Dept. of Animal Hygiene,
Fac. of Vet. Medicine, Assiut University,
Head of Dept. Prof. Dr. Nabila Gazia.

PRELIMINARY STUDY OF USING TREATED WHEAT STRAW IN RABBIT DIETS

(With 5 Tables & 6 Figures)

By

A. M. Abd-Ellah

(Received at 15\5\1995)

دراسة أولية عن أستخدام تبن القمح المعامل كيميائيا فى غذاء الأرانب

عبد الستار عبد اللاه

أجريت ست تجارب هضم على الأرانب البلدى لدراسة تأثير المعاملة الكيميائية لتبن القمح بهيدروكسيد الصوديوم على معاملات هضم عناصره الغذائية وقيمته الغذائية، هذا بالاضافة الى دراسة أثر المعاملة الكيميائية على مكونات التبن من العناصر الغذائية المختلفة. ولاجراء هذه الدراسة تم نقع تبن القمح لمدة ثمان ساعات فى محلول هيدروكسيد الصوديوم عند التركيز ٤٪، ٨٪، بعد ذلك تم غسله بماء مقطر وترك ليجف فى حرارة الشمس قبل تقديمه الى الأرانب فى عليقه حافظه تحتوى على ٨٠٪، ٧٥٪ مخلوط مركزات. استمرت تجربة الهضم لمدة اسبوعين، أحدهما كفترة تمهيدية والآخر كفترة تجميع. أستخدمت الطريقة الجبرية البسيطه فى حساب معاملات هضم العناصر الغذائية لكل من التبن الغير معامل والمعامل وقيمته الغذائية عند تغذيته مع مادة العلف الأساسية (مخلوط مركزات). وقد اسفرت نتائج الدراسة عن: أدت المعاملة الكيميائية لتبن القمح الى زيادة جوهرية فى محتوى كل من الرماد والأليف الخام والى نقص جوهرى فى محتوى كل من مستخلص – الاثير والكربوهيدرات الذائبة والبروتين الخام، بينما كان النقص فى المادة العضوية غير معنوى. وأدت المعاملة الكيميائية لتبن القمح الى تحسن جوهرى فى معاملات هضم عناصرة الغذائية وأيضا قيمته الغذائية. ويستخلص من هذا البحث أن المعامله الكيميائيه لتبن القمح بهيدروكسيد الصوديوم مفيدة وأدت الى تحسن فى معاملات هضم عناصره الغذائيه وأيضا رفع قيمته الغذائية فى الأرانب، ويمكن اضافته بعد المعالجة الكيميائيه فى علائق هذه الحيوانات كمادة علف مالئه ومحسنة.

SUMMARY

Six digestion trials have been carried out on adult male rabbits to investigate the effect of treated wheat straw with sodium hydroxide solution and subsequent neutralization with distilled water on its digestibility and nutritive value for rabbits. The effect of NaoH treatment on the chemical composition of the wheat straw was also studied. Chopped wheat straw was soaked in a solution of 4&8 % NaoH (4&8 g NaoH / 100 g staw). After 8 hours the soaked straw was neutilized with distilled water, while the control (untreated one) was soaked only in distilled water for the same time.The straws (untreated and treated) were exposed to sun to be dried before being offered to rabbits in a maintenance diets containing 80&75 % concentrate mixture. The rabbits were subjected for a 7 days preliminary and other 7 days for collection periods. To

avoid the associative effect of the basal food, the digestibility and the nutritive value of both treated and untreated wheat straw were calculated by using the simple algebric method. The obtained results showed that: The most constituent changes associated with NaoH treatment are a significant higher content of ash and CF, while that for EE and NFE are significantly decreased. The contents of OM and CP are also decreased. The NaoH treatment of wheat straw specially at 8 % significantly improved its digestibility and nutritive value. From these results it could be concluded that NaoH treatment is effective in improving the digestibility and the nutritive value of wheat straw for rabbits.

Keywords: *Wheat straw-Rabbit-diets*

INTRODUCTION

Chemical composition of low quality roughages (cereal straws and stovers) are characterized by high levels of crude fiber, low nitrogen-free extract, low nitrogen and variable ether-extract. Analysis of roughages by detergent procedure *(GOERING & VAN SOEST 1970)* have shown that are high in lignocellulose contents (lignin, cellulose, hemicellulose, etc.)

