Egypt. J. Anim. Prod. 17, No. 2 pp. 131—140 (1977)

Critical Study of the Associative Effect of Direct and Indirect Feeding in Metabolism Trials with Sheep Using Flax Product, Clover Hay and Barley Grains

Y.I.El- Talty and A. K. Abou-Raya
Faculty of Agriculture, Cairo University, Giza, Egypt.

The associative effect in direct and indirect feeding trials as well as the effect of the type of the basal ration on the digestibility and feeding value of feeds were investigated.

Five digestibility trials were performed using two or four Rahmany rams. The direct feeding included three feeds singly fed (clover hay, barley grains and flax product) and two mixtures (flax- product : clover hay and flax- product : barley grains). The two mixtures were used for indirect feeding using four cases of basal rations and tested ones.

Using clover hay as a basal ration, the feeding value of flax product obtained by difference was distinctly lower than that of the product when fed alone (19.7 against 26. % VS). A much lower feeding value of the product was observed (16.2% SV) when barley was used as a basal ration. When the situation was reversed by assuming flax product to be the basal ration, a serious reduction in the feeding value of hay (28 against 34.9% SV) as well as that of barely grains (50.3 against 80.9% SV) occurred.

It was also discovered that the biological addition of two feeds in a mixture would result in a different response producing deviated feeding value from "Weighted means" calculated by mathematical addition (assuming that the feeding value of the single feed would remain the same in the mixture). This assumption is biologically erronious. Such behaviour would make us conclude that adding a feed to another in a mixture a "mutual associative effect" occurs.

This study was a continuation to previous work in this Department (Animal Nutrition Section) on the extent of the associative effect, in digestion trials with ruminants including the type of the basal ration in indirect feeding (Abou-Raya *et al.*, 1966, Abd-El-Rahman, 1966 ; El-Serafy, 1968, Al-Refaai, 1972 and El-Talty, 1973). To realise more fully the extent of this effect, a comparative study between results of indirect and direct feeding with the same feeds was undertaken choosing three distinct feeds which could be fed alone (directly) and indirectly : medium quality roughage (flax product), good quality roughage (clover hay) and a concentrate feed (barley grains).

Asplund and Harris, (1971) set up an experiment with two variable feeds (alfalfa hay and dried beet pulp with molasses) and a mixture of them in equal parts to produce the maximum associative effect. They also compared the results of direct feeding of each feed singly fed with those obtained by difference making use of the mixture. The observed feeding value of the mixture and the majority of nutrient digestibilities were higher than calculated (74% for DM, 72% for GE,-44% for EE and 82% for NFE against 73%, 71%,-14% and 80%, respectively). They also found that the feeding value and digestibilities obtained by difference were more deviated from those obtained from direct feeding. Digestibilities with alfalfa hay fed alone were 59% for OM, 58% for GE, 28% for EE, 79%of N, 52% for CF and 66% for NFE, against 61%, 60%, 15%, 71%, 54% and 71%,respectively when calculated by difference. Results with beet pulp were 86%, 85%,-57%, 63%, 84% and 94% against 88%, 87%-96%, 66%, 87%, and 96%, respectively when directly andindirectly fed.

Meantime, a flax product is accumulated at the flax companies in Egypt after separating seeds including some of the shives. The palatability and the feeding value of this product were necessary seeking a reduction of the cost of roughages in feeding practice owing to the shortage and high price of wheat straw. Various flax products had been recorded in the literature with variable crude protein (CP) content (2-15%) and crude fibre (CF) content (35-70%) according to the proportions of plant parts, capsule hulls, fibres and shives, having a wide range of feeding value from 30 to 44%. Total Digestible Nutrients, TDN (Pott in Ghoneim 1964, Schneider, 1947 and Ministry of Agric, 1968).

Material and Methods

Five metabolism trials were set up using the same duplicate Rahmany rams (three years old, castrated) to determine the digestibilities, feeding value and N-balance, except with Trial 1 when two more rams were used. Flax plant-product (4%CP and 35% CF, dry mather basis) from *Linum usiatissimum*, clover hay (*Trifolium alexandrinum*) sun cured, chopped and barley grains (*Hordeum valgare*), coarsely ground, were used as single feeds (Trials 1, 2 and 3) or combined in two feeds (flax-product : hay, Trial 4, and flax-product: barley Trial 5). Flax product was provided by Tanta Company for Flax and Oil, Gharbieh Governorate, after seed separation including some shiver.

