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A New Approach for Screening Roughages and Predicting Their Nutritive Values

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TO EXAMINE the possibility of developing quick and reliable methods for predicting the nutritive value of roughages with a reasonable degree of accuracy, sixteen roughages commonly used in livestock feeding were tested.

Chemical analysis included crude fiber fractions, gross energy (GE), In Vitro and In Situ dry matter disappearance (IVDMD and ISDMD) were determined for the different roughages.

Simple correlation coefficients were calculated between the parameters to determine the strength of the relationship between them, thus examining the limits of their use in practical application.

Wide variations in the chemical composition of different roughages were recorded i.e. the highest lignin content (19.1%) was that of cotton stalks while the lowest value was that of napier grass and darawa (3.96%).

Correlation coefficient between calculated and determined GE of different roughages was found to be $r = 0.798$.

Highly positive correlations ($P < 0.01$) were recorded between CF content and its fractions NDF ($r = 0.749$), ADF ($r = 0.910$) and ADL ($r = 0.723$).

a) ISDMA = 0.04 + 0.976 IVDMD (at 4 hr)

b) ISDMD = 0.55 + 1.13 IVDMD (at 8 hr)

c) ISDMD = 17.88 + 0.866 IVDMD (at 24 hr)

In Vitro DMD for the different roughages can be predicted from ISDMD values using the following equations.

Key words : Roughages, Nutritive values, Prediction.

In the past, proximate analysis seemed to be of great importance for evaluating the nutritive value of feedstuffs for ruminants.

Crude fiber has been and remains relatively a good indicative for feedstuffs nutritive value. It is, however, grossly misleading and involves large errors on the basis of nutritional and biochemical criteria. In searching for a replacement, there is a conflict among criteria that evaluates the analytical parameters as indicators of feedstuffs nutritive value.

The summative system (Goering and Van Soest, 1970) requires determination of cell wall fractions (cellulose, Hemicellulose, lignin, pectin and cutin).

A silica or insoluble ash correlation may also be needed. For a single measurement of digestibility in mixed populations, the Tilley and Terry (1963) In Vitro procedure or its modification remains the most accurate measure.

The present work was carried out to determine the crude fiber fractions of roughages a long with their gross chemical composition. Correlations were then examined between the different chemical components of roughages and their nutritive value in an attempt to examine the possibility of developing a quick method for predicting the nutritive value of these roughages with a reasonable degree of accuracy.

Material and Methods

This study was carried out at the Animal and Poultry Nutrition and Production Laboratory of the National Research Centre, Cairo and the experimental farm of the Animal Production Department or the Faculty of Agriculture, Ain Shams Univ., Shoubra El-Kheima.

Sixteen samples representing 13 roughages were tested. These were 1 — Berssem (Trifolium Alexandrium) 1st and 2nd cuts 2 — Napier grass (Pennisetum pureum) 2nd and 3rd cuts 3 — Peanut hay 4 — Darawa (Zea mays, L.) 5 — Sudan grass (Sorghum vulgare Var. Sudeneuse, Hitche) 1st and 2nd cuts 6 — Rice straw 7 — Maize stalks 8 — Bean straw (Vicia Faba) 9 — Corn cobs 10 — Sugar Cane Bagasse 11 — Wheat straw 12 — Cotton stalks 13 — Bean hulls (*Vicia Faba*). Samples were collected from 3 Governorates *i.e.* greater Cairo, Giza and Kalubia. Five samples of each ingredient from the same location were mixed together, blended and representative samples were take for analysis.

The chemical composition was determined according to A.O.A.C., 1965. Gross energy was calculated from the proximate analysis and determined by an adiabatic Bomb Calorimeter and CF fractions were adopted according to Goering and Van Soest, 1970. In Vitro dry matter disappearance (IVDMD, Norris *et al.*, 1976) and In Situ dry matter disappearance (ISDMD, Mehrez and Qrskov, 1977) techniques were carried out to determine the rate of degradation of these roughages.

Correlations are calculated between :

(a) Calculated and determined gross energy.
(b) Crude fiber content and it's fractions.
(c) IVDMD or ISDMD and chemical composition including CF fractions
(d) IVDMD and ISDMD.