Chemical procedures to improve the digestibility and hence the nutritive value. of cereal straws have been of interest since the work *BECKMAN (1921)*. More recent experiments have investigatedd a variety of chemials and physical processing methods using a wide range of cellulosic materials *(REXAN et al., 1975 ; McMANUS and CHOUNG, 1976; BRAMAN and ABE, 1977; KLOPFENSTEIN, 1978; and GARRETT et al., 1979)*.

Chemical treatment of cereal straws and stovers with alkali have shown that soluble nutrients like crude protein, nitrogen-free extract and ether-extract are solubilized and lost in solution resulting in increased crude fiber and associated cell wall constituents and ash content *(OLOLADE et al., 1970 ; SAXENA et al., 1971 ; HUTANUWATER et al., 1974; BRAMAN& ABE, 1977 and LEVY et al., 1977)*.

Different alkalis may be used for treatment of low quality roughages. Treatment with sodium hydroxide has been used extensively on a practical scale, as the alkali is relatively cheap and the energy value of straw can be raised as much as to be comporable to the early cut grass or grass silage *(THEANDER, 1982)*.

Wheat straw is relatively high in the known digestibility depressent lignin 12 % and is high in silica 6% *(Musiba et al., 1981)* which also can have a depressing influence on digestibility *(KAWAMURA et al., 1973)*. The chemical treatment of straw increases its digestibility by dissolving the lignin

content of the straw *(GARRETT et al., 1979)*.

Research with several varieties of straw *(SINGH and JACKSON, 1971; JAYASURIYA and OWEN, 1975)* and other roughages *(KLOPFENSTEIN et al., 1972 and OJI et al., 1977)* have demonstrated improved digestibility of organic matter and energy for ruminants when poor quality is treated with NaoH. However, the lower digestibility of nitrogen in the diets containing alkali treated straws has been reported earlier *(Garrett et al., 1974 and OJI et al., 1977)* but is in variable finding *(SINGH and JACKSON, 1971 and KLOPFENSTEIN et al., 1972)*.

In contrast, there appears to be little literature on the use of alkali-treated roughages for rabbits. *CHEEKE (1987)* cited that, the alkali treatment of straw and other low-quality roughages increases fiber digestibility in rabbits. Alkali treatment dissolves lignin, providing greater access to cellulose by bacterial cellulases.Alkali treatment might also promote greater degradation of fibrous feeds to small particles during mastication and increasing their retention in the caecum *(LAPLACE and LEPAS, 1977)*.

Therefore, the purpose of the present investigation is to highlight the effect of sodium hydroxide treatment on the chemical composition of wheat straw and also on its digestibility and nutritive value for Baladi type rabbits.

MATERIALS and METHODS

Adult male rabbits of Baladi type were used to study the effect of sodium hydroxide treatment of wheat straw on its digestibility and nutritive value. Six observations were obtained by randomly assigning five rabbits to receive each diet during the experiment. The rabbits were nearly of the same age (12 months) and weight (1.900 kg). The animals fed were at approximately maintenance level according to NRC (1977).

Wheat straw was chopped into 3-5 cm and bulked into a bag. One kg of each of bulked straw was weighed out and placed into small laboratory plastic silos. The packed materials were treated with sodium hydroxide at 4 and 8 % (as-fed basis). In each treatment, the packed silo was wetted with 4 liters of the NaoH solution for 8 hours. The silo was thereafter drained of excess lye and the contents rinsed once with distilled water. Alkali- treated products were sun-dried before being fed to animals *(MEHREZ et al., 1981 and MUSIMBA, 1981)*.The control straw was soaked only in distilled water and left to be sun-dried.

The control (untreated straw) and the two treated straws were incorporated into diets at the two levels of 20 & 25% to approach the needed maintenance

requirements for rabbits as nearly as possible. The two component mixtures were nearly the same chemical composition and consequently the same digestibilities.