Each of Trial 4 or 5 served for triple purposes for determining the digestibility and feeding value of either the first feed indirectly fed using the second feed as basal ration, or the second feed indirectly fed using the first as basal and thirdly the combined feed mixture directly fed. This will result into five cases of direct feeding and four cases of indirect feeding. The preliminary period was ten followed by a collection period of seven days. Table 1 presents basic information about the trials.

TABLE 1. Dry matter intake and % dry matter of basal ration in different digestion trials.

Trial No.	Feed in trial	Total dry matter intake (g)	% Dry matter of basal in the mixture
	Direct feeding trials		
1	Hay	862.0	—
2	Barley	437.2	—
3	Flax by-product	1153.8	—
4	Hay: flax bp. (mixture) . . .	879.6	—
5	Barley: flax b.p (mixture)	901.3	—
	Indirect feeding trials		
4	(*a*) Hay (tested)	428.1	51.3
	(*b*) Flax b.p. (tested)	541.5	48.7
5	(*a*) Flax b.p.(tested)	639.1	29.0
	(*b*) Barely (tested)	262.2	71.0

The methods of the A.O.A.C. were used for the ordinary nutrient analyses of dry matter (DM), CP, ether extract (EE), CF and ash. Nitrogen-free extract (NFE) was determined by the difference method. The feeding value was recorded as TDN and starch value (SV).

Results and Discussion

Results (Table 2) indicate that the conventional analyses of the hay and barley grains are within the range of nutrients of the same type of feed, particularly Egyptian feeds having relatively high ash content. With flax-product, results were within the range published by Pott (in Ghoneim 1964) and Schneider, (1947) with the majority of nutrients. Ash was higher and CP was lower than published limits.

Results with direct feeding using single feeds and their two component feed mixture

Results (Table 3) with flax fed alone showed that its feeding value was 26.4% SV and 47.4% TDN (on dry matter basis), being similar to medium quality roughage but with relatively low digestible CP (1.3). Although the protein level in the product was low, yet it was more palatable than wheat straw to sheep when fed alone. In this connection Abou-Raya *et al.* (1966) found that the intake of Egyptian wheat straw fed alone was very low (320-

376 g using two adult rams). The intake here during the *ad libitum* feeding (the preliminary period with flax product in 2 × 2 × 1 m. fenced pen) reached 1153.8 g DM daily /ram (being 60.7 g 1. The relative intake (considering the standard 80 g) would be 75%. The intake was not enough, to give the animal the energy requirements for maintenance, in addition the N-balance was slightly negative. Therefore, the flax product could substitute well the wheat straw and still should be mixed with energy and protein supplementing feeds for maintenance and production.

TABLE 2. Nutritive analysis of experimental feeds (%).

Item	Clover hay 7.34% moisture (H)	Barley grains 10.10% moisture (B)	Flax product 7.77 % moisture (F)	(H:F)mixture moisture 48.7: · 51.3%	(B:F)mixture moisture 29 : 71 %
International feed number:	1—01—340	4—08—343	1—02—036	—	—
Nutritive analyses					
Ash	13.00	2.39	13.84	13.44	10.52
Crude protein . .	11.15	12.10	6.97	7.46	6.34
Ether extract . .	2.16	1.97	1.58	1.85	1.70
Crude fibre . . .	28.10	8.90	35.48	31.89	27.75
N-free extract . .	45.59	74.64	45.13	45.36	53.69

* Analyses expressed on dry (100% dry matter) basis.

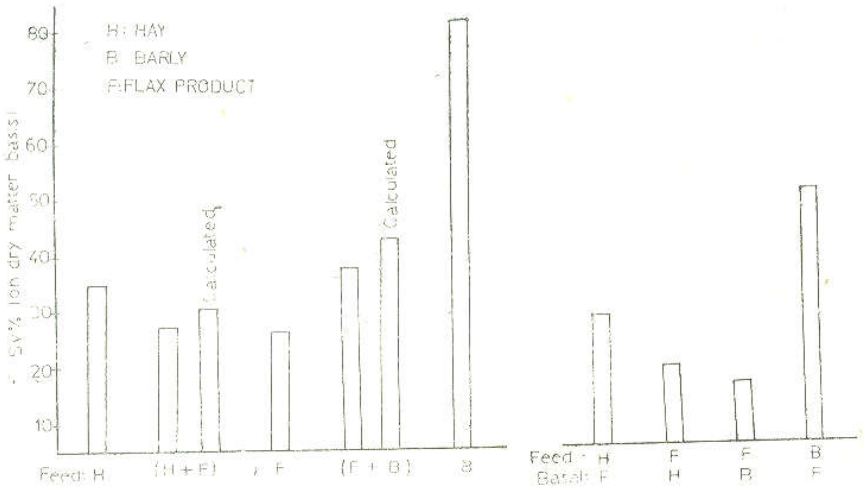
Results with clover hay (11.2% CP and 28.1% CF on DM basis) indicated that the feeding value was similar to that of medium quality of clover hay in Egypt (Abou-Raya *et al.*,1969 including 60 trials), being 34.9% SV, 52.1% TDN and 7.5% digestible crude protein, DCP. It was noticeable that the hay CF digestibility was lower than that of flax product (47.6 against 37.7%), in spite of the fact that hay contained lower CF content. This appeared to be due to differences in the physical nature and chemical composition of CF.