Statistical analysis was done according to Snedecor and Cochran (1967). Simple correlations were calculated and when the correlation coefficients (r) were found to be significant, the regression coefficients (b) were computed then the prediction equation was established if (r) was more than 0.70.

Results

1. *Proximate analysis, combustible and calculated gross energy.*

Proximate analysis, combustible and calculated gross energy (GE) of roughages used in this study are shown in Table 1.

Crude protein (CP) ; crude fiber (CF) and nitrogen free extract (NFE) ranged from 3.10% to 20.8% ; 18.6% to 50.0% and 30.7% to 55.2%, respectively.

Legume, fresh and dry had higher CP (18.6 - 30.6 than non-legume such as straws and hulls. Similar values have been reported by Abou-Raya (1967) and Singh *et al.*, (1976).

Calculated gross energy (X) were significantly correlated (r = 0.798) with combustible energy (y), therefore a regression equation for predicting GE from chemical analysis was computed and found to be :

$$Y = 0.47 + 0.878 \times$$

2. *Fractions of the crude fiber contents*

Data concerning NDF (cellulose, hemicellulose and lignin), ADF (ligno-cellulose), ADL, and silica content of roughages used are presented in Table (2).

Highest values for NDF were recorded for corn cobs (82.2%) and cotton stalks (70.7%), while bean hulls and cotton stalks had the highest ADF (64.2% and 52.0% respectively). Cotton stalks and bean-hulls had the highest ADL content, being 19.1% and 15.5%, respectively. Peanut hay, dried napier grass (3rd cut) and dried darawa or dried napier grass (2nd cut) had the lowest NDF, ADF and ADL, being 36.1%, 25.9% and3.96%, respectively.

TABLE 1. Proximate chemical analysis; combustible and calculated gross energy of the different roughage sources (DM basis*)

Feedstuff	DM %	Ash %	CP %	EE %	CF %	NFE %	GE (KCal/g. DM)	
							Combustible	Calculated[2]
Berseem[1]								
1st cut	95.5	28.3	19.2	3.21	18.6	30.7	3.48	3.43
2nd cut	94.3	17.5	19.4	4.08	22.7	36.3	3.95	3.93
Napier grass[1]								
2nd cut	95.5	18.2	19.6	1.18	24.0	37.0	3.78	3.75
3rd cut	95.8	18.7	20.8	1.00	23.5	36.0	3.75	3.74
Peanut hay	95.8	14.5	11.7	4.10	26.4	43.3	3.76	3.94
Darawa[1]	95.1	13.2	11.7	0.92	30.5	43.7	4.06	3.83
Sudan grass[1]								
1st cut	94.7	12.7	11.1	2.51	32.7	41.0	4.04	3.92
2nd cut	94.8	13.5	13.0	2.20	30.6	40.7	3.85	3.90
Rice straw	96.8	18.2	6.08	1.89	31.2	42.6	3.59	3.58
Maize stalks	94.8	10.6	3.10	0.71	33.0	52.6	3.87	3.79
Bean straw	98.0	13.0	6.22	0.86	33.0	46.9	3.73	3.75
Corn cobs	95.6	3.56	4.59	1.20	35.5	55.2	4.27	4.14
Bagasse	93.5	4.27	3.40	3.85	39.0	49.5	3.90	4.23
Wheat straw	97.7	12.9	3.68	1.98	41.3	40.1	3.59	3.77
Cotton stalks	94.6	4.41	6.52	0.66	47.0	41.4	4.29	4.10
Bean hulls	92.9	3.41	5.36	0.73	50.0	40.5	4.06	4.13
Overall mean	95.3	12.9	10.3	1.94	32.4	42.3	3.87	3.87

* Values in the Table were arranged according to their CF content; from low to high.
1) Dried in an oven at 60°C for 48 hrs.
2) Each g. CP = 5.65 Kcal; g. EE = 9.40 Kcal and g. CF & NFE = 4.15 Kcal according to Blaxter (1968).

TABLE 2. Crude fibre; NDF; ADF; ADL; hemicellulose; cellulose and silica content of the different roughage sources (DM basis).