The rabbits were housed individually in units each containing six hutches.Each individual hutch has a floor area of 60 X 65 cm and 45 cm hight. The mixed diets were fed to the rabbits for a duration of two weeks, one as collection period preceded by another one one as preliminary period *(CHEEKE, 1987).* The food was offered twice daily at 10 a.m. and 3 p.m. Water and mineral-vitamin mixture (12% rabbit premix, 24% common salt and 64% ground limestone) were offered ad libitum.

The feces were collected from each rabbit once daily, dried and stored in screw top glass jars.The dried feces of each rabbit, were mixed at the end of the collecting period , ground and kept for chemical analysis. Samples of the diet ingredients including wheat straw (untreated and treated) were also chemically analysed for determination of the dry matter (DM), crude protien (CP), ether-extract (EE), crude fiber (CF) and ash.. Nitrogen-free extract (NFE) was calculated as residual according to the traditional methods of AOAC (1984).

Calculation of the digestibility

1- The direct method was applied for calculating the digestion coefficients of the nutrients and the nutritive value of the six experimental diets.

2-The simple algebric method (EL-TALTY, 1973) was followed to measure the digestibility and the nutritive value of the wheat straw (untreated and treated) when fed with concentrate mixture in the two component mixtures (20 & 80 and 25 & 75%).In the case of the two-component mixtures having the very close proportions, the acual digestibility of any nutrient for food component was supposed to remain constant and could be calculated if the two digestion trials are undertaken with these mixtures. The concentrate mixture composed of : 32 % white corn , 16 % soybean meal and 52 % wheat bran.

The nutritive values of the wheat straw (untreated and treated), concentrate mixture and diets were calculated as digestible protein (DP), total digestible nutrients (TDN), Starch equivalent (SE) and Metabolizable energy (ME).

The TDN was calculated by using Morrison's factors (1959), while the SE was calculated by using the values cited in *GHONIEM (1964)* for rabbits. The ME was calculated by multiplying the SE obtained by 4.267 as cited in *ABOU-RAYA (1967).* The negative digestible coefficients were considered as zero *(KELLNER, 1926).* The statistical analysis for the data was done according to *SPLEGEL (1972).*

RESULTS

The physical composition of the six

experimental diets used in the current study is shown in table 1, while the chemical composition of the feeds , concentrate mixture and the six diets are shown in table 2. The results cleared that each of the six different diets furnishes the rabbits nearly with their needs for maintenance according to NRC (1977).

To measure the effect of NaoH treatment on the chemical composition of wheat straw, analyses were carried out on the straw prior and after the treatment. In table 3 the effect is expressed as difference in composition and also as a percentage of difference (on air-dry basis) between treated and untreated straw.

The effect of NaoH treatment on the digestibilities of DM, OM, CP, EE, NFE and CF as well as on calculated energy content of the straw is shown in table 4 and figures 1&2 , while the values for the digestibility and nutritive value of the concentrate mixture and the six experimental diets are shown in table 5 and figures 3 to 6 .

DISCUSSION

Feed shortage in the dry season is a general problem in many countries. This has been the incentive for the efforts made in countries in the Third World during the last few years, to improve the feeding value of low quality roughages. Sodium hydroxide is the most well known and used alkali for treatment of low quality roughages to improve their digestibilities and hence their nutritive value.

Several workers have conducted experiments designed to determine the effect of amount of alkali on digestibility in vivo. The optimum level varies from experiment to another. In general, the digestibility of the straw has been found to be increased by sodium hydroxide treatment (4-8 g NaoH / 100 g straw) *(ANDERSON & RALSTON, 1973 and WESTGAARD, 1981)*. Therefore the two levels of NaoH 4 and 8 g /100 g straw were choosen in the current study.

The rationale of determining straw digestibility as part of diet containing 80 & 75% concentrate mixture was based on the primise that practical diets would contain at least this rate of supplementation to provide the animals with its needs from different nutrients specially crude fiber (14 %) according to NRC (1977).

There are discrepancies in the literature concerning the actual effect of alkali treatment on the nutritive value of poor quality roughages for animals. The nutritive value of such products was mainly evaluated by the classical indirect feeding trials using a basal feed together with the tested product. The reason for these discrepancies was found

to be mainly due to the type and level of the basal feed *(AL- REFAAI, 1972)*. So the possibility of the associative effect of concentrate mixture (basal food) upon straw digestibility was taken in the consideration and therefore can be excluded in the present study by applying the simple algebric method for measuring the digestibility and the nutritive value of wheat straw.

