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THE EFFECT OF TREATING RICE HULLS WITH AMMONIA ON ITS NUTRITIVE VALUE

by

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Summary

In a latin square designed experiment, rice hulls and ammoniated rice hulls were compared with wheat straw and ammoniated wheat straw regarding the coefficients of digestibility, total digestible nutrients, nitrogen retention and rumen microbial activity using four adult Barky rams.

The total digestible nutrients of ammoniated wheat straw and wheat straw were significantly higher than the total digestible nutrients of ammoniated rice hulls which is a reflection of higher coefficients of digestibility of NFE and crude fiber of the former. There were no significant differences in coefficients of digestibility of crude protein between roughages. Variations in ether extract digestion approached high significance between wheat straw and rice hulls but was only significant between wheat straw and ammoniated rice hulls. There was a significant difference between ammoniated rice hulls and rice hulls in crude fiber digestibility.

The nitrogen retention values were higher when the rams received ammoniated rice hulls or ammoniated wheat straw than when they received normal rice hulls or wheat straw supplemented with the same concentrate mixture and these variations were highly significant.

On wheat straw the volatile fatty acid production in the rumen of sheep tended to be higher than when rice hulls were fed. The ammoniated roughages tended to give higher VFQ and ammonia nitrogen curves than non-ammoniated roughages.

Introduction

It has been shown that rice hulls could be used with advantage to replace part or all of the roughage on drylot feeding (Fahmy *et al* 1968) and as a supplement to berseem (*Trifolium alexandrinum*) + a concentrate feed (Badr and Abou Akkada, 1965).

Lignin and silica content of rice hulls are mainly responsible for its low nutritive value, together with the fact that it contains no digestible crude protein. Many workers have shown that treating low quality roughages with alkali improve its nutritive value (Lucifero, 1958; Abdulwahab *et al.* 1953); Hussein *et al.* 1953).

More recently (Zafren, 1961; Chomyszyn *et al*, 1959) the use of ammonia for treating straw was shown to improve the feed value and pro-

tein value. Other roughages have also been treated with ammonia and acetic acid and a definite improvement of nutritive value was observed (Lotfy *et al.* 1966).

The present experiments were done in order to estimate the effect of treating rice hulls and wheat straw on their nutritive value.

Materials and Methods

Rice hulls (RH.) and ammoniated rice hulls (ARH.) were compared with wheat straw (WS.) and ammoniated wheat straw (AWS.), in latin square designed digetibility trials. Four Egyptian Barky rams (Nos. 1039, 1095, 1227 and 1236) each over 2 years old and of similar weight were used for estimating the coefficient of digestibility, total digestible nutrients and nitrogen retention. Each trial consisted of 15 days preliminary period followed by 7 days collection period.

During collection the animals were housed in individual metabolic cages; the animals were fed as to cover their maintenance requirements. In trial 1, each ram. was fed daily 7.4 kg. berseem 2nd cut. In trial 2, each ram was fed daily 0.5 kg. concentrate mixture at 9 am.+3.75 kg. berseem 2nd cut introduced at 2 pm In trials 3, 4, 5 and 6 each ram was fed daily 0.5 kg. concentrate mixture + 0.75 kg. from the tested feeds. One percent of common salt and 2% calcium carbonate were added to the concentrate mixture. Digestion coefficients were determined by difference.

Faeces were collected daily in nylon bags and were mixed thoroughly, weighed and 10% of each days collection was used for dry matter determinations. Samples from each ram taken over the whole collection period (7 days) were pooled together, ground and kept in tightly closed containers for chemical analysis.

The volume of urine was measured daily and 10% portions of each urine collection were taken. Urinary nitrogen was determined daily. In trials 3, 4, 5 and 6, at the end of each collection period the rumen activity was studied. Rumen samples were taken by a stomach tube before and after 1, 2, 3, 5, 5 and 7 hrs of feeding for volatile fatty acids and ammonia determination.

