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By-Product Utilization for Animal Production

Proceedings of a workshop on applied research held in Nairobi, Kenya, 26-30 September 1982

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BY-PRODUCT UTILIZATION FOR ANIMAL PRODUCTION

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Editors: Berhane Kiflewahid, Gordon R. Potts, and Robert M. Drysdale

Résumé[1]

L'utilisation de sous-produits agricoles pour la production animale a fait l'objet d'un grand intérêt de la part des spécialistes de l'alimentation du bétail et à cet égard, le Centre de recherches pour le développement international (CRDI) a subventionné un certain nombre de projets de recherche sur l'alimentation du bétail faisant appel aux sous-produits agricoles et à de nouveaux aliments au cours des neuf dernières années.

Cette monographie est le compte rendu des travaux et délibérations d'un atelier tenu à Nairobi, au Kenya, du 26 au 30 septembre 1982, pour examiner les résultats de recherches prometteuses, qui semblent sur le plan technique et économique être applicables aux systèmes d'alimentation des animaux, pour discuter et recommander les méthodes de recherche appropriées à l'évaluation des sous-produits spécifiques destinés aux systèmes de production animale identifiés ainsi que la normalisation des méthodes d'analyse pour la description de la valeur alimentaire des sous-produits et des aliments nouveaux.

On y trouvera une description des résultats de recherches sur les sous-produits effectuées en Égypte, au Soudan, en Indonésie, en Tanzanie, au Pakistan et au Kenya, suivie d'un résumé des débats sur les avantages et inconvénients de l'approche et des méthodes utilisées dans les essais de composition et de rations de ces sous-produits. Y figurent également des rapports sur les essais de bilan de la valeur nutritive des aliments, l'évaluation des expériences sur les animaux, et les aspects économiques dont il est nécessaire de tenir compte en matière de recherches sur l'utilisation de sous-produits pour l'alimentation du bétail. Et en dernier lieu, cette monographie traite des essais réalisés dans des exploitations agricoles, dans les conditions réelles d'emploi.

[1] Chaque communication du présent compte rendu des travaux et délibérations est accompagnée d'un résumé en anglais, en français et en espagnol.

Resumen[1]

El empleo de subproductos agrícolas para la producción pecuaria es un tema que ha recibido la atención de los especialistas en nutrición animal. El Centro Internacional de Investigaciones para el Desarrollo (CIID) ha apoyado durante los últimos nueve años un buen número de proyectos de investigación sobre alimentación de ganado con subproductos agrícolas y otros alimentos no convencionales.

Este libro contiene los trabajos presentados en un taller celebrado en Nairobi, Kenia, del 26 al 30 de septiembre de 1982 con el objeto de revisar los avances investigativos que se consideran técnica y económicamente factibles de aplicar en sistemas de alimentación animal, de discutir y recomendar metodologías de investigación que permitan evaluar subproductos específicos con destino a sistemas definidos de producción animal, y de discutir la normalización de los métodos analíticos empleados en la descripción del valor nutritivo de los subproductos y las raciones no convencionales.

Los resultados de las investigaciones sobre subproductos en Egipto, Sudán, Indonesia, Tanzania, Paquistán y Kenia, van seguidos de un recuento de las discusiones sostenidas sobre la validez o debilidad de los enfoques investigativos aplicados en la modificación y administración de los subproductos. También se presentan los trabajos sobre medición de la calidad nutricional de los alimentos, su evaluación en pruebas de alimentación y los aspectos económicos que deben tenerse en cuenta en este tipo de investigaciones. Finalmente, se describen y discuten ensayos en finca de los subproductos como alimento animal.

[1] Cada trabajo va accompañado de un resumen en español, francés e inglés.