From the results given in table 3, it is evident that the most constituents changes associated with NaoH treatment are higher ash and CF contents and lower NFE and EE contents. It was observed that there was a significant increase in ash content ($P< 0.01$) when wheat straw was treated with 4% or 8% NaoH, the average increase was ranged between 32 & 42% .The increase in ash content of NaoH treated straw is expected since about 2.3% sodium is added when 4% NaoH is used *(GARRETT et al., 1979)*. In spite of an increasing content of ash with increasing concentration of solution, the DM content of the treated straw was nearly constant. This might reflect a greater ability of water absorption at higher levels of NaoH treatment. The data also show that there was a significant increase (17 & 15%) in the CF content ($P< 0.01$) of the two levels of treatment (4% or 8%).

In contrast, the EE and NFE were significantly decreased ($P< 0.01$) by about 21, 31 & 16, 15% the EE and NFE, respectively in both alkali concentration. The CP was also significantly decreased ($P< 0.05$) in wheat straw treated with 8% NaoH, the average decrease was 13%, but 4% level has a negligable effect. On the other hand, the effect of alkali treatmant on the OM content of the straw is small. The increase percentage is only 2 & 3%, respectively in both concentration . The previous findings are agreed with those reported by *OLOLADE et al., 1970 ; SAXENA et al., 1971; HUTANUWATR et al., 1974 ; BRAMAN and ABE, 1977 and LEVY et al., 1977* who found that the soluble nutrients of straws like CP, NFE, and EE are solubilized and lost in solution as a result of alkali treatment for the srtaws resulting in increased CF and assocaited cell wall constituents and ash.

The results presented in table 4 indicated that the NaoH treatment for the wheat straw by either concentrations significantly ($P< 0.01$) increased the digestibilities of all its nutrients particularly of CF and NFE. The 4% NaoH treatment of wheat straw improved the digestibilities of DM, OM,CP, EE, CF and NFE by about 5, 5, 6, 5, 10 and 12% units, respectively (fig. 1) .

Doubling the amount of NaoH used, significantly increased the digestibilities of all wheat straw nutrients. The improvement in the digestibility coefficients for the DM, OM, CP, EE, CF and NFE were 8, 9, 10, 9, 15 and 16%,

respectively. These findings are in accordance with those reported by *JAYASURIYA and OWEN, 1975; GARRETT et al., 1979 and MEHREZ et al. 1981* who found that the alkali treatment of the straws improved its nutrients digestibilities in ruminants. The obtained findings are also supported in rabbits by *CHEEKE (1987)* who cited that, alkali treatment of straw and other low-quality roughages increases fiber digestibility. The increase in fiber digestibility increases the digestibilities of other nutrients and consequently increases the nutritive value of the straw.

The increase in digestibility indicates that, the treatment brings about some changes in the straw, making the hemicellulose and cellulose more accessable for degradation in the rumen or caecum. *AMAN and THEANDER (1977)* proposed the hypothesis that the lye treatment leads to swelling in the cell wall partly physical and partly chemical by breaking bonds between lignin on one hand and hemicellulose on the other.

The appparent complete indigestibility of CP of the untreated straw could be explained in terms of the amount of metabolic fecal N being equal or in excessed the digested N of the CP of treated straw. The improved digestibility of CP associated with NaoH treatment was probably due to the increase availability of energy for caecum microbes and subsequent inrease in microbial protien synthesis.

Regarding the nutritive value of the wheat straw (untreated and treated), the obtained results in general indicated the improvement in the nutritive value of treated straw in terms DP, TDN, SE and ME by about 0.15% , 8% , 8% and 336 kcal / kg, respectively (fig. 2). The response when increasing the concentration of NaoH from 4 to 8 g per 100 g straw were 0.10%, 4%, 4% and 132 kcal / kg units. This improvement in the nutritive value of wheat straw attributed to the improvement in the digestibilities of its nutrients.These findings are agreed with the previous cited by *CHEEKE (1987)*.

