \times 100 = 70\%
\]
The following terms were used for the *in vivo* digestibility coefficients:

- **D.M.D.** = Dry matter digestibility (%) = \[
\frac{\text{Dry matter intake - Dry matter in faeces}}{\text{Dry matter intake}} \times 100
\]

- **O.M.D.** = Organic matter digestibility (%) = \[
\frac{\text{Organic matter intake - organic matter in faeces}}{\text{Organic matter intake}} \times 100
\]

- **D.O.M.D.** = Digestibility of organic matter in the dry matter (%) = \[
\frac{\text{Organic matter intake}}{\text{Dry matter intake}} \times \frac{\text{Organic matter}}{\text{Dry matter}} \times 100
\]

- **D.C.P.** = Digestibility of crude protein (%) = \[
\frac{\text{Protein intake - protein in faeces}}{\text{Protein intake}} \times 100
\]

- **T.D.N.** = Total Digestible Nutrients (%) = \[
\frac{\text{D.O.M.D. x Dry matter}}{\text{Dry matter intake}} \times 100
\]

- **ME** = Metabolizable Energy (Kcal)

1 Kg T.DN = 3.6 Mcal ME (N.R.C. 1971)

**F.U.** = Scandinavian Feed Unit

1 F.U. = 1 kg barley.

*In vitro method*

The *in vitro* digestibility procedure followed is essentially similar to that proposed by Tilley and Terry (1963). It comprises an initial 48-hour rumen microbial digestion followed by a 48-hour pepsin-hydrochloric acid digestion at 38°C. About one litre of rumen liquor was withdrawn from four fistulated sheep for the first stage digestion. After the second stage of digestion the residue, considered to be indigestible was recovered by filtration through fibre glass paper as suggested by Alexander and McGowan (1961).

**Chemical methods of analysis**

Samples of citrus peels, acacia leaves and vine canes were chopped and dried at 65°C for 48-hours. All samples were ground in an Apex cutter mill and passed through a 2 mm screen. Proximate analyses and the determination of potassium, sodium, calcium, magnesium and phosphorus were carried out according to standard procedures (A.O.A.C., 1960).

Trace element determinations were carried on samples as received without any preliminary washing to remove possible contaminants. Cobalt and molybdenum were determined colorimetrically using a Beckmann double beam Spectrophotometer (The Society of Analytical Chemistry, 1963). The rest of the trace elements were determined in a Jarrell Ash atomic absorption spectrophotometer (Ramirez-Munoz, 1968).

**RESULTS**

The chemical composition (dry matter, crude protein, crude fibre, crude fat, ash, nitrogen free extractives and major and trace minerals) of the feedingstuffs used for the digestibility trials is shown in Table 1.
### Table 1: The Chemical Composition of Some Agricultural By-Products