Contents

Use of By-Products in Animal-Feeding Systems in the Delta of Egypt

M.A. Naga and K. El-Shazly[1]

The gap between available and required amounts of animal feeds in Egypt was calculated to be 9 million tons per year. Almost two-thirds of this gap can be fulfilled by: redistributing consumption of presently consumed feeds over the entire year to provide animals with a well-balanced ration during both winter and summer; supplementing the poor-quality ingredients with urea, molasses, and minerals; chopping the lignocellulosic materials and treating them with some alkali to delignify them (ammonia treatment through the application of urea is recommended as the best treatment); and trying to transfer this knowledge to the small farmer. Due to the weakness of agricultural extension services in Egypt, however, it is thought that the introduction of the new knowledge might be more successful if feed mills of reasonable capacity (e.g., 10 t/hour) could be established. A prefeasibility study for such a plant was presented and the price of the manufactured product was adjusted within the feed efficiency of local animals and prevailing feed and meat prices in the Egyptian market.

En Égypte, la différence entre les besoins en alimentation du bétail et la quantité de produits disponibles a été évaluée à 9 millions de tonnes par an. Environ deux tiers de cette quantité pourraient être obtenus comme suit : en répartissant la consommation actuelle sur toute l'année, afin que les animaux puissent recevoir des rations équilibrées, autant en hiver qu'en été ; en ajoutant de l'urée, de la mélasse et des minéraux aux rations carencées ; en hachant la lignocellulose et en la traitant aux alcalis qui la décomposent par fusion (le traitement à l'ammoniac, par application d'urée, est considéré le plus satisfaisant) ; et en transmettant ces connaissances aux petits fermiers. Cependant, vue l'insuffisance des services de vulgarisation agricole en Égypte, il semble que l'introduction de ces nouvelles connaissances pourrait mieux se faire par l'établissement d'usines de fabrication d'aliments pour le bétail, d'une capacité appropriée (de 10 t/h par exemple). Une étude préliminaire a été effectuée sur la faisabilité d'une industrie de ce type et le prix de ces produits a été fixé en fonction de leur aptitude à satisfaire les besoins du bétail local et des prix de la viande et des aliments pour animaux sur le marché égyptien.

En Egipto, la diferencia entre la cantidad disponible y la cantidad requerida de alimento animal se ha calculado en nueve millones de toneladas por año. Casi dos terceras partes de esta diferencia podrían ser cubiertas si se redistribuyera el consumo de los alimentos que actualmente se ingieren durante todo el año, con el fin de suministrar a los animales una ración bien balanceada tanto en invierno como en verano; si se suplementaran los ingredientes pobres con úrea, melazas y minerales; si se picaran los materiales lignocelulosos y se trataran con algún álcali para deslignificarlos (se recomienda el amoníaco mediante aplicación de úrea) y si se transfiriera de este conocimiento al pequeño agricultor. Como los servicios de extensión agrícola de Egipto son insuficientes, se piensa que la divulgación de los nuevos conocimientos podría tener más éxito instalando moledoras de alimento de una capacidad razonable (por ej. 10 t/hora). Se presentó un estudio de pre-factibilidad para tal planta y se ajustó el precio del

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producto manufacturado entre la eficiencia alimenticia del ganado local y el alimento animal, y los precios de carne prevalecientes en el mercado egipcio.

The gap between available and required amounts of animal feed in Egypt is estimated to be about 9 million tons, of which 4 million tons are concentrates and the remainder roughage. Annual production of animal feed in Egypt meets no more than about 60% of the calculated requirements of the existing animal population. This low nutritional level is reflected in the productivity of Egyptian animals, with local production of animal protein meeting only one-third of the minimum needs of the Egyptian people. The Egyptian government is trying to solve the problem by importing poultry, eggs, milk and milk products, and red meat (beef and lamb). Imports of red meat reached 90 000 tons in 1981. This amount of meat costs about US$170 000, which places a strain on the balance of foreign exchange within the country. Moreover, the government sells this meat at a subsidized price (50%) to the public.

Under such conditions, the utilization of nontraditionally consumed field by-products becomes an obligation. There are about 6 million tons of corn stalks, rice straw, vegetable wastes, and cotton stalks, in addition to another 2 million tons of bagasse and other agroindustrial by-products, that could be introduced as animal feed. There are two limitations to such a trend, however: (1) the incompetent use of these materials, e.g., farmers using them as fuel; and (2) a lack of knowledge of the proper way to include these materials in the animals' diet.