Regarding the digestibility and the nutritive value of the concentrate mixture (basal feed) and the six experimental diets used in this investigation, the obtained data (table. 4) demonstrated that the values for the digestibility of the basal feed and its nutritive value in terms DP, TDN, SE and ME were nearly similar (figures 3&4). This finding reflect that the NaoH treatment had no clear effect on the digestibility of the basal feed. However, the data presented in table 5 indicated an increase in the values of the digestibilities and consequently in the nutritive value of the diets containing alkali treated straw (figures 5&6). The

increase was probably due to the improvement in the digestibility of wheat straw after treatment with NaoH and did not due to any other causes which support the previous findings with the digestibility of the treated straw. It was noted also that the rabbits fed the treated straw did not showed any apparent health problem during the experiments.

Further researches are needed to investigate these effects with other treated roughages on metabolism and blood picture in rabbits.

REFERENCES

Abou- Raya, A.K. (1967): Animal and Poultry Nutriion.1 st ed. Maktabet Dar- El-Maarf (ArabicText Book), 76.

Al-Refaai, A.M.M. (1972): Studies on some factors affecting the feeding value in digestion trials with ruminants. M. Sc. Thesis, Fac. of Agric., Univ. of Cairo, 64 - 72.

Aman, P. and Theander, O. (1977): Chemical modification of straw by alkaline treatment. In: Quality of forage. Proceedings of a seminar organized by NJF, Uppsala 1977. Institutionen for Husdjurens Utfodring och vard. Rapport nr. 54. 151-161.

Anderson, D.C. and Ralston, A. T. (1973): Chemical treatment of ryegrass digestibility and composition changes. J. Anim. Sci., 37, 148.

Association of Official Analytical Chemists (AOAC) (1984): Official methods of analysis, 12 th Washington Dc. 132- 145.

Beckman, E. (1921): Conversion of grain straw and lupins in feed of high nutri-ent value. Chem. Abstr. 16, 765.

Braman, W.L. and Abe, R.K. (1977): Laboratory and in vivo evaluation of the nutritive value of NaoH treated rice straw. J. Anim. Sci., 46, 396.

Cheeke, P. R. (1987): Rabbit Feeding and Nutrition, Academic press Inc.,89-209.

El- Talty, Y.I. (1973): Some factors affecting the feeding value of roughages with reference to lignin. Ph.D. Thesis, Fac. of Agric., Cairo Univ.,41-49

Garrett, W. N. ; Walker , H.G. ; Kohler, G. O., Waiss, Jr. ; Graham, R.P. ; East, N. E and Hart, M. R. (1974) : Nutritive value of NaoH and NH3 treated rice straw, Proc. West.Sec. Aer. Soc. Anim. Sci., 25, 317.

Garrett, W. N. ; Walker, H. G.; Kohler, G. O. and Hart, M. R. (1979): Response of ruminants to diets containing NaoH or NH3 treated straw. J. Anim. Sci., 48, 1,, 92-103.

Ghoniem, A. (1964): Animal Nutrition, principles and feedingstuffs. Anglo -Egyptian lib., Cairo, (Text Book in Arabic), 82 -87.

Goering, H. K. and Van Soest, P. J. (1970): Forage Fiber Analysis, Agric. Handbook, 379, 92 - 98, Agric. Res. Serv., USDA.

Hutanwater, N. F. ; Hinds, C. and Davis, C, L. (1974): An evaluation of methods for improving the in vitro digestibility of rice hulls. J. Anim. Sci., 38,140.

Jayasuriya, M. C. N. and Owen, E. (1975): NaoH treatment of barlely straw ; Effect of volume and concentration of solution on digestibility and intake by sheep. Anim. Prod., 21, 313.

Kawamura, O. ; Senshu, T. ; Horiguchi, M. and Matsumoto, T. (1873): Histochemical studies on the rumen digestion of rice straw cell wall and on the chemical determination of its non - nutritive residue, Tohoku J. Agri. Res., 24, 183.

Kellner, O. (1926): The Scientific feeding of Animals. 2 nd ., Authorized translation by Welliam Good vin, Duck Worth, London W.C.P.,53 - 58.