Preparation of Ammoniated Rice Hulls and wheat Straw

Commercial ammonia solution of 17% (v/v) and commercial acetic acid of 52% (w/v) were used in the treatment. Fourteen litres of ammonia solution and 200 litres of water were mixed with 100 kg. of each of the used roughages and then kept in covered barrels for three days. On the fourth

day the barrels were emptied and the roughage was mixed with 18 litres of acetic acid and 100 litres of water and kept for one more day in the covered barrels. On the sedond day the roughages were put in bags and dried in a stream of cold air.

Methods of Analysis

Analysis of feedstuffs and faeces were carried out according to the official methods of the A.O.A.C. (1960). Total nitrogen in urine was estimated by the microkjeldahl method (Chibnall *et al.* 1943) using the Markham micro-distillation apparatus (Markham, 1942). Rumen liquor used in all determinations was strained in cheese cloth and deporteinized by mixing a 10 ml. sample with 10 ml. 0.1 N HCl in a 50 ml. volumetric flask and was completed with distilled water (Warner, 1956). The filtrate was used for the estimation of volatile fatty acids and ammonia nitrogen.

TABLE 1.

Analysis of feedstuffs used in the experiments.

Feed	Dry matter	Crude protein	Ether extr.	Soluble carbon.	Crude fiber	lignin	Ash
Berseem 2nd cut	15.33	2.66	1.09	5.83	3.73	—	2.02
Concentrate mixture	93.13	17.00	11.05	43.10	12.37	—	9.61
Wheat straw	89.32	2.36	1.26	37.70	36.85	22.55	11.13
Ammoniated wheat straw	87.64	4.24	1.24	34.39	36.33	21.73	11.44
Rice hulls	89.91	3.36	1.53	26.11	39.52	30.10	19.39
Ammoniated rice hulls	86.88	4.62	1.29	21.07	41.44	27.18	18.46

Concentrate mixture consisted of cotton seed cake and rice bran in the ratio of 1:1+2% calcium carbonate and 1% common salt.

Volatile fatty acids were determined by steam distillation and titration with standard alkali taking precautions against CO_2. Ammonia-N was determined by using Van Slyke and Cullin's aeration tubes Hawk *et al.* (1952).

Lignin was determined in feedstuffs by treatment with 72% H_2SO_4 at room temperature for 3 hr (Salo, 1957).

Results

Table 2 shows the coefficients of digestibility and total digestible nutrients of feeds used in this experiment. Statistical analysis clearly

TABLE 2

The average coefficients of digestibility of ammoniated and non-ammoniated roughages.

Feeds	Coefficients of digestibility (%)				TDN
	Crude protein	Ether extract	NFE	Crude fiber	
Berseem 2nd cut	71.15±1.92	85.53±0.61	80.05±1.29	62.49±2.44	10.9±0.30
Concentrate mixture	64.95±1.14	82.00±3.09	58.36±2.93	17.62±2.39	58.76±2.99
Ammoniated wheat straw	21.94±17.71	70.95±21.6	80.95±5.67	76.90±3.68	58.63±7.41
Wheat straw	19.07±19.07	87.37±8.19	72.56±2.53	71.25±2.25	56.51±3.47
Ammoniated rice hulls	17.46± 6.70	60.90±23.1	41.56±7.92	32.97±3.82	24.99±5.48
Rice hulls	7.40± 5.82	47.95±17.5	41.95±4.68	21.39±6.83	21.36±4.40

showed that the TDN of ammoniated wheat straw or wheat straw were significantly higher than that of ammoniated rice hulls or rice hulls. The differences between ammoniated and non-ammoniated wheat straw or rice hulls concerning TDN were not statistically significant.

It also appeared that there were no statistically significant differences between ammoniated wheat straw, wheat straw, ammoniated rice hulls and rice hulls in coefficients of digestibility of crude proteins. Variation in ether extract approached high significance between wheat straw and rice hulls but was only significant between wheat straw and ammoniated rice hulls.

