Lucerne quality and possibilities for its estimation

Kirilov A.

in

Lucerne quality and possibilities for its estimation

A. Kirilov

Institute of Forage Crops, Gen. Vladimir Vazov str. 89, 5800 Pleven, Bulgaria

SUMMARY – Lucerne quality is examined in the article as a generalizing concept covering forage chemical, morphological and physical composition, digestibility, intake, energy and protein value. Classical methods and some non-conventional approaches for evaluation of quality characteristics in lucerne are mentioned in a summarized form. Quality Index (QI) calculated on the basis of the net energy ingested with the forage when fed *ad libitum* in relation to that necessary for life maintenance [QI = (DMI FUG)/(FUG for maintenance)] and Index of Protein Value (IPV) calculated on the basis of the protein digestible in intestines (PDI) ingested with the forage in relation to the needs for maintenance [IPV = (DMI PDI)/(PDI for maintenance)] are described. As complex characteristics for the feeding value of lucerne they stand closer to real nutritive value of forage. The relation of QI and IPV with the mean stage of development in lucerne (MSW) shows that they are predictable characteristics and can participate in mathematical models for lucerne quality prediction.

Key words: Lucerne, quality, feeding value.

RESUME – "La qualité de la luzerne et les méthodes d'estimation". La qualité de la luzerne est examinée dans l'article comme une notion généralisante couvrant la composition chimique, morphologique et physique, la digestibilité, l'ingestibilité, la valeur énergétique et protéique du fourrage. Les méthodes classiques et quelques approches non traditionnelles pour l'évaluation des caractéristiques de qualité chez la luzerne sont mentionnées dans une forme résumée. L'Indice de Qualité (IQ) calculé sur la base de l'énergie nette (unité fourragère pour croissance – UFC) ingérée avec le fourrage distribué ad libitum par rapport à celui nécessaire pour l'entretien de la vie [IQ = (MS ingérée UFC)/(UFC pour l'entretien)] et l'Indice de la Valeur Protéique (IVP) calculé sur la base de la protéine digestible dans l'intestin (PDI) ingérée avec le fourrage par rapport aux besoins pour l'entretien [IVP = (MS ingérée PDI)/(PDI pour l'entretien)] sont décrits. Comme caractéristiques complexes pour la valeur fourragère de la luzerne ils se trouvent plus près de la valeur alimentaire réelle du fourrage. La relation de l'IQ et de l'IVP avec le stade moyen de développement chez la luzerne (MSW) montre que ce sont des caractéristiques prévisibles et qu'ils peuvent participer à des modèles mathématiques pour prévision de la qualité de la luzerne.

Mots-clés : Luzerne, qualité, valeur alimentaire.

Introduction

Lucerne quality is a generalizing concept covering forage chemical, morphological and physical composition, digestibility, intake, energy and protein value. Every one of these characteristics can be considered with regard to quality, but it should not be identified only with one of them. The products obtained from the animals fed with the respective forage give the most complete and correct information about the forage quality. However this approach is difficult and it is impossible to apply it to every type of forage or plants from the breeding process. There are different methods for evaluation of quality characteristics on the basis of *in vivo* and laboratory methods, as well as for their prediction on the basis of the relationships between the plant developmental stage and age on the one hand and the nutritive value on the other hand or between the forage composition, digestibility and nutritive value.

The classical and some non-conventional approaches for evaluation of lucerne quality will be examined in a summarized form in this article.

Evaluation of quality

Composition

The characteristics related to the lucerne quality or nutritive value are morphological composition

(leaf:stem ratio), chemical composition [crude protein (CP = N   6.25, Kjeldahl method), crude fat, nitrogen-free extract (NFE) and crude fiber (CF, Weende analysis) or structural fiber (NDF, ADF, lignin, Van Soest, 1963)]. The leaf:stem ratio is an often-used characteristic which gives an idea of lucerne nutritive value. The leaves and stems have different chemical compositions and different digestibilities. The leaves contain 2.5-3 times more crude protein and as many times less crude fiber than the stems. They have almost 2 times higher digestibility than that of the stems (Krachunov, 1995). The increase of leaf proportion is one of the ways to increase the CP content and digestibility of lucerne (Juan *et al.*, 1993; Frame *et al.*, 1998). The content of CP, CF, NFE, or NDF, ADF and lignin are main elements of quality. The energy and protein value of forage depend on their quantity in the forage and digestion by ruminants. Their mode of change during the vegetation depending on fertilizing, soil-climatic conditions or conservation are an object of permanent interest from a point of view of animal nutrition. The changes in the content of lucerne quality characteristics are most often related to the stage of development and its exact determination is of importance for the use of table data on the forages when feeding ruminants (INRA, 1988).