Klopfenstein, T.J. (1978): Chemical treatment of crop residues. J. Anim. Sci., 46, 841.

klopfenstein, T. J. ; Krause, V. E. ; Jones, M. J. and Walter Woods (1972): Chemical treatment of low quality roughages. J. Anim. Sci. , 35, 418.

Laplace, J. P. and Lebas, F. (1977): Le transit digestiif chez le lapin. 7. Influence de la finess du broyage des constituents d'un aliment granule. Ann. Zootech., 26, 413 - 420 (cited in Cheeke ,1987).

Levy, D. ; Holzer, Z. ; Neumark, H. and Polman, Y. (1977): Chemical processing of wheat straw and cotton by - products for fattening cattle. 1- performance of animals receiving the wet material shortly after treatment. Anim. Prod., 25, 27.

McManus, W. R. and Choung, C. C. (1976): Alkali treatment of rice straw and rice hulls. J. Agri. Sci., 86, 453.

Mehrez, A. Z. ; Shinnawy, M. M.; Abou-Raya, A.K. and El-Ayek, M. (1981): A proposed approach for evaluating NaoH- treated roughages. Workshop on utilization low quality roughages in Africa, The Agri. Univ. of Norway 25 - 27.

Morrison, F.B. (1959): Feeds and Feeding, 2 nd . The Morrison Publishing Co., Iowa, U.S.A., 330 - 340.

Musimba, N.K.R. (1981): Chemical composition of maize stover, rice straw and wheat straw treated with NaoH. Workshop on utilization low quality roughages in Africa, The Agri. Uni. of Norway, Norway, 17- 20.

National Research Council (NRC)(1977): Nutrient Requiremants of Rabbits. Nat. Acad. Sci., Washington, D. C., 123- 125.

Oji, U. I. ; Mowat, D.N. and Winch, J.E. (1977): Alkali treatments of corn stover to increase nutritive value. J. Anim. Sci., 44, 798.

Ololade, B. G.; Mowat, D. N. and Winch, J. E.(1970): Effect of processing methods on the in vitro digestibility of NaoH treated roughages. Can. J. Anim. Sci., 50, 657- 662.

Rexen, F. ; Stigsen, P. and Frus Kristensen, V. (1975): The effect of a new alkali technique on the nutritive value of straws. Proc. 9 th Nutr. Conf. for Feed Manuf., Univ. of Nottingham, 65.

Sexena, S.K. ; Otterby, D.E. ; Donker, J. D. and Good, A. L. (1971): Effect of feeding alkali treated straw supplemented with soybean meal or non- protien nitrogen on growth of lambs and on certain blood and rumen liquor parameters. J. Anim. Sci., 485- 490.

Singh, M. and Jackson, M. (1971): The effect of different levels of NaoH spray treatment of wheat straw on consumption and digestibility by cattle. J. Agri.Sci. Camb., 77, 5 -10.

Splegel, M. R. (1972): Statistics. McGraw-Hill Publ. Co., London & New York. 211 - 222.

Theander, O. (1982): Fiber in human and animal nutrition, The Royal Soc. of New Zealand, 20, 233- 241.

Table 1: Physical composition of the six experimental diets (%)

Diets	untreated straw	Treated straw	Concentrate mixture
1	20	0.0	80
2	25	0.0	75
3	0.0	20	80
4	0.0	25	75
5	0.0	20	80
6	0.0	25	75

Table 2 : Chemical composition of the feeds, concentrate mixture and diets used.

Items	Chemical composition, %						
% NaoH	DM	OM	CP	EE	CF	NFE	Ash
Feeds :							
White corn	89.50	98.28	8.46	4.03	1.78	73.51	1.72
Soybean meal	91.50	95.00	42.57	1.58	4.87	37.48	5.00
Wheat bran	88.90	94.70	11.73	2.54	11.22	58.11	5.30
Wheat straw.untreated	89.88	93.90	2.83	1.30	36.10	43.55	6.10
4	90.70	91.97	2.80	1.03	42.17	36.67	8.03
8	90.50	91.34	2.46	0.90	41.63	37.06	8.66
Conc. mixture	89.51	95.89	15.61	2.87	7.19	59.73	4.11
Diets (calculated) :							
1	89.58	95.49	13.05	2.56	12.97	56.49	4.51
2	89.60	95.39	12.42	2.48	14.42	55.69	4.61
3	89.75	95.11	13.05	2.50	14.19	55.12	4.89
4	89.81	94.91	12.41	2.41	15.94	53.97	5.09
5	89.71	94.98	12.98	2.48	14.08	55.20	5.02
6	89.76	94.75	12.32	2.38	15.80	54.06	5.25