It could also be noticed that the ammoniated wheat straw and wheat straw had a higher coefficient of digestibility of NFE than ammoniated rice hulls and the variations approached high significance. However, the differences in the digestibility of NFE between ammoniated and non-ammoniated wheat straw or rice hulls were not statistically significant. Ammoniated wheat straw and wheat straw had a significantly higher crude fiber digestibility than ammoniated rice hulls or rice hulls. There was no significant difference between ammoniated wheat straw and wheat straw but there was a significant difference between ammoniated rice hulls and hulls in the crude fiber digestibility.

TABLE 3

Average nitrogen retention values

	Berseem 2nd cut	Concentrate mixture +				
		Berseem 2nd cut	Ammoniated wheat straw	wheat straw	Ammoniated rice hulls	rice hulls
N-intake(g./day	31.49± 0.00	29.56± 0.00	18.10± 0.20	15.91± 0.22	18.08± 0.62	17.10± 0.31
N-excreted in faeces (g./day)	9.09± 0.61	9.37± 0.32	8.95± 1.11	8.76± 1.30	8.84± 0.56	9.69± 1.39
in urine (g./day)	2.27± 0.13	3.70± 0.24	1.37± 0.18	1.42± 0.15	1.68± 0.20	1.57± 0.17
N-retained (g./day)	20.14± 0.68	16.49± 0.49	7.77± 1.12	5.73± 1.35	7.56± 0.35	5.85± 1.33
N-retained/ N-intake%	63.94± 2.18	55.79± 1.72	42.99± 6.27	36.01± 8.63	41.81± 1.18	34.42± 8.00
N-retained/ N-absorbed%	89.82± 0.65	81.56± 1.34	84.29± 2.42	78.01± 4.27	81.87± 1.89	75.41± 7.37

Results given in Table 3 showed that nitrogen retention values (g/day) were higher when the rams received ammoniated rice hulls or ammoniated wheat straw than when they received normal rice hulls or wheat straw and the variations were highly significant. The differences between ammoniated and non-ammoniated rice hulls and rice hulls or wheat straw, in retained-N / N-intake ratio or in retained-N/absorbed-N were not statistically significant, although ammoniated roughages had higher values than non-ammoniated roughages in these two ratios.

Volatile fatty acids (VFA) were determined at six intervals on the same day as shown in Fig. 2. It appears that the VFA curves tended to be higher when the animals were fed wheat straw in three animals out of four than when rice hulls were fed. It can also be observed that ammoniated roughages tended to give higher VFA curves than non-ammoniated roughges.

Fig. 2 shows the day to day variations in VFA production. Fig. 1 also indicated the degree of variation between the animals on the same type of ration. It is apparent that greater variations occur among the animals than day to day variations in the same animals.

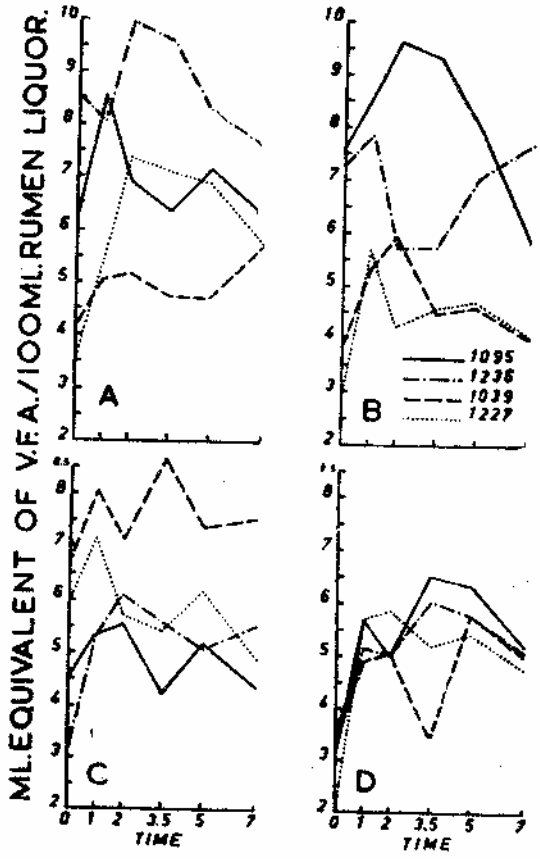

Fig. 1. Volatile fatty acid concentration in the rumen of sheep due to feeding treated and untreated wheat straw and rice hulls.