Feedstuff	CF	NDF-ash	ADF-ash	ADL	Hemicellulose*	Cellulose**	Silica
	%	%	%	%	%	%	%
Berseem							
1st cut	18.6	36.7	27.2	6.70	9.50	20.5	8.14
2nd cut	22.7	40.9	26.8	6.98	14.1	19.8	1.96
Napier grass							
2nd cut	24.0	50.2	29.7	3.96	20.5	25.7	2.38
3rd cut	23.5	43.3	25.9	5.92	17.4	20.0	2.17
Peanut hay	26.4	36.1	30.1	7.55	6.00	22.6	2.60
Darawa	30.5	60.7	35.2	3.96	25.5	31.2	3.39
Sudan grass							
1st cut	32.7	58.4	35.3	5.62	23.1	29.7	3.19
2nd cut	30.6	59.3	37.4	7.18	21.9	30.2	4.18
Rice straw	31.2	59.6	38.9	5.43	20.7	33.5	8.42
Maize stalks	33.0	68.3	37.9	5.78	30.4	32.1	3.66
Bean straw	33.0	45.8	30.3	8.56	15.5	21.7	7.48
Corn cobs	35.5	82.2	43.5	10.9	38.7	32.6	2.09
Bagasse	39.0	67.8	39.8	6.00	28.0	33.8	3.58
Wheat straw	41.3	59.4	39.3	8.18	20.1	31.1	8.17
Cotton stalks	47.0	70.7	52.0	19.1	18.7	32.9	1.65
Bean hulls	50.0	69.4	64.2	15.5	5.20	48.7	2.32
Overall mean	32.4	56.8	37.1	7.96	19.7	29.1	4.09

* Hemicellulose = NDF – ADF

** Cellulose = ADF – ADL

These results were in close agreement and within the range reported by lechtenberg *et al.*, (1974); Thomas and Emery (1975); Vansoest, (1975); Koller *et al.*, (1978) and El-Serafy *et al.*, (1981 a).

Highly significant correlations were detected between CF content (x); NDF ($_1$y) ADF ($_2$y) and ADL ($_3$y). The values for (r) were 0.749; 910 and 0.723, respectively, and the prediction equations were : —

$_1Y = 19.17 + 1.16 \times$

$_2y = 3.03 + 1.05 \times$

$_3y = 0.339 \times - 3.04$

Based on the results of this particular work it was possible to predicte the NDF, ADF and ADL content of a given roughage source from their CF content. Such practice is of prime importance in practical and applied conditions as Van Soest assay is costly, time consuming and requires high technically — skilled personnel compared with the CF assay.

3. *In Vitro dry matter disappearance (IVDMD)*

Mean values for IVDMD for the different roughage samples are shown in Table 3.

TABLE 3. Average *In Vitro* dry matter disappearance (IVDMD) of the different roughage sources (DM basis)

Feedstuff	Incubation period (hrs.)			
	4	8	24	48
Berseem				
1st cut	31.8	38.7	44.7	54.7
2nd cut	32.5	38.4	45.3	55.4
Napier grass				
2nd cut	33.3	39.2	54.3	55.3
3rd cut	30.4	39.2	49.1	52.9
Peanut hay	38.3	41.6	48.2	65.2
Darawa	25.2	28.2	30.0	36.1
Sudan grass				
1st cut	27.4	31.5	34.8	44.0
2nd cut	25.3	29.6	35.4	46.6
Rice straw	11.4	13.5	23.0	31.1
Maize stalks	14.2	18.6	22.2	27.3
Bean straw	24.2	36.0	41.2	48.8
Corn cobs	16.1	17.6	22.4	26.7
Bagasse	17.8	19.0	23.4	32.5
Wheat straw	17.4	18.3	28.3	40.1
Cotton stalks	13.3	21.6	26.5	35.1
Bean hulls	7.50	8.50	13.0	20.5
Overall mean	22.9	27.5	33.9	42.0

Peanut hay had the highest IVDMD values at 4 hr (38.3%); 8 hr. (41.6%) and 48 hr. (65.2%) of incubation period, while dried napier grass (2*nd* cut) had highest IVDMD after 24 hr. of incubation (54.3%).