<table>
<thead>
<tr>
<th>Dry matter</th>
<th>Crude protein</th>
<th>Crude fibre</th>
<th>Ether extract</th>
<th>Ash</th>
<th>Nitrogen-free extracts</th>
<th>Ca</th>
<th>P</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>Cu</th>
<th>Mn</th>
<th>Fe</th>
<th>Zn</th>
<th>Mo</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus peels</td>
<td>15.1</td>
<td>6.0</td>
<td>12.7</td>
<td>1.5</td>
<td>4.1</td>
<td>75.7</td>
<td>0.84</td>
<td>0.08</td>
<td>0.12</td>
<td>0.29</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>89.7</td>
<td>6.4</td>
<td>13.2</td>
<td>1.5</td>
<td>7.1</td>
<td>71.8</td>
<td>2.05</td>
<td>0.11</td>
<td>0.29</td>
<td>0.20</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grape marc</td>
<td>92.5</td>
<td>12.3</td>
<td>35.4</td>
<td>8.5</td>
<td>4.6</td>
<td>39.2</td>
<td>0.81</td>
<td>0.22</td>
<td>0.15</td>
<td>0.26</td>
<td>1.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vine canes</td>
<td>72.0</td>
<td>4.1</td>
<td>40.5</td>
<td>0.9</td>
<td>3.8</td>
<td>50.7</td>
<td>0.77</td>
<td>0.10</td>
<td>0.15</td>
<td>0.22</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acacia</td>
<td>28.3</td>
<td>16.0</td>
<td>16.6</td>
<td>2.2</td>
<td>14.0</td>
<td>51.2</td>
<td>3.79</td>
<td>0.13</td>
<td>0.52</td>
<td>0.33</td>
<td>1.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carob meal</td>
<td>91.4</td>
<td>4.0</td>
<td>8.1</td>
<td>0.5</td>
<td>2.9</td>
<td>84.5</td>
<td>0.47</td>
<td>0.07</td>
<td>0.08</td>
<td>0.12</td>
<td>1.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley straw</td>
<td>92.7</td>
<td>3.8</td>
<td>41.7</td>
<td>2.2</td>
<td>5.5</td>
<td>46.8</td>
<td>0.33</td>
<td>0.05</td>
<td>0.10</td>
<td>0.17</td>
<td>1.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Concentration of element or substance on a dry weight basis.
The dry matter content of citrus peels and acacia leaves were low 15 and 28% respectively and of vine canes high (72%). The dry matter of the other feedingstuffs were around 90%. The protein content of all feedingstuffs was low (4–6%) except for acacia leaves and grape marc, 16.0 and 12.3%, respectively. The crude fibre content was high i.e. 41.7, 40.5 and 35.4% in barley straw, vine canes and grape marc respectively, and low in other tested feedingstuffs. The crude fat content of grape marc was high 8.5%. The ash content was particularly high (14%) in acacia leaves.

The calcium content was particularly high in acacia leaves (3.8%) and dried citrus pulp (2.0%) but in general it was high in all feedingstuffs. The phosphorus content was low in all tested feedingstuffs except grape marc (0.22%). The magnesium content was high in acacia leaves (0.5%) and dried citrus pulp (0.3%). The copper content was high in grape marc (24.5 ppm) and acacia leaves (16.6 ppm). Manganese and zinc were high i.e. 105 and 35 ppm in acacia leaves and 46 and 47 ppm in vine canes respectively. Manganese was also high in barley straw (38 ppm). Molybdenum was high in acacia leaves (2.35 ppm).

The in vivo digestibility coefficients of dry matter, organic matter and protein of the basic ration and of the mixed rations (when tested feedingstuffs were given along with the basic ration) are shown in Table 2. From this table it could be seen that the addition of vine canes, grape marc and acacia leaves caused a depression of the digestibility of dry matter and organic matter of the basic ration. The digestibility of protein of the basic ration was reduced also in all cases but the depression was considerably high when acacia leaves, carob meal and grape marc were added in the ration.

### Table 2.—Mean Values of In Vivo Digestibility Coefficients of the Basic and Mixed Rations

<table>
<thead>
<tr>
<th></th>
<th>D.M.D.</th>
<th>O.M.D.</th>
<th>D.O.M.D.</th>
<th>D.C.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic ration</td>
<td>63.6</td>
<td>66.6</td>
<td>61.1</td>
<td>70.8</td>
</tr>
<tr>
<td>Citrus peels</td>
<td>63.8</td>
<td>66.6</td>
<td>61.8</td>
<td>65.3</td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>69.9</td>
<td>73.9</td>
<td>68.0</td>
<td>62.9</td>
</tr>
<tr>
<td>Grape marc</td>
<td>53.2</td>
<td>55.3</td>
<td>51.3</td>
<td>57.1</td>
</tr>
<tr>
<td>Vine canes</td>
<td>52.2</td>
<td>55.0</td>
<td>51.1</td>
<td>61.7</td>
</tr>
<tr>
<td>Acacia leaves</td>
<td>57.2</td>
<td>60.3</td>
<td>54.6</td>
<td>52.7</td>
</tr>
<tr>
<td>Carob meal</td>
<td>61.1</td>
<td>64.2</td>
<td>59.8</td>
<td>54.7</td>
</tr>
<tr>
<td>Barley straw</td>
<td>59.6</td>
<td>62.8</td>
<td>58.1</td>
<td>61.5</td>
</tr>
</tbody>
</table>