A. Ammoniated wheat straw. B. Wheat straw.
C. Ammoniated rice hulls. D. Rice hulls.

The ammonia nitrogen caoncentration in rumen liquor (Fig. 3) showed that the ammoniated roughages tended to give higher curves than the non-ammoniated roughage. It also appears that ammoniated rice hulls have higher NG_3-N curves than ammoniated wheat straw in two cases and similar levels in one case. Rice hulls induced higher ammonia-N production than wheat straw in three cases. Fig. 4, gives the degree of variation from day to day on the same animals. Fig. 3, also indicates the degree of variation among the animals given the same ration. Again as for VFA, the degree of variation among animals was greater than the day to day variation in the same animals. The figure also indicates higher ammonia production in ammoniated roughages than non-ammoniated.

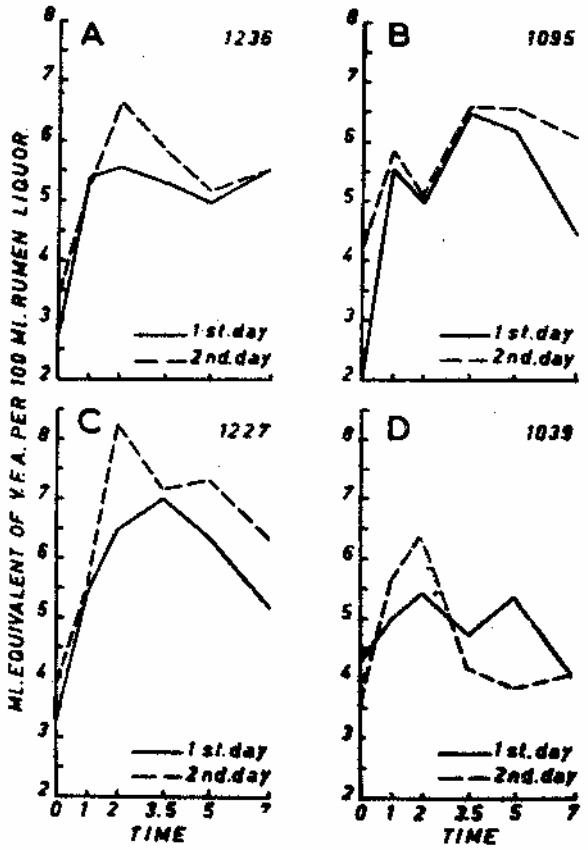

Fig. 2. Volatile fatty acid concentration in the rumen of sheep due to feeding treated and untreated rice hulls and wheat straw. The figure distinguishes day to day variations.

A. Ammoniated rice hulls. B. Rice hulls.
C. Ammoniated wheat straw. D. Wheat straw.

Discussion

Treating wheat straw or rice hulls with ammonia solution and acetic acid, as shown previously, resulted in an increase in the crude protein associated with a decrease in dry matter, ether extract, nitrogen free extract and ash. This decrease may be due to the use of a large quantity of water which removed a portion of these constituents, because neither rice hulls nor wheat straw could absorb this quantity of water which escaped before drying. Higher retentions were observed in the work of Lotfy *et al.* (1966). The only difference was in the use of plastic bags rather than barrels.