DM = dry matter OM = organic matter CP = crude protein
EE = ether-extract CF = crude fiber NFE = nitrogen-free extract

Table 3 : Effect of NaoH treatment on the nutrients content of wheat straw

% NaoH	DM	OM	CP	EE	CF	NFE	Ash
	The difference % (between treated and untreated straw)						
4	+0.82	-1.93	-0.03	-0.27	+6.07	-6.88	+1.93
8	+0.62	-2.56	-0.37	-0.40	+5.53	-6.49	+2.56
	% of difference						
4	+0.91	-2.06	-1.06	-20.77	+16.81	-15.80	+31.64
8	+0.69	-2.73	-13.07	-30.77	+15.32	-14.90	+41.97

Table 4 : Digestibilities and nutritive value of wheat straw and concentrate mixture calculated by the simple algebric method

Items	Digestion coefficients						Nutritive value			
	DM	OM	CP	EE	CF	NFE	DP	TDN	SE	ME
	%	%	%	%	%	%	%	%	%	Kcal/kg
Wheat straw :										
Untreated	20.31	26.15	- 20.16	40.51	20.44	30.66	0.00	21.92	21.91	935
4% NaoH	2526	31.34	5.53	46.43	30.11	43.31	0.15	29.81	29.78	1271
8% NaoH	28.22	35.24	10.32	50.21	35.33	47.42	0.25	33.55	32.88	1403
Concentrate mixture :*										
1	70.45	72.61	60.55	73.84	40.54	74.52	9.45	59.51	58.31	2488
2	70.43	73.11	61.31	72.86	41.24	74.99	9.57	59.91	58.69	2504
3	70.86	73.43	60.87	73.33	40.66	74.72	9.50	59.65	58.44	2494

DP : digestible protein. TDN : total digestible nutrients.
SE : starch equivalent. ME : metabolizable energy.
* Concentrate mixture composed of : 32 % white corn. 16 % soybean meal and 52 % wheat bran.
1 : Concentrate mixture fed with untreated straw.
2 : ~ ~ ~ ~ ~ 4 % NaoH treated straw.
3 : ~ ~ ~ ~ ~ 8 % NaoH treated straw.

Table 5 : Digestibilities and nutritive value of the six experimental diets calculated by direct feeding.

Diets	Digestion coefficients, %						Nutritive value			
	DM	OM	CP	EE	CF	NFE	DP	TDN	SE	ME
	%	%	%	%	%	%	%	%	%	Kcal/kg
1	65.23	67.33	52.11	66.33	35.11	60.22	6.80	49.19	48.16	2055
2	64.51	66.52	51.63	65.74	33.65	59.70	6.41	48.18	47.20	2014
Average	64.87	66.93	51.87	66.04	34.38	59.96	6.16	48.69	47.68	2035
3	68.41	69.30	55.66	67.66	37.22	64.11	7.26	51.69	50.58	2158
4	67.61	68.66	54.71	66.88	36.11	63.81	6.79	50.61	49.58	2116
Average	68.01	68.98	55.19	67.27	36.67	63.96	7.03	51.15	50.08	2137
5	70.11	70.22	58.33	69.51	39.34	66.55	7.57	53.72	52.57	2243
6	69.55	68.91	57.73	68.88	38.71	65.89	7.11	52.54	51.45	2195
Average	69.83	69.57	58.03	69.20	39.03	66.22	7.34	53.13	52.01	2219

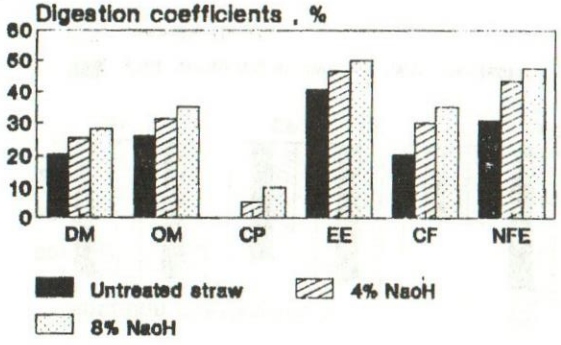

Fig.1: Digestibility of wheat straw.