The corresponding in vivo and in vitro digestibility coefficients of the tested feedingstuffs are shown in Table 3. The digestibility coefficients of protein for citrus peels, citrus pulp and grape marc were 15, 65 and 19% respectively and none for the other tested feedingstuffs.
### Table 3.—MEAN VALUES OF IN VIVO AND IN VITRO DIGESTIBILITY COEFFICIENTS OF SOME AGRICULTURAL BY-PRODUCTS

<table>
<thead>
<tr>
<th></th>
<th>D.M.D.</th>
<th>O.M.D.</th>
<th>D.O.M.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus peels</td>
<td>67.0</td>
<td>91.4</td>
<td>68.8</td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>91.9</td>
<td>91.0</td>
<td>96.0</td>
</tr>
<tr>
<td>Grape marc</td>
<td>28.4</td>
<td>21.6</td>
<td>29.7</td>
</tr>
<tr>
<td>Vine canes</td>
<td>19.9</td>
<td>28.1</td>
<td>21.8</td>
</tr>
<tr>
<td>Acacia leaves</td>
<td>31.8</td>
<td>49.2</td>
<td>35.5</td>
</tr>
<tr>
<td>Carob meal</td>
<td>56.0</td>
<td>60.5</td>
<td>58.7</td>
</tr>
<tr>
<td>Barley straw</td>
<td>48.2</td>
<td>45.9</td>
<td>52.6</td>
</tr>
</tbody>
</table>

From the in vivo digestibility coefficients the energy value of each feedingstuff was expressed in different energy systems and are shown in Table 4. Dried citrus pulp had the highest energy value (3.20 Mcal/kg D.M.), citrus peels 2.35 Mcal/kg D.M. and vine canes the lowest energy value 0.75 Mcal/kg D.M.

### Table 4.—THE ENERGY CONTENT OF FEEDS EXPRESSED IN TOTAL DIGESTIBLE NUTRIENTS (T.D.N.), FEED UNITS (F.U.) AND METABOLIZABLE ENERGY (ME)

<table>
<thead>
<tr>
<th></th>
<th>As fed</th>
<th>Dry basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T.D.N. (%)</td>
<td>F.U.</td>
</tr>
<tr>
<td>Citrus peels</td>
<td>9.8</td>
<td>0.13</td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>80.3</td>
<td>1.03</td>
</tr>
<tr>
<td>Grape marc</td>
<td>26.4</td>
<td>0.34</td>
</tr>
<tr>
<td>Vine canes</td>
<td>15.0</td>
<td>0.19</td>
</tr>
<tr>
<td>Acacia leaves</td>
<td>8.8</td>
<td>0.11</td>
</tr>
<tr>
<td>Carob meal</td>
<td>52.1</td>
<td>0.68</td>
</tr>
<tr>
<td>Barley straw</td>
<td>46.3</td>
<td>0.58</td>
</tr>
</tbody>
</table>

### DISCUSSION

**Dried citrus pulp and citrus peels**

Both dried citrus pulp and citrus peels were low in protein and phosphorus. The addition of lime where in the drying process of citrus peels to facilitate water extraction usually results in high calcium and magnesium content in dried citrus pulp. The values obtained for the different chemical constituents were within the range reported by Cunha (1973), Sanchez (1969), Coutyn and Boucquie (1969), Maymonne and Duttilo (1958) and Garcia et al. (1953). The crude fibre content of both citrus pulp and citrus peels was around 13% and on their crude fibre content they are generally considered as concentrate feedstuffs.
The in vivo and in vitro results of digestibility for dried citrus pulp were in excellent agreement (Table 3). In studies with sheep Sanchez (1969) reported for dried citrus pulp D.M.D. and O.M.D. values of 64 and 74%, respectively, whereas Cotyn and Bouque (1969) a D.M.D. value of 84%. The digestible protein content in the dry matter was 4.05%. Corresponding values reported by other workers for citrus pulp are as follows: 3.90 (N.R.C., 1971), 3.50 (Min. Agr. Israel), 4.25 (Cunha, 1973), 2.70 (Sanchez, 1969), 3.11 (Cunha and Bouque, 1969). The metabolizable energy (ME) per kg dry matter was 3.20 Mecal or 1.03 F.U. ME values reported for citrus pulp by N.R.C. (1971) and Cunha (1973) were 2.86 and 2.90 Mecal or 0.91 F.U. (Min. Agr. Israel).