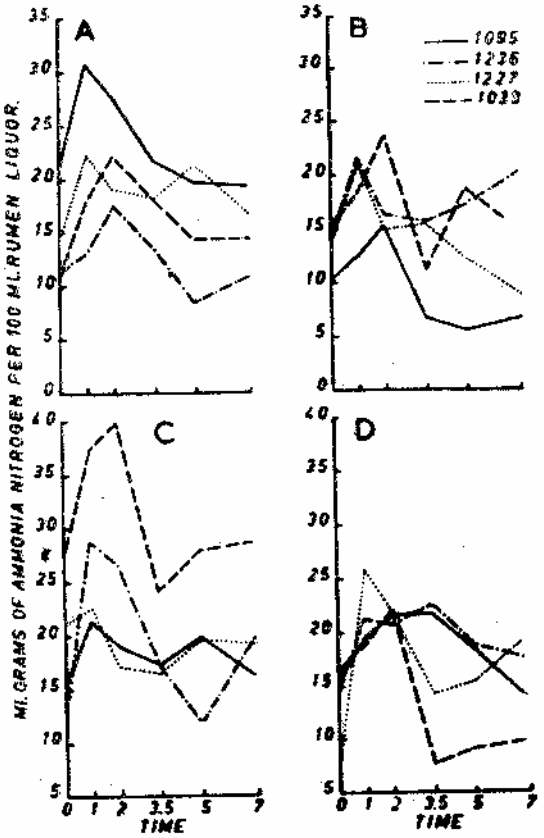

Fig. 3. Ammonia-N concentration in the rumen of sheep due to feeding treated and untreated wheat straw and rice hulls. The figure describes the variations among the animals.

A. Ammoniated wheat straw. B. Wheat straw.
C. Ammoniated rice hulls. D. Rice hulls.

There was no statistically significant difference among coefficients of digestibility of ammoniated and non-ammoniated wheat straw or rice hulls except in crude fiber coefficients of digestibility this was mostly because the coefficients of digestibility were determined indirectly in the presence of concentrates. This is clear since wheat straw has a TDN value which never exceeded 45% when determined alone but had a TDN value of 56% in the present work.

Concentrates are good sources of protein with high digestible values and soluble carbohydrates which provide microflora with a good source of energy and stimulate fermentation and digestion of the roughage.

Campling, (1966), Montgomery and Baumgardt (1965), Putman and Loosli (1959) and Hibbs *et al.* (1956) reported that the when concentrates

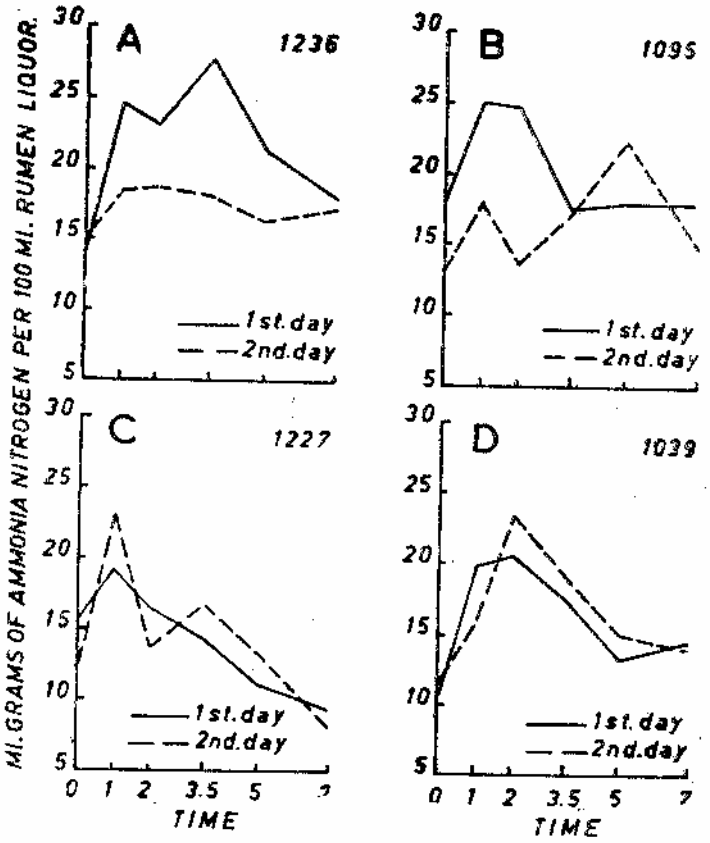

Fig. 4. Ammonia-N concentration in the rumen of sheep due to feeding treated and untreated wheat straw and rice hulls. The figure shows the day to day variations.