With barley grains, results were within the published range (80.9% SV, 84.4 TDN and 9.6DCP.) by Schneider, (1947), Ministry Agric., (1968); Abou-Raya, (1967); Abd-El-Motagali, (1972), and Abou-Raya and El-Talty (1976). The CF digestibility was very low (27.4%) most likely due to the high soluble carbohydrates content of the grains. Although the obtained feeding value with barley grains when fed alone was high, it was observed that at the end of the collection period, faecal material became soft as a sign to start slacking.

TABLE. 3. Comparative study on the effect of direct and indirect feeding on digestibility and feeding value of feeds.

Items	Direct feeding							Indirect feeding			
	Flax (F)	Hay (H)	Barley (B)	(H+F) 48.7%+51.3%		(B+F) 29%+71%		Flax as basal		Hay as basal	Barley as basal
				Exp.	Calcu.	Expt	Calcu.	(H)	(B)	(F)	(F)
No.of trial	1	2	3	4		5		4	5	4	5
Nuts.digestibility											
OM. . . .	54.0 ± 1.69	58.3	83.7	51.6	56.1	54.6	63.4	49.2	56.0	45.2	41.1
CP	32.4 ± 3.80	67.4	79.2	51 1	57.2	47.6	58.4	58.2	60 0	8.1	8.2
EE	39.2 ± 2.18	53.2	88.6	66.0	47.1	81.4	49.2	86 4	162.5	82.4	87.5
CF	47.6 ± 2.26	37.7	27.4	29.7	43.4	11.9	45.7	6.0	0.0	23.7	10.3
NFE	61.4 ± 1.28	69.0	91.6	66.5	65.1	23.3	73.6	71.8	99.2	64.1	66.6
Feeding value (DM)											
SV	26.4 ± 1.27	34.9	80.9	27.1	30.5	37.9	42.2	28.0	50.3	19.7	16.2
TDN . . .	47.4 ± 1.29	52.1	84.4	46.2	49.7	50.6	58.1	45.2	53.4	40.5	37.1
DCP . . .	1.3 ± 0.15	7.5	9.6	3.8	4.3	3.0	3.7	6.5	7.3	0.3	0.3

The observed feeding value and nutrients digestibilities of the feed mixtures in Trial 4 and 5, by direct feeding were examined. Comparison was made in each mixture with calculated figures as a weighted mean by a knowledge of the proportion of each feed in the mixture and its data when fed alone (direct feeding) assuming no change in digestibilities or feeding value after mixing with the other feed (Table 3 and Histogram 1).



Histogram 1. Direct and indirect feeding value of feeds

It was found that the calculated weighted mean differed from that experimentally obtained. The observed figures with H : F mixture were noticeabley lower in feeding value (27.1against 30.5% SV) and OM digestibility (51.6 against 56.1) and distinctly low with CF digestibility . On the other hand those withCP were distinctly lower (51.1 against 57.2) and slightly higher with NFE (66.5 against 65.1) but EE digestibility was distinctly higher (66 against 47.1). This means that combining H and F in the mixture has a variable extent of depressing or increasing effect on nutrient digestibility, *i.e.* varying in sign and magnitude according to the nutrietn. The overall result has a depressing effect on the feeding value.

In the case of F : B mixture, the effect of the combination was clearer producing distinct decrease with OM digestibility (54.6 against 63.4) and a very sharp decrease in the case of CF (11.9 versus 45.7) and NFE (23.3 versus 73.6). A distinct decrease occurred with CP (47.6 versus 58.4) but very sharp increase with EE (81.4 versus 49.2). The resultant was a distinct decrease in the feeding value (37.9 versus 42.2% SV).

