The effect of feeding clinoptilolite (zeolite) to laying hens

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One hundred and twenty 4-month-old, single-combed, brown Hy-Line pullets were fed two isocaloric diets containing 16 or 13,5% protein with and without 5% clinoptilolite in four treatments with thirty hens per replicate. Sterile river sand was used as a filler in the other two diets not containing clinoptilolite so as to keep the diets isocaloric. The hens were housed in individual cages in a naturally ventilated laying house and fed the four different diets for twelve 28-day periods. No significant differences in live mass, egg mass, Haugh Units and shell thickness were observed between the four treatments. Significant treatment effects ($P \leq 0{,}05$) were noticed in the days to first egg, number of eggs laid per hen, egg size percentages, feed consumed per hen and feed efficiency (kg feed/ kg eggs). Highly significant differences ($P \leq 0{,}01$) between treatments were found in faecal moisture percentage and bacterial colony counts in the proximal and distal ends of the intestine. Conflicting results between this experiment and others reported in the literature require further investigation.
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Twee isokaloriese diëte bevattende 16 en 13,5% proteïen met en sonder 5% clinoptilolite is aan een honderd-en-twintig 4 maande-oue, enkelkam, bruin Hy-Line hennetjies gevoer. Daar was derhalwe 4 behandelings met 30 henne per herhaling. Steriele riviersand is as vulvoer gebruik in die twee diëte wat nie clinoptilolite bevat het nie om die diëte isokalories te hou. Die hennetjies is in individuele lê-koue in 'n natuurlik geventileerde lê-huis gehuisves en is vir twaalf 28-dae periodes gevoer. Geen statistiese verskille is in lewende massa, eiermassa, Haugheenhede en eierdopdiktes tussen die vier verskillende behandelings verkry nie. Statistiese verskille ($P \leq 0{,}05$) is waargeneem in die aantal dae tot eerste eier, aantal eiers gelê per hen en doeltreffendheid van voerverbruik (kg voer/kg eiers). Hoogsbeduidende verskille ($P \leq 0{,}01$) tussen behandelings is verkry vir persentasie misvog en bakterie-kolonie tellings in die proksimale en distale eindes van die dunderm. Teenstrydige resultate tussen hierdie eksperiment en andere wat in die literatuur gerapporteer is, vereis verdere ondersoek.
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Introduction

Clinoptilolite is a natural zeolite. Zeolites are a family of alumino-silicates with an unusual crystalline structure enclosing pores occupied by cation and water molecules, both of which have considerable freedom of movement, permitting within limits, reversible ion exchange and reversible dehydration.

The ideal chemical formula of clinoptilolite is $CaNa_4K_4(AlO_2)_6(SlO_2)_{30}24H_2O$ whereas PRATLEY clinoptilolite used in this study has the following formula $(MgCaNa_2K_2)2{,}6(AlO_2)_7(SlO_2)_{30}21H_2O$. The main impurities of PRATLEY clinoptilolite are montmorillonite and quartz. However, X-ray diffraction studies have established that it contains between 80 and 90% clinoptilolite.

Reviews on the chemistry and application of zeolites in agriculture are given by Mumpton & Fishman (1977). They reported that both ion exchange and absorption properties of natural zeolites can be used to make more efficient use of feed nitrogen in animal nutrition, to reduce intestinal disease in pigs and ruminants and to control the moisture content of animal manure. Onogi (1966) feeding up to 10% clinoptilolite-tuff in the diet of Leghorn chickens found no significant difference with regard to mortality but found that mass gain and feed efficiency were improved on the clinoptilolite diets. He concluded that clinoptilolite should be used to economize on the feed and to reduce the moisture content of chicken droppings.

Later work by Nakaue & Koelliker (1981) with White Leghorn pullets showed that there were no significant differences with regard to mortality, egg mass, body mass gains, shell quality or interior egg quality when up to 10% clinoptilolite was fed in the diet. However, they did obtain significant differences with regard to percentage egg production, daily feed consumption per hen, feed conversion and faecal moisture level. This study was undertaken to find out what the effect of feeding 5% clinoptilolite would be on the production characteristics of laying hens.

Procedure

One hundred and twenty sixteen-week-old, single-combed, brown Hy-Line pullets were fed four different diets using thirty pullets per treatment. The composition of the four diets fed are shown in Table 1. The diets were isocaloric but contained two different protein levels with and without clinoptilolite. Clinoptilolite was used in powdered form and was obtained from PRATLEY Mining Company. Sterile river sand was used to replace the clinoptilolite in the other two diets to keep them isocaloric.