For about 6 years, a group of animal nutritionists in the Department of Animal Production at the University of Alexandria, in cooperation with the International Development Research Centre, has been involved in a project to evaluate methods of improving the nutritive value of poor-quality roughage. The highlights of the information obtained from this project are summarized in this paper.

Present Situation

Currently, two animal-feeding patterns are followed in Egypt: (1) berseem (Egyptian clover), for the most part by itself, is fed to animals between December and May; and (2) wheat or barley straws with some concentrates are fed to animals throughout the remainder of the year. This system has the following disadvantages, in addition to the basic problem of a shortage of feed: about half of the protein content of berseem (20% on a dry-matter basis) is wasted; there is no source of carotene during the summer period; the animals suffer from heat stress during the summer due to the hot weather and high specific dynamic action of the feed straws; and the irregularity of the feed levels and feeding pattern results in depressing animal productivity.

Recommended Use of Available Feed

Berseem, which is practically the sole green forage crop available to the animals and contains (on a dry-matter basis) almost double the amount of protein required, should be fed to animals at half the rate that is presently being used during the winter season. The other half of the berseem crop should be preserved in the form of silage with half of the wheat and barley straw crops and some molasses. This silage would provide the animals with a succulent, balanced, and palatable diet during the summer season. At the same time, the remainder of the wheat and barley straws should be fed to the animals during the winter season along with berseem. This would bring about a better nutrient balance to the winter diet.

Acceptance of this proposal by farmers would have two benefits: (1) The animals would receive a balanced diet of constant composition over the whole year, thus avoiding a seasonal disturbance in production. (2) The nutritive value, i.e., total digestible nutrient (TDN) percentage, of wheat and barley straws would be improved by not less than 50%. (About 2.5 million tons of wheat and barley straws are produced annually, all of which is used for animal feed. The TDN content of these straws averages 42%. It was found repeatedly that feeding straws combined with berseem resulted in no change in berseem's nutritive value as long as the straw ratio in the diet (on a dry-matter basis) did not exceed 50%. This means that the TDN content of the straws fed with berseem would be increased from 42 to 65%. This 54.7% improvement in the nutritive value of the straws is equivalent to a gain of about 1.36 million tons of straws).

Availability of Nontraditional Agricultural By-Products for Animal Feed

It has been determined that some agricultural by-products that have been used traditionally as fuel or are left in the soil as fertilizers can also be used in animal feed. Such materials and their annual production rates (million tons) include corn stalks and cobs, 2.9; sorghum stalks, 1.1; rice straw and hulls, 2.0; bagasse and pith, 1.2; molasses, 0.4; and cotton stalks, 2.4.

A precise survey would be required to estimate the current uses of these materials and the amounts available for use in animal feed, but current estimates indicate that about one-third of the rice straw is used in paper factories; all of the sorghum stalks produced at upper Egypt are used as fuel for burning (hardening) mud bricks; the majority of corn stalks and cobs, as well as cotton stalks, are used by farmers as fuel for cooking and baking; and about one-quarter to one-third of the bagasse is used as fuel in sugarcane refineries, the remainder of the bagasse not being used at all. The following amounts (million tons/year), therefore, are available for use in animal feed: corn stalks and cobs, 0.5; rice straw and hulls, 1.3; bagasse, 0.8; and molasses, 0.4. To this can be added an unestimated amount of vegetable wastes.

Recommended Treatment for Improving the Nutritive Value of Low-Quality By-Products

Field by-products, generally, have low nutritive value because of their relatively high content of lignocellulose and low content of protein and perhaps some other nutrients. Improving the nutritive value of these materials can be achieved by adding the deficient nutrients, correcting the nutrient imbalance, and solubilizing or cracking the lignin layers coating the cells to enable enzymes of microorganisms or the digestive tract of the animal to digest the cell contents.