From the previous results, it was clear that relying on the feeding value of single feeds directly fed to calculate the feeding value of a combination of mixtures from such feeds would result in a serious error. The biological addition of two feeds in the mixture would result in a different response producing feeding value deviating from "weighted means" calculated by mathematical addition (supposing that the feeding value of the single feed would remain the same in the mixture). The deviation in biological addition is due to a certain associative effect which may decrease or increase the digestibility of a certain nutrient. In other words a negative or positive associative effect might occur. This will lead us to think of each nutrient alone ; the specific associative effect of CF digestibility might vary in sign as well as in magnitude from that of the CF. Asplund and Harris, (1971) concluded that the magnitude of the associative effect was relatively small and might be of minor importance compared to other sources of error and variation in the assessment of the value of feeds. This conclusion must be ristricted to the studied case because our results indicate great differences and great effect of the associative effect giving greatly different figures which are more than could be ignored and exceeding the experimental error in the digestion trials.

Such behaviour would make us to conclude that adding feed A with feed B in a mixture a "mutual associative effect" occurs, feed *i.e.* feed A introduces an effect on B and *vice versa* resulting into decreasing or increasing effect in digestibility having variable intensity according to the nutrient in question. In other words one cannot assume that the digestibility of a certain nutrient in feed A would remain the same when feed B is added to A. The same would be with the nutrient in B, its digestibility changes by mixing feed A to B.

This comparison of direct feeding in feed mixtures as well as single feed clarified to us the doubtfulness in the principle of determing the digestibilities calrified to us the doubtfulness in the principle of determing the digestibilities of tested ration *via* application of a basal ration, *i.e.* the so called "the difference method" (indirect feeding). Assuming that the digestibilities of nutrients in the basal ration to remain the same when adding the tested ration appeared not to rely on sound physiological basis.

To clarify this, careful critical study is presented on the effect of "indirect feeding" not only on digestibility of nutrients in the tested ration but also on the basal ration (considering the reverse situation).

Results with tested ration fed along with basal ration using the indirect feeding

When hay was taken as a basal ration in Trial 4, the feeding value of flax product obtained by difference, was distinctly lower than that of the product when fed alone (19.7 against 26.4% SV). A distinct decrease in the digestibility of OM, CP and CF, occurred while a distinct increase occurred with that of EE and slight increase in the case of NFE. It was clear that assuming that hay nutrient digestibilities remained as obtained when hay was fed alone in

Trial 2, would make the "mutual associative effect" (already proved to be present) to be charged on the expense of nutrient digestibility in flax-product, this would result in an "apparent" distinct decrease in flax-product feeding value.

The same argument could be discussed with flax product when using barley as basal ration (Trial 15). But here "the mutual associative effect appeared to be greater and to the negative side resulting in a great lowering effect on OM, CP and CF digestibility and a much lower feeding value (16.2 against 26.4% SV). The type of the basal ration decidedly affect the digestibility results obtained by the "difference method."

Reversing the situation in Trial 4 and 5, assuming flax-product to be the basal ration to calculate digestibilities of the tested rations, hay and then barley grains, it was clear that a serious reduction in the hay feeding value (28 against 34.9% SV) as well as that of barley grains (50.3 against 80.9% SV) occurred. The two feeds singly fed had much higher feeding value. This apparent reduction when using the basal ration resulted without doubt from assuming the same digestibility of nutrients of the "flax-product" in the two cases : fed alone or being used as a basal ration. The "mutual associative effect" between hay and flax-product or flax-product and barley grains in two component feed mixture outlined in the previous discussion with direct feeding, would be charged against the tested ration when following the indirect feeding principle. Following this principle appeared to lead to faulty determination of digestibilities and feeding value of the tested ration beside producing "impossible digestibilities" such as over-100 figures.

More logically, it seems that the nutrient digestibilities of the feed A when fed alone cannot remain the same when mixed with another feed B. The reverse appeared to be true, B digestibilities when fed alone would be altered when added to feed A. The concept of "mutual associative effect" among feeds when mixed should start to be accepted. A mean for determing the extent of such "associative effect" on each single feed in the mixture, should be searched for.

References

Abd-El-Motagalli, Z.M.Z. (1972) *The suitability of the metabolizable energy as a feeding standard with ruminants.* Ph. D. Thesis, Cairo Univ., Fac. Agric.

Abd-El-Rahman, M.M. (1966) *Feeding buffalo male calves on different rations for meat production.* Ph. D. Thesis, Cairo Univ., Fac. Agric.

Abou Raya, A.K. (1967) "*Animal and Poultry Nutrition*" 1st. Edit, Dar-El-Maarif (Arabic Textbook).

————————, Abou-El-Hassan, A. and Galal, A.G.H. (1966) The effect of the basal ration in digestibility trials with sheep on the feeding value of the feeding-stuffs. *Proc. 2 nd Anim. Prod. Conf. Cairo*, 1963, 2,507-13.