Stage of development in lucerne

The changes occurring in the composition, digestibility, intake, energy and protein value are related to plant developmental stage or age. There is a great number of mathematical models for prediction of lucerne composition and nutritive value depending on plant age (INRA, 1981, 1988). However the visual assessment of the lucerne developmental stage is inexact and rather subjective. The estimation of lucerne morphological development by an index called Mean Stage by Weight (MSW), introduced by Kalu and Fick (1981) provides a possibility to obtain an exact, numerical expression of the stage of lucerne. The MSW is narrowly correlated with the forage quality and on this basis mathematical models were developed to predict the content of CP, NDF, ADF and digestibility of lucerne (Kalu and Fick, 1983; Fick and Janson, 1990; Krachounov, 1995).

Digestibility and intake

The digestibility and intake are criteria which give information about the forage nutritive value and its degree of utilization by the animals. On the basis of *in vivo* results for forage digestibility and utilization many new systems for evaluation of forage energy and protein value have been developed during the last twenty years (INRA, 1978; Aleksiev *et al.*, 1983). The classical *in vivo* determination of digestibility in trials on animals is difficult, slow and expensive and for that reason different laboratory methods simulating the processes of digestion in the rumen are used. The *in vitro* method on the basis of ruminal juice (Tilley and Terry, 1963), the method on the basis of forage enzymatic degradability (Jones and Hayward, 1975; Auffrere, 1982; De Boever *et al.*, 1986) or *in vitro* gas production of forage incubated in ruminal juice (Menke and Steingass, 1988) found wide application. The results from the enzymatic degradability can be successfully used for prediction of metabolizable and net energy content of fresh and preserved lucerne forages (Krachounov *et al.*, 1997) and the data from *in sacco* degradability have a good relation with the lucerne *in vivo* digestibility and intake (Kirilov, unpublished results). Lately the prediction of forage composition and digestibility by the method of near infrared reflectance spectroscopy finds a very wide application (Norris *et al.*, 1976). Many studies were carried out with this method in lucerne (Atanassova *et al.*, 1994; Krachounov, 1998; Van Waes *et al.*, 1998).

Compared to digestibility, the intake is a newer characteristic as an object of study. It is measured by the forage quantity that an animal can ingest when fed *ad libitum*. The intake is a resultant value from forage palatability and physical and chemical characteristics. A system (Fill Unit) has been developed in France for evaluation of forage intake (INRA, 1978). The data on intake are present together with the other data on the quality in the tables of forage nutritive value (INRA, 1981 and 1988).

The intake of a greater quantity of lucerne means intake of more protein and saving of protein concentrates. The decrease of digestibility and intake of lucerne is a natural process related to maturity of plants. The quality of produced forage depends both on the chosen time of harvesting and method of preservation.

Other approaches for evaluation of lucerne quality

Lucerne, as well as the other forage crops provides the animals with energy and protein. The contents of energy and protein evaluated by some of the existing systems for estimation of energy and protein value of forages for ruminants give an objective idea of forage nutritive quality (INRA, 1978; Todorov, 1990, 1995). However the feeding value depends not only on nutritive value, but also on the quantity of ingested forage, respectively energy and protein when the forage is fed *ad libitum* to animals. Recently complex characteristics are used for evaluation of forage quality on the basis of forage intake and energy value (Moore, 1994; Kirilov, 2000) or on the basis of intake and protein value (Kirilov, 2001). A Quality Index of forage (QI) is suggested (Kirilov, 1999) using the intake of dry matter (DMI) and the net energy content in it (feed units for growth – FUG). The QI is calculated on the basis of net energy ingested from the forage fed *ad libitum* in relation to that necessary for life maintenance [QI = (DMI   FUG)/(FUG for maintenance)]. For a complex evaluation of forage protein value on the basis of forage intake and content of protein digestible in intestines (PDI) an Index of Protein Value (IPV) of forage is suggested (Kirilov, 2001). The principle of calculation of IPV is similar to that for QI, namely it is expressed by PDI ingested by the forage fed *ad libitum* in relation to the PDI for maintenance [IPV = (DMI   PDI)/(PDI for maintenance)].