Urea Supplementation

Supplementation with urea, at levels between 0.5 and 2%, improves digestibility of the nutrients contained in the supplemented material. The TDN content of artichoke crown leaves was progressively improved by increasing levels of urea supplementation. TDN content of corn stalks or bagasse increased from 44 and 45% to 56 and 54%, respectively, due to urea supplementation (Borhami et al. 1975; Mohamed et al. 1971). The nutritive value of low-quality by-products is improved further if the contents of true protein and nitrogen-free extract are reasonable (about 5 and 25% respectively) (Coombe et al. 1971; Mulholland et al. 1976; Clanton 1977; Burroughs et al. 1950 a,b,c). When urea–nitrogen in the diet exceeds 30%, potassium losses in urine may increase, resulting in exhaustion of the animal's body potassium (Juhaz et al. 1975). In the early stages of this phenomenon, bacteria in the rumen begin to suffer from potassium deficiency. The potassium requirements of the plant kingdom (including bacteria) are much higher than those of members of the animal kingdom. The first symptom of the disorder, caused by feeding high concentrations of urea for long periods of time, is depressed bacterial growth and activity in the rumen. Consequently, synthesis of the B-vitamins in the rumen decreases, with a resultant loss of appetite and the development of cerebrocortical nicrosis (Naga et al. 1978).

Mineral Supplementation

Burroughs et al. (1950 a,b,c) pointed out the beneficial effect of alfalfa ash on fibre digestion of poor-quality roughages. They also reported a positive relationship between the digestibility of dry matter and its mineral content. Six sheep were fed a rice straw + concentrate (1:1) diet. The TDN content of this diet and ash balance of these animals were 37% and −21.8 g/head/day respectively. Of the 10 minerals studied, only phosphorus and sulfur balances were positive, the rest being negative. When the deficient minerals were supplemented in amounts sufficient to correct the imbalance, the TDN percentage and ash balance became 57.5% and 11.2 g/head/day respectively. Adjusting the ash balance by the addition of the proper mineral supplements to the diet of calves resulted in the improvements shown in Table 1.

Combined with Good-Quality Ingredient(s)

A low-quality by-product diet could be improved by the addition of protein or energy-rich supplements, or by being combined with good-quality ingredient(s). Supplements are not supposed to exceed 25% of the diet's dry matter otherwise they become a substitute (Crabtree and Williams 1971). Farid and Hassan (1976) concluded that a well-balanced supplement is better for improving low-quality roughage than a supplement rich in only protein or energy. It seems that feeding low- and high-quality ingredients together, at the ratio of 1:1, is more economical. Table 2 shows the results of four combinations of concentrates and by-products fed to growing lambs.

Feeding combinations of ingredients provides the so-called associative effect, i.e., the TDN combination exceeds that calculated by adding the TDN contents of the ingredients (Table 3).

Ensiling with Good-Quality Roughage

Ensiling of rice straw with berseem (1:1 on a dry-matter basis) was compared with feeding rice straw treated with 5% sodium hydroxide and offered with berseem silage (Table 4). Simple ensiling of raw rice straw and berseem proved to be more effective and economic than the other three combinations.

Recommended Alkali Treatments

Sodium Hydroxide

The Beckman NaOH-treatment method appears to be superior to other techniques. Raw rice straw or treated with NaOH according to different methods was included in a complete diet with concentrate mixture and fed to sheep (Table 5).

Ammonium Hydroxide from Urea

Due to the lack of skilled labour in Egypt, it is safer to deal with urea as an indirect source of ammonia than with gaseous or liquid ammonia. It is also cheaper in the Egyptian market. The by-product is sprayed with an equal weight of water, which contains a urea equivalent of 5% of the material's dry-matter weight. The heap is then covered completely with a plastic sheet to prevent exposure to the air. Ammonia

Table 1. Improvement of calves' performance through proper mineral supplementation.

	Mineral supplementation		Percentage improvement
	Without	With	
Feed intake (g/head/day)	1528	2700	76.7
Dry-matter digestibility (%)	64	79.2	23.8
TDN content of the diet (%)	51.3	63.6	24.0
Digestible protein (DP) content of the diet (%)	12.9	17.9	38.8
Daily body-weight gain (g/head)	345	470	36.2

Table 2. Effect of the ratio of high- and low-quality ingredients in the diet of growing lambs.