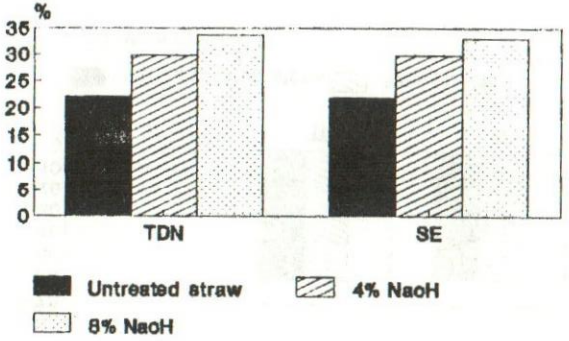

Fig.2:Nutritive value of wheat straw.

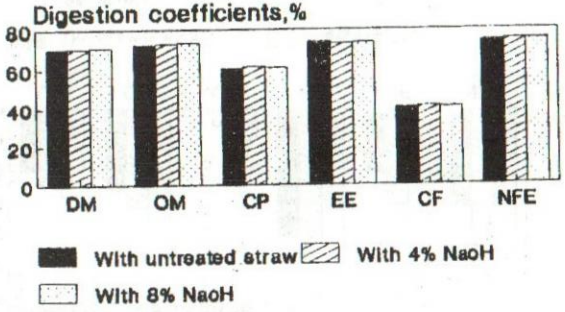

Fig.3:Digestibility of conc. mixture in three treatments.

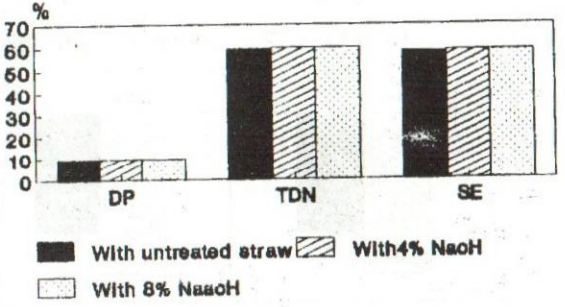

Fig.4:Nutritive value of conc. mixture in three treatments

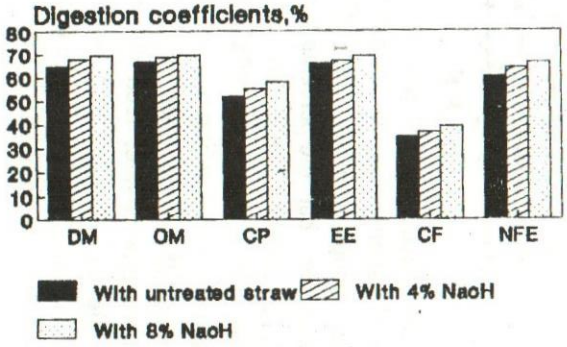

Fig.5: Digestibility of the three diets.

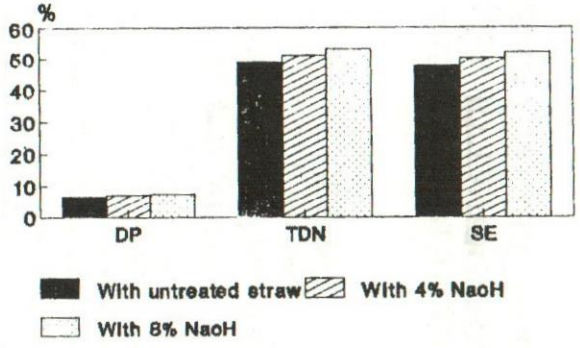

Fig.6:Nutritive value of the three diets