The in vivo digestibility of citrus peels was lower by about 20 units than the corresponding in vitro value, although the in vitro digestibility for both citrus peels and citrus pulp were identical. The difference may be due either to an over-estimation of the digestibility by the in vitro method, the procedure of which involves drying of citrus peels before running the digestibility test, or to sampling error for dry matter determination leading to an underestimate of dry matter intake by the animals and thus underestimate of the digestibility. Maymone and Dattilo (1958) reported that there was little difference in the digestibility of citrus peels from orange, lemon or pergamon, when fed to sheep and found an O.M.D. value of 92%. The digestible protein content in the dry matter was 0.9%, because of the low digestibility coefficient (15%). This value is lower than the reported 2.4 (Maymone and Dattilo, 1958), 3.5 (Min Agr. Israel) and 1.8 for citrus silage (N.R.C., 1971). The ME value was 2.35 Mecal or 0.13 F.U. in comparison with 3.30 Mecal for citrus silage (N.R.C., 1971) and 0.18 F.U. for citrus peels (Min. Agr. Israel).

Grape marc

The crude protein, crude fibre and crude fat content of grape marc were high. It was also high in calcium and copper. These results are in close agreement with those of Tretjakow (1970) and Sandila (1971).

The in vitro digestibility values were 7—10 units lower than the in vivo values. This difference is due to the high fat content of grape marc which affects the results of the in vitro method. With the in vitro method the digestible fat is not included in the total digestible nutrients, since its digestion takes place in the small intestine. It is also possible that the digestibility of cellulose is depressed under the conditions of the in vitro determination.

The in vivo coefficients of digestibility for dry matter, organic matter and protein were 28.4, 29.7 and 19.5%, respectively. Corresponding values reported with sheep by Sanchez (1971) were 32, 32 and 21.7%. The digestible protein in the dry matter was 2.3%, compared with 2.55, 1.90 and 2.8% reported by Sanchez (1971), Tretjakow (1970) and Dzinic (1969). The energy content was 1,030 Kcal ME/kg dry matter, 26.4% T.D.N., 0.35 F.U. and 25.2% starch equivalent. Corresponding values reported by other workers were 1,450 Kcal (Sanchez, 1971), 40.3% T.D.N. (Sanchez, 1971), 0.24 F.U. (Tretjakow, 1970) and 21.5 Starch equivalent (Maymone & Salerno, 1945). Thus the energy value of grape marc appears to be similar with that reported by Tretjakow (1970) and Maymone & Salerno (1945) and lower than that reported by Sanchez (1971). However, there was a close agreement between the coefficient of digestibility of organic matter in this work and that reported by Sanchez, 29.7 and 32%, respectively.

Most of the difference is due to the method of estimation of the T.D.N. value. Sanchez estimated the T.D.N. value from the digestibility coefficients of all energy
yielding materials in grape marc, whereas in this work it was estimated from the digestible organic matter in the dry matter. In view of the high fat content in grape marc and the high energy value of fat it is considered that Sanchez’s estimation is more accurate.

**Carob meal**

The chemical composition of carob meal was within the range of values reported by Maymone & Battaglini (1951), Binder et al. (1959), Alumot et al. (1964) and Charalambous et al. (1966). The in vivo and in vitro D.M.D. and O.M.D. coefficients (Table 3) were in excellent agreement. There were no similar values in the literature for comparison. The digestibility of protein was found to be zero. Similar values were reported by Neto (1964), Ministry of Agriculture Israel and Maymone and Battaglini (1951). The energy value of carob meal was 2.05 Mcal ME/kg D.M. or 0.68 F.U. Reported values in the literature are 0.77 (Min. Agr. Israel), 0.63 (Maymone and Battaglini, 1951), and 0.60 F.U. (Neto, 1964).