	Percentage of concentrates[a]/by-products[b]		
	100/0	70/30	50/50
Number of lambs	12	11	11
Daily feed intake (g/head)	1.67	1.76	1.77
Daily body-weight gain (g/head)	188	206	188
Feed efficiency (feed/gain)	8.88	8.54	9.41
Dry-matter digestibility (%)	69.3	67.1	66.9

[a] Concentrates (%): cottonseed cake, 20; rice bran, 5; wheat bran, 36; corn, 29; urea, 2; molasses, 5; and salts, 3.
[b] By-products (%): grape wastes, 32; date seeds, 29.3; orange peel, 19; pea pods, 16; urea, 2; and salts, 1.7.

Table 3. Associative effect gained when different ingredients were fed in combinations.

Combination	Parts of each ingredient	TDN percentage of each component	Calculated sum of TDN percentages	Actual TDN percentage	Percentage improvement
Rice straw	1	42			
Dried berseem	1	63	55.3	75.7	37
Concentrate mix	1	61			
Corn stalks	1	44	50.0	66.5	33
Dried berseem	1	63			
Wheat straw	1	40	55.0	62.0	13
Rice gluten	2	63			
Rice straw	1	41	50.5	65.0	29
Dried berseem	1	60			
Wheat straw	1	42	50.0	59.0	18
Dried berseem	1	58			

Table 4. Results of feeding different combinations of rice straw, offered with berseem silage, to sheep.

Combination	Estimated TDN percentage using sheep
Berseem silage + raw rice straw	69
Berseem silage + 5% NaOH-treated rice straw	74
Ensiled raw rice straw with berseem	75
Ensiled 5% NaOH-treated rice straw with berseem	68

Table 5. Comparison of the effect of different NaOH treatments on the nutritive value of rice straw.

NaOH-treatment method	TDN percentage	
	Of the whole diet	Of rice straw alone (calculated by difference)
Control	59	46
Beckman[a]	72	69
Boliden[b]	69	62
Jackson[c]	55	44
Pigden[d]	58	44

[a] Soaked in 1.25% NaOH followed by two water soakings.
[b] Sprayed with 4% NaOH + 2% $Ca(OH)_2$ followed by neutralization with H_3PO_4.
[c] Mixed with equal volume of 5% NaOH.
[d] Sprayed with 40% NaOH to provide 5% NaOH on the straw.

evolves within 12–24 hours from the urea as a result of microbes contaminating the surface of the material. After 3–4 weeks during the summer or 5–6 weeks during the winter, the treatment is complete. The heap can then be uncovered to enable the removal of the ammonia that was released.

Improvement in nutritive value in response to the application of urea by the above method was greater than through supplementation of the material with urea. Table 6 compares the nutritive value of corn stalks under various conditions. The treatment resulted in a considerable improvement in both the voluntary intake and TDN content of the material. More important is the improvement in the initial mineral balance. The treatment converted the mineral content to a more readily available form.

Use of By-Products on an Industrial Scale

Along the edges of the delta, about 324 000 ha have recently been reclaimed. The population in this area is very limited due to its location inside the delta. There is a surplus of by-product materials, therefore, that can be manufactured on an industrial scale to produce complete animal feed or improved roughage. These two types of manufactured animal feeds are unfamiliar to Egypt. Recently, the Egyptian Ministry of Agriculture agreed to the licencing of feed mills to produce complete animal diets. Efforts are now under way to obtain the ministry's approval for producing manufactured roughage. In this way, the use of

Table 6. Comparison of the effect of using urea to treat corn stalks or as a supplement.

	Type of corn stalks		
	Raw	Urea-supplemented	Urea-treated
Intake (g/head/day)	694	957	1279
TDN content (%)	50.8	61.0	65.0
Digestible protein content (%)	2.0	3.1	3.9
Nitrogen balance (g/head/day)	0.0	0.8	0.8
Ash balance (g/head/day)	−40	−28	39

by-products will be under government control, which will help in the government's efforts to direct agricultural activities in Egypt.