If the value of QI or of IPV equals one, then the animal fed *ad libitum* ingests FUG or PDI equal to these necessary for maintenance. At values more than one the animals will satisfy their needs for maintenance and will realize products (milk, weight gain, work), and at values less than one they will lose live weight.

Both the QI and IPV for lucerne decrease with the maturity of plants. Being resultant values from the intake and digestibility or from the contents of net energy and PDI (Fig. 1) they correlate very well with the developmental stage (MSW).

QI = 2.178 - 0.198.MSW
R^2 = 0.948

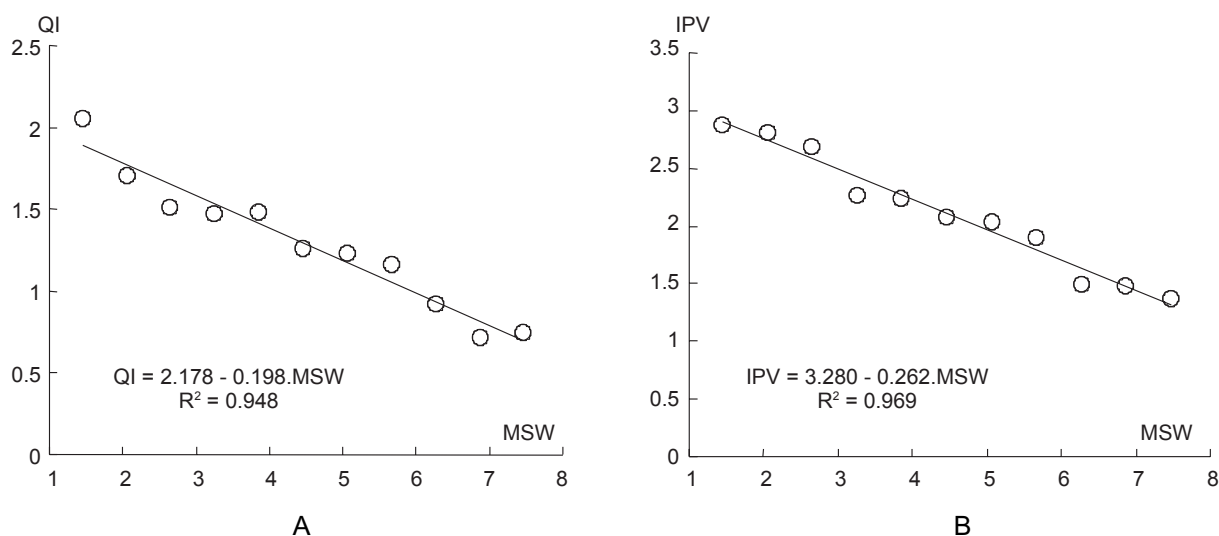IPV = 3.280 - 0.262.MSW
R^2 = 0.969

Fig. 1. Relationship in lucerne between: (A) mean stage of development (MSW) and Quality Index (QI), acc. Kirilov, 1999; (B) mean stage of development (MSW) and Index of Protein Value (IPV), acc. Kirilov, 2001.

The QI and IPV give information about the potential ability of forage to satisfy the needs of animals with energy and protein, respectively. They can be used for better compaison between forages or for better evaluation of yield from a given forage crop (Kirilov, 2000). The relation of QI and IPV with the developmental stage of lucerne shows that they are predictable characteristics and can participate in mathematical models for prediction of forage nutritive or feeding value (Kirilov, 1999).

References

Aleksiev, A., Stojanov, V., Todorov, N., Vladimirov, I., Russev, V., Krasteva, E., Marinov, B., Peteva-Vancheva, Z. and Anguelova, L. (1983). *Nutrition of Animals*, Vol. 1. Zemizdat, Sofia, 269 pp.

Atanassova, S., Pavlov, D. and Todorov, N. (1994). Estimation of the chemical composition, the net energy and the protein value of lucerne by NIRS and by regression equation on the basis of the days of vegetation or the accumulated temperature. *Journal of Agricultural Science (Sofia),* 3: 325-335.

Auffrere, J. (1982). Etude de la prévision de la digestibilité des fourrages par une méthode enzymatique. *Ann. Zootech.,* 31: 111-130.

De Boever, J.L., Cottyn, B.G., Buysse, F.X., Wainman, F.W. and Vanaker, J.M. (1986). The use of an enzymatic technique to predict digestibility, metabolizable and net energy of compound feedstuffs for ruminants. *Anim. Feed Sci. Technol.*, 14: 203-214.