In general, IVDMD values increased as the period of incubation prolonged from 4 to 48 hr. As expected, dried berseem, dried green grasses, or hays had higher IVDMD values than straws, stalks, cobs or hulls.

Correlations between IVDMD and chemical composition are presented in Table (4) and summarized as follows : —

TABLE 4. Correlations and regressions recorded between IVDMD and chemical analysis of the different roughage sources.

Factors (x)		IVDMD % (Y)			
		4 hrs.	9 hrs.	24 hrs.	48 hrs.
CP%	r	0.803**	0.811**	0.837**	0.757**
	r^2	0.645	0.658	0.701	0.573
	Equation (y=a+bx)	y=11.09+1.14×	y=13.41+1.36×	y=17.63+1.57×	y=26.41+1.51×
CF%	r	-0.820**	-0.801**	-0.804**	-0.748**
	r^2	0.673	0.641	0.646	0.599
	Equation	y=50.78-0.860×	y=59.59-0.990×	y=70.19-1.12×	y=77.70-1.10×
Ash%	r	0.652**	0.662**	0.710**	0.691**
	r^2	0.425	0.438	0.504	0.478
	Equation	—	—	y=17.44+1.27×	—
NDF%	r	-0.823**	-0.845**	-0.851**	-0.902**
	r^2	0.678	0.714	0.725	0.814
	Equation	y=54.52-0.557×	y=65.81-0.675×	y=77.26-0.764×	y=00.70-0.857×
ADF%	r	-0.830**	-0.835**	-0.832**	-0.797**
	r^2	0.688	0.697	0.693	0.635
	Equation	y=50.92-0.756×	y=67.17-0.898×	y=71.32-1.01×	y=79.85-1.02×
ADL%	r	-0.521*	N.S -0.423	N.S -0.443	N.S -0.384
	r^2	0.272	0.179	0.196	0.148
	Equation	—	—	—	—
Silica%	r	N.S -0.125	N.S -0.097	N.S -0.046	N.S -0.026
	r^2	0.016	0.009	0.002	0.001
	Equation	—	—	—	—

N.S Not significant at 5 % level of probability.

* Significant at 5 % level of probability.

** Significant at 1 % level of probability.

(1) Correlations between IVDMD and both CP and ash contents were positive and highly significant ($P < 0.01$).

(2) Correlations between IVDMD and each of CF, NDF and ADF were negative and highly significant ($P < 0.01$).

(3) Correlations between IVDMD and both ADL and silica were negative and not significant.

Since the regression equations for predicting IVDMD varied according to the strength of r and r^2 also IVDMD is affected strongly by specific chemical components in roughages, namely CP % and CF %.

4. *In Situ dry matter disappearance (ISDMD)*

Mean values for ISDMD for the different roughage samples at different incubation periods are shown in Table 5.

TABLE 5. Average In Situ dry matter disappearance (ISDMD) of the different roughage sources (DM basis).

Feedstuff	Incubation period (hrs.)			
	4	8	24	48
Berseem				
1st cut	36.1	57.5	69.7	76.2
2nd cut	38.8	60.1	66.2	76.8
Napier grass				
2nd cut	24.3	41.1	53.3	57.3
3rd cut	30.6	38.2	67.9	74.5
Peanut hay	40.3	41.6	58.1	61.7
Darawa	25.2	28.6	54.8	62.8
Sudan grass				
1st cut	18.2	30.0	48.5	59.0
2nd cut	16.7	30.1	53.0	69.5
Rice straw	15.0	16.3	33.5	39.5
Maize stalks	17.1	25.3	38.2	49.0
Bean straw	32.7	40.8	42.4	49.6
Corn cobs	3.72	6.77	21.7	45.0
Bagasse	16.3	17.9	30.9	32.6
Wheat straw	23.4	30.4	40.4	45.0
Cotton stalks	8.28	23.4	30.0	33.0
Bean hulls	11.2	17.3	46.6	81.5
Overall mean	22.4	31.6	47.2	57.1

In general, ISDMD increased as the period of incubation prolonged. As expected rate of disappearance was greater during the first 4 hr. (5.6% μ/hr.) than the second 4 hr. (2.3% μ/hr) and decreased greatly thereafter (1.0 and 0.4% μ/hr.) for the third 16 hr. and the final 24 hr., respectively. Rate of disappearance was higher for dried berseem, dried green grasses or hay than the other roughage sources. Extent of disappearance after 48 hr. of incubation followed a similar trend, except for bean-hulls which showed higher extent of disappearance than any other roughage sources.