The pullets were reared in a controlled environment house and fed *ad lib.* on chicken starter mash from day-old to six weeks, growing mash from six to 12 weeks and pullet developer mash from 12 to 16 weeks of age. At 16 weeks of age the pullets were caged on a randomized basis and fed the four different diets shown in Table 1. The pullets were housed in individual wire cages measuring 23 cm × 50 cm × 42 cm in a naturally ventilated laying house. From day-old to 20 weeks of age daylight length was held constant at 15 hours with the aid of artificial light. The lighting was increased by 15 min a week from twenty weeks until a maximum of 17 hours of daylight was reached.

Table 1 Isocaloric laying diets containing two different levels of protein with and without clinoptilolite

Composition (%)	Diets			
	1	2	3	4
Yellow maize meal	59,0	59,0	62,7	62,7
Sorghum meal	10,0	10,0		
Sunflower oil cake meal	3,2	3,2		
Fish meal	10,0	10,0	3,2	3,2
Blood meal	3,0	3,0		
Carcass meal	0,2	0,2		
Lucerne meal			3,9	3,9
Soyabean oil cake meal			14,6	14,6
Limestone powder	9,2	9,2	9,1	9,1
Monocalcium phosphate			0,8	0,8
Salt			0,16	0,16
DL Methionine			0,10	0,10
L Lysine			0,04	0,04
Sand	5,0		5,0	
Clinoptilolite		5,0		5,0
Vitamin & Mineral premix	0,4	0,4	0,4	0,4
Calculated Analysis:				
Crude protein %	16,0	16,0	13,5	13,5
Metabolizable Energy MJ/kg	11,7	11,7	11,7	11,7
Calcium %	3,6	3,6	3,5	3,5
Lysine %	0,97	0,97	0,75	0,75
Methionine %	0,35	0,35	0,35	0,35

The mass of the pullets was measured at 140 days, at first egg and at the termination of the experiment at 476 days. Special feed bins with a feed capacity of 5 kg were allocated to each hen and feed consumption was measured every 28 days from twenty to sixty eight weeks giving a total of twelve 28-day periods.

Eggs were recorded daily as were their individual masses. Twice every 28-day period the eggs were used for egg quality studies. Haugh Units were calculated according to the formula

H.U. = 100 log $(H - 1{,}7W^{0,37} + 7{,}6)$ Where H = albumen height and W = egg mass. Shell thickness was determined at the broad end of the broken open shells by means of a micrometer screw. The shell membranes were not removed.

Faecal moisture levels were recorded towards the end of the 12 th – 28th-day period. Manure was collected from 36 hens for 24 hours on dropping boards placed underneath the cages, giving nine hens per treatment. The manure from three hens per treatment was pooled, giving three replicates per treatment, and the pooled samples were dried in a drying oven at 110°C for 7 days. The dried samples were then remeasured and the moisture percentage calculated.

At the termination of the experiment at 476 days of age, three hens per treatment were randomly selected and sent to the Veterinary Laboratory at Onderstepoort for bacterial analysis of the intestine.

Analysis of variance procedures as stated by Rayner (1967) were used to test for significant differences between the treatments.

Results and Discussion

The body masses of the hens during the experiment and the number of days to first egg are shown in Table 2. It can be seen that no significant differences were observed between treatments with regard to body mass at 20 weeks, first egg or at 68 weeks respectively. This is in agreement with the work done by Nakaue & Koelliker (1981) with White Leghorn pullets. However, there were significant differences ($P \leq 0{,}05$) between treatments with regard to the number of days to first egg. Hens fed the diets containing clinoptilolite laid their first egg, on average, earlier than the hens not fed clinoptilolite, although only the 16% diet without clinoptilolite was significantly different ($P \leq 0{,}05$) from the two diets with clinoptilolite. Why clinoptilolite should encourage earlier egg production is not known as Onogi (1966) stated that clinoptilolite is expected to delay the time of first egg. Further work is therefore necessary in this respect. The results of clinoptilolite on the various egg production characteristics are shown in Table 3. The number of eggs laid per hen over the 48-week laying period showed significant differences ($P \leq 0{,}05$) between treatments (Table 3). The hens on the clinoptilolite diets laid more eggs than those on the diets containing no clinoptilolite. The hens on the 13% protein diet with clinoptilolite laid an average of 26 and 30 more eggs per hen than those on the 13 and 16% protein diets without clinoptilolite, respectively. However, Nakaue & Koelliker (1981) working with White Leghorn hens obtained a higher hen day egg production with hens fed no clinoptilolite than with those that were fed clinoptilolite. Their diet containing 10% clinoptilolite, however, had a better hen day production than the 2,5 and 5% clinop-