A. Rice hulls B. Ammoniated rice hulls.
C. Wheat straw D. Ammoniated wheat straw.

were given to cows fed on hay, digestibility of organic matter in the hay increased. Apparent coefficients of digestibility of dry matter, crude protein, ether extract, N-free extract and total carbohydrate fraction increased as the proportion of concentrates in the ration increased. Eriksson (1952), Burroughs, *et al.* (1949) reported that the digestibility of the organic matter, crude protein, crude fiber and energy of the ration increased with increasing protein content. The amount of metabolisable energy expressed as a percentage of gross energy increased linearly with increasing protein level.

The improvement due to treatment with ammonia was, therefore, hidden because of the use of the concentrates. Treatment with ammonia or addition of ammonium salts to the roughages has been used with

good results. Lotfy *et al* (1966) reported improvement of corn cobs treated with ammonia up to 38%. The digestibility of ammonia-N was found to be about 64-80% (Chomyszyn *et al.* 1959).

In the present experiment coefficients of digestibility of crude protein were on the average higher in the treated than in the untreated roughages. There was greater variability in crude protein coefficient of digestibility than in any other component. Some of the animals fed on untreated roughages (Table 2) showed positive coefficients although there was practically no nitrogenous constituents in these roughages. The reason for these strange results is mostly due to carry-over effects from previous trials. Such positive coefficient only appeared when in the sequence of the latin square design experiment, the trials with untreated roughages followed those of the treated roughages. This would mean that a preliminary period of 15 days is not enough for depleting the N-reserves from previous rations.

Differences between rice hulls and wheat straw in TDN were statistically highly significant. These reflect mainly the differences in degree of digestibility of crude fiber and N-free extract.

Chemical analysis of wheat straw and rice hulls showed that rice hulls contained higher percentages of crude fiber, lignin and silica. Highly significant negative correlation is known to exist between total digestible nutrients and crude fiber and lignin content (Eng, 1964; Hagemeister, 1964; Pond *et al.* 1962; Blanche, 1962; Quarterman, 1961; Crampton and Maynard, 1938). On the other hand Ellis and Pfander (1958) reported that the depressing effect of cellulose on digestibility of organic matter and TDN was due in part to the diluting effect of the cellulose and inpart to an inherent depressive action. It was suggested that other organic constituents of the diet form an indigestible complex compound with cellulose.

Nitrogen retention study in the latin square design experiment indicated that animals fed on ammoniated roughages retained more nitrogen (Table 3). Treatment with ammonia increased digestibility of crude protein and nitrogen retention. Ammonia is a good source of nitrogen for ruminants and ruminal microorganisms could easily utilize it in building microbial protein. The ruminants derive 60-80% of their nitrogen from microbial sources (Weller *et al.* 1958).

More volatile fatty acids were formed in the rumen of sheep fed wheat straw than those fed rice hulls. This is again, in favour of wheat straw as a roughage for stimulating microbial activity. Wheat straw has more total digestible nutrients than rice hulls. There is a significant positive correlation between digestible carbohydrates, and total digestible nutrients and concentration of volatile fatty acid production *in vitro* (el-Shazly *et al*, 1963). Higher VFA production was also found for ammoniated roughages

than for non-treated roughages. Ammonia is known to stimulate rumen activity (Balch and Rowland, 1957; Davis *et al.* 1957; Gray and Pilgrim 1952).