TABLE 6. Correlations and reqressions recorded between ISDMD and chemical analysis of the different roughage sources.

Factors (x)		ISDMD % (Y)			
		4 hrs.	8 hrs.	24 hrs.	48 hrs.
CP%	r	0.627**	0.764**	0.869**	0.678**
	r^2	0.393	0.584	0.755	0.459
	Equation (y=a+bx)	—	y=13.70+1.73×	y=27.14+1.94×	—
CF%	r	0.713**	-0.714**	-0.705**	N.S -0.430
	r^2	0.509	0.510	0.497	0.185
	Equation	y=51.57-0.90×	y=70.19-1.19×	—	—
Ash%	r	0.720**	0.765**	0.750**	N.S 0.453
	r^2	0.518	0.585	0.562	0.205
	Equation	y=7.24+1.17×	y=10.26+1.65×	y=26.51+1.60×	—
NDF%	r	-0.952**	-0.901**	-0.839**	-0.521*
	r^2	0.907	0.813	0.704	0.271
	Equation	y=66.45-0.776×	y=86.80-0.972×	y=97.98-0.894×	—
ADF%	r	-0.772**	-0.716**	-0.594**	N.S -0.205
	r^2	0.596	0.512	0.353	0.042
	Equation	y=53.79-0.847×	y=70.79-1.04×	—	—
ADL%	r	N.S -0.461	N.S -0.322	N.S -0.393	N.S -0.140
	r^2	0.213	0.104	0.154	0.019
	Equation	—	—	—	—
Silica%	r	N.S 0.197	N.S 0.127	N.S -0.035	N.S -0.179
	r^2	0.039	0.016	0.001	0.032
	Equation	—	—	—	—

Correlations between ISDMD and chemical composition are presented in Table 6 and can be summarized as follows :

(1) Crude protein and ash contents were positively and highly correlated with ISDMD ($P < 0.01$).

(2) Crude fiber ; NDF and ADF contents were negatively and highly correlated with ISDMD ($P < 0.01$).

(3) Correlations between ISDMD and both ADL and silica contents were negative and not significant.

5. *Relationship between IVDMD and ISDMD*

Mean values for IVDMD and ISDMD recorded after 4, 8, 24 and 48 hr. were 22.9% and 22.4%, 27.5% and 31.6%, 33.9% and 47.2% and 42.0% and 57.1%, respectively.

Correlations between IVDMD (x) and ISDMD (y) were positive and highly significant ($p < 0.01$). Similar results were reported by Monson *et al.*, (1969). The predication equations were as follows :

Incubation time (hr.)						
4	ISDMD	=	0.04	+ 0.976	IVDMD	(r = 0.810)
8	ISDMD	=	0.55	+ 0.13	IVDMD	(r = 0.836)
24	ISDMD	=	17.88	+ 0.866	IVDMD	(r = 0.728)

General Discussion

Relationship between estimated and calculated GE

There was a highly significant correlation (r = 0.798) between combustible and calculated GE. This finding was in general agreement with the results of Thomson (1966) and El-Serafy *et al.*, (1981 a) who reported higher values than this of the present study which may be due to differences in both the number of samples used in each study and their chemical composition.

The present results demonstrated that the calculated GE can be used as a good predictor of combustible or estimated GE in roughages which could be determined with good accuracy from the gross chemical composition analysis usually done in nutritional experiments.

Crude fiber fractions

The results indicated that 2*nd* cuts dried berseem and sudan grass had higher lignin content than their corresponding 1*st* cuts, and the 3*rd* cut napier grass had higher lignin content than the 2*nd* cut. This may be related to stage of maturity of the plants. (Stitty, 1970 and El-Talty, 1973).