Table 2 Mean body masses of hens at different ages and days to first egg on diets containing different protein levels with and without clinoptilolite

Diet	20 Week mass	Mass at 1st egg	Mass at 68 weeks	Days to 1st egg
16% Protein + Sand	$1856{,}3^{a}$	$2141{,}4^{a}$	$2623{,}4^{a}$	$181{,}0^{b}$
16% Protein + Clinoptilolite	$1857{,}1^{a}$	$2154{,}5^{a}$	$2669{,}3^{a}$	$174{,}3^{a}$
13% Protein + Sand	$1855{,}0^{a}$	$2176{,}9^{a}$	$2737{,}3^{a}$	$178{,}8^{ab}$
13% Protein + Clinoptilolite	$1858{,}8^{a}$	$2166{,}1^{a}$	$2716{,}6^{a}$	$174{,}3^{a}$
L.S.D. ($P<0{,}05$)	107,9	150,1	166,4	6,6

Results not bearing same letters (^{a,b}) in columns are significantly different ($P \leq 0{,}05$).

Table 3 Mean performance data of hens fed diets with and without clinoptilolite

Diet	Number of eggs per hen	Av. egg mass	XL	L	M	S	Haugh Units	Shell thickness
16% + Sand	254,5[a]	62,0[a]	53,4[ab]	40,3[a]	5,8[ab]	0,53[a]	92,8[a]	34,8[a]
16% + Clinoptilolite	267,8[b]	60,8[a]	49,0[a]	41,7[a]	8,9[b]	0,38[a]	97,1[a]	33,6[a]
13% + Sand	258,3[ab]	62,3[a]	55,1[ab]	38,8[a]	5,7[b]	0,48[a]	91,9[a]	33,9[a]
13% + Clinoptilolite	284,3[c]	62,5[a]	61,2[b]	33,5[a]	4,8[a]	0,45[a]	96,0[a]	33,3[a]
L.S.D. $P \leq (0,05)$	12,8	1,8	11,8	9,9	3,7	0,33	6,7	2,1

Results not bearing same letter ([a,b,c]) are significantly different ($P \leq 0,05$).

tilolite diets. Thus further research on the effect of clinoptilolite on egg production is necessary to clear up the conflicting results obtained.

No significant differences ($P \leq 0,05$) were observed between treatments with regard to average egg mass; this was also noticed by Nakaue & Koelliker (1981) in their study with White Leghorn pullets. There were, however, significant differences ($P \leq 0,05$) with regard to the percentage of extra large (XL) eggs. The 13% protein clinoptilolite diet was significantly different from the 16% protein clinoptilolite diet but not from the other two diets containing no clinoptilolite. The trend was almost opposite for the medium (M) eggs, with the 16% protein clinoptilolite diet being significantly different ($P \leq 0,05$) from the 13% protein clinoptilolite diet and the other two diets containing no clinoptilolite falling in-between. There were no significant differences between treatments with regard to large (L) and small (S) eggs. It can therefore be concluded that since there were no significant differences with regard to egg mass, differences were not expected with regard to egg size. Because hens on the clinoptilolite diet laid their first eggs earlier, it was expected that hens on the clinoptilolite diets would lay more small and medium eggs than those not on the clinoptilolite diets, but this was not the case.

There were no significant differences between treatments with regard to Haugh Units although the Haugh Units were on average higher on the clinoptilolite diets than on those without clinoptilolite. This trend was opposite to that reported by Nakaue & Koelliker (1981) although they also obtained no significant differences. Eggs with thicker shells favoured the diets with no clinoptilolite although again there were no significant differences between treatments. Nakaue & Koelliker (1981) using specific gravity as a criterion also found that there were no significant differences between treatments with regard to shell strengths.

The food consumption and feed efficiency results are shown in Table 4. The average feed consumed per hen showed significant differences ($P \leq 0,05$) between treatments (Table 4). The hens on the 13% protein diets with and without clinoptilolite consumed more feed than those on the 16% protein diets; this can be expected as the hens on the lower protein diets would need extra protein for egg production. A greater amount of food was consumed per hen on the 13% than on the 16% protein diet containing clinoptilolite. This was also the trend obtained by Nakaue & Koelliker (1981) who observed that the pullets on the 10% clinoptilolite diet consumed more feed than those on the 5 and 2,5% clinoptilolite diets, respectively.