In spite of the fact that the TDN value of rice hulls (21.36%) was much lower than that of wheat straw (56.51%), growth rate, feed consumption and efficiency of feed utilization in the group feeding experiment (Fahmy *et al.* 1968) was not significantly different.

This can only mean that the presence of rice hulls in the diet improved the utilization of feed constituents. Although this is difficult to understand there is evidence (Gooley and Burroughs, 1962) that the addition of sand to a diet high in concentrates stimulated better utilization of the ration. The relatively high silica in the rice hulls may have produced a similar effect in the present experiment. It is also possible that the texture of the ration was also responsible for such a difference. Rice hulls were finely ground while wheat straw was administered in the normal form. There is a volume of data (Woods and Rhodes 1962, Meyer *et al.* 1959; Blaxter and Graham, 1956a) indicating better utilization of feed constituents when rations were finely ground despite lower digestibilities.

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تأثير معاملة سرس الارز بالامونيا على قيمتها الغذائية

الملخص

عومل سرس الارز وتبن القمح بمحلول الأمونيا وذلك بالنقع لمدة ثلاثة أيام ثم معادلة الزيادة من الأمونيا بمحلول حمض الخليك ثم التجفيف بتيار من الهواء البارد ثم قورن سرس الارز العادى والمعامل بالأمونيا بتبن القمح العادى والمعامل بالامونيا من حيث معاملات الهضم ومجموع المواد الغذائية المهضومة والأزوت المحتجز وكذلك من حيث نشاط الاحياء الدقيقة فى الكرش وتكوينها للاحماض الدهنية الطيارة وكذلك لكمية الازوت الموجودة فى صورة أمونيا فى سائل الكرش وذلك باستخدام أربعة ذكور من الأغنام البرقى وباستعمال تصميم المربع اللاتينى .

وقد قدم لكل حيوان نصف كيلو جرام من مخلوط كسب القطن ورجيع الارز وكذلك ثلاثة أرباع كجم من أى من المواد المالئة .

وقد وجد من هذه التجارب أن التبن المعامل أو التبن العادى كان مجموع المواد الغذائية المهضومة اكبر منها فى حالة سرس الأرز المعامل أو سرس الارز العادى وكانت الزيادة جوهرية جدا ولكن الاختلافات بين كل من تبن القمح المعامل وتبن القمح العادى كذلك سرس الأرز المعامل وسرس الارز العادى لم تكن جوهرية احصائيا ، ولم توجد اختلافات جوهرية فى معامل هضم البروتين الخام بين كل من المواد المالئة الاربعة وان كان معامل هضم البروتين الخام فى المواد المعاملة فى الأمونيا أعلى منها فى حالة المواد الغير معاملة .

وقد كان معامل هضم الألياف الخام فى حالة سرس الارز المعامل أعلى منها فى حالة سرس الارز العادى وكان الاختلاف جوهريا ويرجع انخفاض مجموع المواد الغذائية المهضومة فى حالة سرس الارز المعامل والعادى الى احتوائها على نسبة كبيرة من الالياف الخام تبلغ حوالى ٤٠ ٪ وكذلك انخفاض معامل هضم الالياف الخام .

وقد كانت نسبة الآزوت المحتجز الى الأزوت الممتص أكبر فى حالة سرس الارز وتبن القمح المعامل عنها فى سرس الارز وتبن القمح الغير معامل .

وتميل منحنيات الاحماض الدهنية الطيارة بأن تكون أعلى فى حالة التبن المعامل والغير معامل عن تلك الناتجة من السرس المعامل والغير معامل وهو ما يتفق مع ما هو معروف عن العلاقة الطردية بين مجموع المواد الغذائية المهضومة والاحماض الدهنية الطيارة المتكونة فى الكرش ولم يكن التحسين نتيجة المعاملة بأمونيا مؤكدا احصائيا وذلك نظرا لوجود مخلوط المواد الغذائية المركزة الذى يعتبر مصدرا غنيا بالبروتين والكربوهيدرات سهلة الذوبان .