Fick, G.W. and Janson, C.G. (1990). Testing mean stage as a predictor of alfalfa forage quality with growth chamber trials. *Crop Sci.*, 30: 678-682.

Frame, J., Charlton, J.F.I and Laidlaw, A.S. (1998). *Temperate Forage Legumes*. CAB International, Wallingford, Oxon, UK.

INRA (1978). *Alimentation des Ruminants.* INRA Publication, Versailles.

INRA (1981). *Prévision de la Valeur Nutritive des Aliments des Ruminants.* INRA Publication, Versailles.

INRA (1988). *Alimentation des Bovins, Ovins et Caprins*. INRA, Paris.

Jones, D.H. and Hayward, M.V. (1975). The effect of pepsin pretreatment of herbage on the prediction of dry matter digestibility from solubility in fungal cellulase solution. *J. Sci. Food Agric.*, 26: 711-718.

Juan, N.A., Sheaffern, C.C., Barnes, D.K., Swanson, J.F. and Halgerson, J.H. (1993). Leaf and stem traits and herbage quality of multifoliate alfalfa. *Agron. J.,* 85: 1121-1127.

Kalu, B. and Fick, G.W. (1981). Quantifyng morphological development of alfalfa for studies of herbage quality. *Crop Sci.,* 21: 267-272.

Kalu, B.A. and Fick, G.W. (1983). Morphological stage of development as a predictor of alfalfa herbage quality. *Crop Sci.*, 6: 1167-1172.

Kirilov, A. (1999). Relations between mean stage by weight (MSW), and intake and digestibility of lucerne. In: *13th Eucarpia* Medicago *Group Meeting,* Perugia (Italy), 13-16 September 1999.

Kirilov, A. (2000). Estimation of yield according to forage quality. In: *Grassland Science in Europe,* Vol. 5, Soegaard, K., Ohlsson, C., Sehested, J. Hutchings, N.J., Kristensen, T. (eds), pp. 163-165.

Kirilov, A. (2001). Changes in protein content and intake of lucerne and sainfoin during first growth. *Paper 1/90, EGF Occasional Symposium on Organic Grassland Farming*, 10-12 July 2001, Witzenhausen (Germany).

Krachunov, I. (1995). *Changes in quality of lucerne forage before harvesting and possibilities for its prediction*. PhD Thesis, Sofia.

Krachunov, I. (1998). Estimation of near infrared reflectance spectroscopy (NIRS) for estimation of lucerne energy nutritive value for ruminants. *Animal Science (Sofia),* 35(2): 36-41.

Krachounov, I., Weissbach, F., Schmidt, L., Kuhla, S., Jelyazkov, T. and Kirilov, A. (1997). Estimation of metabolizable energy and net energy for lactation in lucerne for ruminants on the basis of a cellulase method. *Animal Science (Sofia),* Supplementary issue: 113-116.

Menke, K.H. and Steingass, H. (1988). Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. *Animal Research and Development,* 28: 7-55.

Moore, J.E. (1994)*.* Forage quality indices: Development and application. In: *National Conference Forage Quality, Evaluation and Utilization,* Fahey, G.C. (ed.), Lincoln, 13-15 April 1994.

Norris, K.H., Barnes, R.F., Moore, J.E., Shenk, J.S. (1976). Predicting forage quality by infrared reflectance spectroscopy. *J. Anim. Sci.,* 43: 889-897.

Tilley, J.M.A. and Terry, R.A. (1963). A two stage technique for the in vitro digestion of forage crops*. J. Brit. Grassl. Soc.,* 18: 104-111.

Todorov, N. (1990). A project for a new system of evaluating the protein nutritiousness of forages and the protein needs of ruminants in Bulgaria. *Agricultural Science (Sofia),* 28(3): 46-55.

Todorov, N. (1995). *Nutrient Requirements of Cattle and Buffalo*. Publishing House NIS-UZVM, Stara Zagora.

Van Soest, P.J. (1963). The use of detergents in the analysis of fibrous feeds. II. A rapid method for determination of the fiber and lignin. *J.A.O.A.C.,* 46: 829-835.

Van Waes, C., Kirilov, A., Krachounov, I., Petkov, P. and Carlier, L. (1998). Prediction of in vitro digestibility and chemical composition of lucerne by NIRS. *Plant Science (Sofia),* 35(9): 708-711.