———————— and El-Talty, Y.I. (1976) New concept on digestibility in feed mixtures. First *International Symposium, Feed Composition, Animal Nutrient Requirements, and Computerization of Diets.* U.S.A.

Rafat, M.A., Hathout, M.K., and Khafagi, E.A. (1969) Methods of evaluating clover hay (*Trifolium alexandrinum*) from different localities. 1. The nutritive analysis and feeding value as TDN and S.V. *Agric. Res. Rev.* 47, 116.

El-Refaai, A.M.M. (1972) *Studies of some factors affecting the feeding value in digestion trials with ruminants.* M.Sc. Thesis, Cairo Univ., Fac. Agric.

Asplund, J.M. and Harris, L.E. (1971) Associative effects on the digestibility of energy and the utilization of nitrogen in sheep fed simplified rations. *J.Anim. Sci.* **32**, 152.

El-Serafy, A.M. (1968) *Some nutritional studies on the suitable combinations of molasses with certain feeding-stuffs.* M.Sc. Thesis, Cairo Univ., Fac. Agric.

El-Talty, Y.I. (1973) *Some factors affecting the feeding value of roughages with reference to lignin.* Ph. D. Thesis, Cairo Univ., Fac. Agric.

Ghoneim, A. (1964) "*Animal Nutrition, Principles and Feeding Stuffs*". 1st. Edt. Anglo-Egyptian Library, Cairo (Arabic Textbook).

Ministry of Agriculture, A.R. Egypt (1968) Animal and Poultry Nutrition. *Technical Bull.* No. 3-1968 (*In Arabic*).

Schneider, B.H. (1947) "*Feeds of the World, Their Digestibility and Composition*". *West Virginia Agr. Expt. Sta.*

دراسة متقدمة عن التأثير الاضافى للأعلاف فى حالة التغذية المباشرة وغير المباشرة فى تجارب تمثيل غذائى على الضأن باستخدام هدير الكتان ودريس البرسيم وحبوب الشعير ٠

يحيى ابراهيم التلتى و أحمد كمال أبو رية
كلية الزراعة ، جامعة القاهرة

عنى البحث بدراسة التأثير الاضافى بين العلفين المخلوطين فى تجارب الهضم المباشرة وغير المباشرة بالاضافة الى دراسة تأثير العليقة الأساسية على كل من معاملات الهضم والقيم الغذائية للاعلاف المختبرة ٠

وقد أجريت خمس تجارب هضم باستخدام كبشين أو أربعة كباش فى تجارب التغذية المباشرة للاعلاف المستخدمة وهى الدريس والشعير وهدير الكتان ٠ كما شملت هذه الدراسة مخلوطين هما هدير الكتان مع كل من الدريس (كمخلوط أول) ومع الشعير ـ (كمخلوط ثان) وهذان المخلوطان استخدما فى حسابات تجارب الهضم غير المباشرة باستخدام أى من العلفين كعليقة أساسية لحساب معاملات الهضم والقيم الغذائية للعلف الآخر ٠

وقد وجد أن استخدام الدريس كعليقة أساسية أدى الى انخفاض القيمة الغذائية لهدير الكتان (المقدرة بطريقة الفرق) بصورة ملحوظة عن مثيلتها المقدرة بطريقة التغذية المباشرة وكانت النتائج هى ١٩ر٧٪ ، ٢٦ر٤٪ معادل نشا على التوالى ٠

وعندما عكس الوضع (استخدم الهدير كعليقة أساسية لحساب الدريس) كانت النتائج منخفضة بوضوح وكانت قيمة الدريس ٢٨٪ معادل نشا من التغذية غير المباشرة بينما مع التغذية المباشرة كانت ٣٤ر٩/ كما كان الانخفاض واضحا جدا للشعير عندما استخدم الهدير كعليقة أساسية فكانت قيمة الشعير من التجربة المباشرة ٨٠ر٩٪ وانخفضت الى ٥٠ر٣٪ معادل نشا ٠

وقد اكتشف ان اضافة علفين فى مخلوط يعطى قيمة غذائية بيولوجية مختلفة عما يمكن حسابه من معلومية القيم الغذائية لكل علف على حدة (بفرض أن القيمة الغذائية للعلفين تظل ثابتة فى المخلوط) وهذا الفرض ثبت خطؤه بيولوجيا وهذا السلوك للأعلاف فى التغذية المباشرة والغير مباشرة أمكن منه الاستنتاج بحدوث التأثير الاضافى المتبادل بين علف وقرينه فى مخلوط مكون منهما ، لأن دراسة التأثير الاضافى فى التغذية الغير مباشرة كانت تدرس التأثير الاضافى من جانب واحد ٠