When feed efficiency (kg feed taken to produce a kg of eggs)

Table 4 Mean food consumption and feed efficiency (kg feed/kg eggs) of hens fed different protein diets with and without clinoptilolite

Diet	Feed consumed per hen (kg)	Feed efficiency
16% Protein + Sand	41,9[a]	2,66[a]
16% Protein + Clinoptilolite	43,0[a]	2,65[a]
13% Protein + Sand	45,2[b]	2,86[b]
13% Protein + Clinoptilolite	45,8[b]	2,58[a]
L.S.D. ($P \leq 0,05$)	1,7	0,12

Results not bearing same letters ([a,b]) are significantly different ($P \leq 0,05$).

was the criterion the clinoptilolite diets were found to be more efficient on both levels of protein used in the experiment. Nakaue & Koelliker (1981) found the opposite trend; the hens receiving no clinoptilolite in the feed being the most efficient and those on the 10% clinoptilolite being the most inefficient. In this experiment the 13% protein diet without clinoptilolite was the most inefficient and was significantly different ($P \leq 0,05$) from the other three diets. Kondo & Wagai (1968), using young pigs, found that when the feed was supplemented with 5% clinoptilolite the feed efficiency improved by 35% on that of pigs that received no clinoptilolite. They also observed that the faeces of pigs receiving the diets without clinoptilolite were richer in nitrogen than the faeces of those fed clinoptilolite. This indicates that clinoptilolite contributed towards a more efficient conversion of feedstuff nitrogen into animal protein. In this experiment it is possible that the hens on the 13% protein diet with clinoptilolite made better use of the protein and were therefore more efficient converters of feed. Since a 15% protein diet is usually recommended for laying hens, it is possible that the 16% protein diet was more than sufficient for egg production and thus that clinoptilolite on a higher protein diet was not as beneficial to the hens as it was on a lower protein diet.

Faecal moisture percentages and the intestinal bacterial analysis results are shown in Table 5. The faecal moisture level of hens was significantly lower ($P \leq 0,01$) on diets with clinoptilolite than on diets with no clinoptilolite. Nakaue & Koelliker (1981) obtained significantly lower ($P \leq 0,05$) faecal moisture levels when a 10% clinoptilolite diet was fed to White Leghorn hens, but no significance was observed with the 5% or 2,5% clinoptilolite levels when compared with the faecal moisture content of hens fed no clinoptilolite in the diet. Onogi (1966) noted that the moisture content of chicken droppings could be lowered if powdered clinoptilolite was added to the diets. This is in agreement with the work done in the present study.

Table 5 Mean faecal moisture percentages and bacterial colony counts of the intestine observed in hens fed diets with and without clinoptilolite

Diet	Faecal Moisture %	Proximal 2/8 of intestine	Distal 7/8 of intestine
16% Protein + Sand	72,8[b]	388,0[b]	4333,3[b]
16% Protein + Clinoptilolite	67,6[a]	62,0[a]	1700,0[a]
13% Protein + Sand	73,7[b]	376,3[b]	4350,0[b]
13% Protein + Clinoptilolite	68,4[a]	63,3[a]	1673,3[a]
$P \leq 0{,}05$	3,1	51,2	921,1

Results not bearing same letters ([a,b]) are significantly different ($P \leq 0{,}05$).

The proximal and distal intestinal colony counts were both significantly lower ($P \leq 0{,}01$) in the hens on the two clinoptilolite diets than in those hens not fed clinoptilolite. This could possibly mean that the hens on the clinoptilolite are healthier and less susceptible to disease than those hens not fed clinoptilolite. Since there was no mortality during the experiment this hypothesis could not be verified. However, Arscott (1978) according to Mumpton & Fishman (1977) found that the presence of zeolite in the diet of broiler chickens prevented mortality when compared with broilers fed no zeolite or antibiotics in the diet. Torii (1977) found that a 6% clinoptilolite diet fed to pigs markedly reduced the death rate and the incidence of disease when compared with pigs not fed clinoptilolite.

From this study and others reported in the literature there appear to be conflicting results and thus further research on the effects of clinoptilolite on broiler and laying hens is necessary.

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