The differences in the chemical composition, especially CF and possibly ash content may explain differences in their NDF; ADF and ADL. (Van Soest, 1975 and Koller *et al.*, 1978).

The high silica content recorded for some roughages was possibly related to their high ash content.

Relationship between chemical composition and IVDMD

Rate of IVDMD during the 1*st* 4 hr. of incubation was 5.7% decreased to 1.2% during the 2*nd* 4 hr., 0.4% for the following 16 hr. and 0.3% for the final 24 hr.

Generally, the higher the CP content the higher the IVDMD values. On the contrary, the higher the CF ; NDF ; ADF ; ADL and silica contents the lower the IVDMD values. These results support those of Koller *et al.,* (1978) with other feedstuffs.

It may be concluded that CP ; CF ; NDF and ADF can be used as good predictors for IVDMD at 4 ; 8 ; 24 and 48 hr. of incubation period.

Relationship between chemical composition and ISDMD

Generally, ISDMD values were higher for roughages contained higher levels of CP. It also increased as their CF, NDF, ADF, ADL and silica content decreased. Thus CP ; CF, NDF, ADF and ash contents can be used as a good pre-idictors for ISDMD.

Relationship between IVDMD and ISDMD

Average ISDMD values were higher than IVDMD in roughages and this may be due to the fact that, in the nylon bag method, the sample is exposed to a large volume of rumen fluid ; while In Vitro samples are exposed to a limited quantity of rumen fluid. Moreover it appears that the washing technique had a marked effect upon the amount of DMD (Van Dyne, 1962).

Generally, ISDMD can be used as a good prediction of IVDMD at 4, 8 and 24 hr. Such observation is of prime importance as it provides more flexibility in studies concerning the determination of the nutritive value of different feeds. However, factors that may have interfered with this relationship leading to the slightly low value (r^2) should be identified and eliminated partially or completely if possible in order to establish a strong relationship between the two estimates. As there is a strong relationship between IVDMD and ISDMD, it would be of interest to examine the relationship between ISDMD and In Vivo DMD in further studies.

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مفهوم جديد لتفصيص مواد العلف الخشنة والتنبؤ بقيمتها الغذائية

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تم تقييم ستة عشر مادة علف خشنة شائعة الاستخدام فى الحيوان المجتر بالطرق السريعة المتطورة والموثوق بها للتنبؤ بالقيمة الغذائية لهذه المواد بدرجة دقيقة .

تم اجراء التحاليل الكيميائية لهذه المواد الخشنة المختلفة وقد شملت التركيب الكيماوى مكونات الالياف الخام ـ الطاقة الكلية ـ معدل اختفاء المادة الجافة على فترات زمنية ٤ـ٨ـ٢٤ـ٤٨ ساعة بطريقة الكرش الصناعى والاكياس النايلون ، ثم حساب معاملات الارتباط البسيطة بين القياسات المختلفة لتحديد قوة العلاقة بينها لدراسة امكانية استخدامها فى التطبيق العملى

وتم الحصول على النتائج :

هناك تباين كبير فى مكونات الالياف الخام لمواد العلف المدروسة حيث تراوحت نسبة الهيمسليلوز بين ٢ر٥ ٪ (قشر الفول) ، ٧ـ٣٨ ٪ (قوالح الذرة) ونسبة اللجنين بين ٣ر٩٦ ٪ (دراوه ـ علف الفيل) ١ر٩١ ٪ (حطب القطن) ـ اما بالنسبة لمحتوى السليكا فقد سجل قش الارز اعلى قيمة بينما سجل حطب القطن أقل قيمة .

كانت قيمة معامل الارتباط بين الطاقة الكلية المقدرة والمحسوبة ٧٩٨ر.

وجدت علاقة موجبة عالية المعنوية بين الالياف الخام ومكوناتها .

وجدت علاقة سالبة وعالية المعنوية بين الالياف الخام ومكوناتها (باستثناء اللجنين) من جهة ومعامل هضم المادة الجافة المقدرة معمليا من جهة أخرى ، بينما كانت هناك علاقة موجبة وعالية المعنوية بين البروتين والرماد كل على حده مع معامل هضم المادة الجافة المقدرة معمليا