Operational Characteristics of the Feed Mill

About 35 km south of Alexandria is a large agricultural company cropping about 12 000 ha. This company, Mariut Co., is a model in the newly reclaimed area. The resources available to the company at the site and the amounts required annually are presented in Table 7. The average price (EG£) per ton of air-dried mixtures of these ingredients is 7.8. At a rate of 300 working days/year, 2 shifts/day, 7 hours/shift, and a mill capacity of 48 000 tons, the hourly capacity of the mill is 11.4 tons/hour.

Costs

The capital cost to the mill of collecting and transporting raw materials to the mill amounts to EG£28 000.

It is beneficial for animals to receive a constant diet over the whole year in order to avoid a decrease in production due to shifting from one diet to another. Therefore, about half of the ingredients produced during a season will be stored for another season. It is estimated that 19 000 tons need to be stored. The average density of these materials is about 0.4. The area required for storage, therefore, would be 47 000 m^3. If this amount is stored as bales in blocks 3 m high and covering an area of 6 m × 12 m, with 2 m roads between each block, the area required for storage would amount to 2 ha. To rent an area of this size would cost EG£1000/year or EG£0.05/ton, which might reach EG£0.2/ton after adding in the cost of labour.

Treatment with urea (5%) is the recommended method for delignifying and enriching the mixture of these materials with nitrogen. Treatment of 80−100 tons takes place in a ditch coated with asphalt, the material being heaped to a height of about 1 m above the ground. During the heaping process, it is sprayed with urea solution. The heap is then covered with plastic or jute sheets coated with mud. The cost per ton of the final product is EG£7.3.

The treated materials should then be dried before they are ground. This is accomplished using a negative pressure jet-flow forage dryer, heated with oil, with a capacity of 20 tons/hour. The cost of the drying process is EG£6.56/ton.

A conveyer belt then receives the dried material and feeds it to the hammer mill. The material is conveyed to a mixer where minerals are added, a conditioner where molasses is added, a press for pelleting, a cooler, and then the bagging unit. The cost of this process is estimated to be EG£19.99/ton.

If a lorry of 10 tons capacity is used for transporting the feed bags to clients in Alexandria (about 30 km distance), the

Table 7. Requirements of the Mariut Co.

	Thousand tons/year	Price (EG£)	
		Per ton	Total
Sorghum (green)[a]	89	6	534000
Corn stalks (dry)	9	15	135000
Berseem and alfalfa (green)[b]	65	9	585000
Vegetable wastes[c]	9	10	90000
Total	172[d]		1344000

[a] Equivalent to 24 000 tons air-dried material.
[b] Equivalent to 11 000 tons air-dried material.
[c] Equivalent to 4 000 tons air-dried material.
[d] Equivalent to 48 000 tons air-dried material.

transportation cost per ton will be EG£2.50/ton.

The total cost/ton of the manufactured by-products, therefore, comes to EG£45.265/ton.

Marketing

If the final product is sold for EG£55.35, the profit (22.2%) will be encouraging enough for investors to provide the required capital. A price of EG£55.35 is very low in comparison with the prices of wheat straw or berseem hay in the Egyptian market. Moreover, the TDN and digestible protein contents of the product (65 and 10% respectively) are considerably higher than those contained in the hay or straw. This price is within the limits of the farmer. The governmentally fixed price for 1 kg live weight of animals is EG£1.08. Assuming that 20% of this price is profit for the producer (farmer), then the cost of producing 1 kg live body weight would be EG£0.864. It is well known that feed costs account for 65% of the total cost of production. The feed costs to produce 1 kg of body live weight, therefore, would be EG£0.562. Because the feed efficiency of Egyptian cattle averages 10 units of feed to 1 unit of body weight, the EG£0.562 should be the price of 10 kg of feed. This means that any feed that could be purchased at EG£56.5/ton would be consistent with prices currently prevailing in the Egyptian market.

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