**Straw**

The chemical composition of barley straw was typical of cereal straws, low in protein and phosphorus and high in crude fibre. The in vivo dry matter digestibility coefficient of barley straw was 48% compared to 46% obtained by the in vitro method. Other in vitro results for barley straw obtained at this Institute expressed in D.M.D., O.M.D. and D.O.M.D. varied between 46—55, 45—54 and 42—47, respectively. The digestible protein was zero. A value of 0.5% is given by N.R.C. (1971) and values from 0.9% to —0.8% by McDonald et al. (1969) and zero in Israel (Min. Agr. Israel). The energy value was 1.80 Mcal ME/kg dry matter compared with 1.71 (N.R.C., 1971) 1.76 (A.R.C., 1965) and 1.68 to 1.78 (McDonald et al., 1969).

**Acacia leaves**

The chemical composition of acacia leaves were very high in certain major and trace elements. Though there was a difference of 17 units in the D.M.D. values between the in vivo and in vitro methods, this difference was reduced to 7 and 5 units, in the O.M.D. and D.O.M.D. values respectively. The latter is the more accurate estimate of the energy value of a certain food and here too the in vivo and in vitro results in close agreement. The protein digestibility was zero and the energy value 1.09 Mcal ME/kg dry matter.

**Vine cones**

The crude fibre content was high. The O.M.D. and D.O.M.D. values obtained with the in vivo and in vitro methods were again in close agreement. The protein digestibility was zero and the energy value 0.75 Mcal ME/kg dry matter.

**The in vitro digestibility method**

The determination of the digestibility of feedingstuffs using animals (in vivo method) is the standard procedure. However, this method is time consuming and rather expensive and other methods such as the in vitro have been tried to overcome these disadvantages. The most reliable in vitro method from which the digestibility of feedingstuffs can be predicted with considerable accuracy is that of the “artificial rumen”, in which the conditions pertaining in the rumen and the abomasum of the live animal are simulated in the laboratory. This method has been successfully used for the determination of the digestibility of forage crops and equations have been derived from which in vivo digestibility coefficients can be predicted from in vitro values (O’Shea and Wilson, 1965; Tilley and Terry, 1963; and Joshi, 1972).
The results obtained in this study for citrus pulp compare closely with those of other workers and it is suggested that the metabolizable energy be taken to be 3,000 Kcal per kg dry matter and the digestible protein as 9% (barley grain 3,100 Kcal ME and 8% DCP).

In contrast, the energy content and digestible protein of fresh citrus peels were found to be lower than reported in the literature. However, in actual practice the differences are insignificant because the proportion of dry matter intake from citrus peels in the total ration is very low. Feeding fresh citrus peels directly to the animals presents a number of difficulties in preservation, transportation and disposal which may be overcome either by drying or proper ensiling.

The energy value of grape marc is estimated at 1,450 Kcal metabolizable energy per kg dry matter and its digestible protein at 2.3%. Because of its low energy content it is suitable for fattening animals on ad libitum feeding.

The energy value of carob meal is estimated at 0.70 F.U. and zero digestible protein, compared with 1.0, F.U. and 8.0% digestible protein for barley grain. Carob meal should be considered as a feedingsuff providing to ruminants only energy and replacing barley grain approximately at the rate of 3 parts to 2 parts with increased supplementation of protein in the diet.

Barley straw is high in energy and deficient in certain minerals and vitamins and contains no digestible protein. However, straw can play an important role to ruminant nutrition in properly balanced diets.

The contribution of vine canes and acacia leaves in ruminant feeding would remain insignificant not only because of their poor feeding value but also of the difficulties in collecting and feeding.

The results of this study showed that the in vitro method could be satisfactorily used for determining the digestibility of feedingsuffs. It would be particularly useful for obtaining approximate digestibility values for a large number of samples for farm roughages for advisory purposes: for determining the digestibility of small samples for screening plant breeding material and forage crops harvested at different cutting stages in trials designed to estimate yield, and nutritive values.

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