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Description

The present invention is in the general field of poultry farming and relates particularly to the feeding of laying fowl or layers.

The demand for poultry eggs, especially chicken eggs has expanded considerably over the last decade. The poultry industry has grown from a home industry to a large scale manufacturing industry in which tens of thousands of eggs are produced daily at single farms or egg laying installations. Some eggs are produced for eating and some eggs are produced for hatching. One problem with such large scale egg producing is breakage. Even a slight crack in an egg makes it unsuitable for hatching and most other marketing purposes. It is estimated that some six percent of all eggs produced are lost for marketing because of cracking or breakage. Shell strength is very important to inhibit breakage. The stronger the egg shell, the less likely the egg will be cracked or broken. Machinery and techniques necessary for carefully handling the eggs to avoid breakage are expensive and time consuming.

Another substantial loss of egg production estimated to be about a seven percent loss is the production of shell-less eggs. Any reduction in shell-less eggs can be an important factor in large scale egg production.

Zeolites are crystalline, hydrated alumino-silicates of alkali and alkaline earth cations, having infinite, three-dimensional structures.

Zeolites consist basically of a three-dimensional framework of SiO_4 and AlO_4 tetrahedra. The tetrahedra are cross-linked by the sharing of oxygen atoms so that the ratio of oxygen atoms to the total of the aluminum and silicon atoms is equal to two or $O/(Al+Si) = 2$. The electrovalence of each tetrahedra containing aluminum is balanced by the inclusion in the crystal of a cation, for example, a sodium ion. This balance may be expressed by the formula $Al/Na = 1$. The spaces between the tetrahedra are occupied by water molecules prior to dehydration.

Zeolite A may be distinguished from other zeolites and silicates on the basis of their composition and X-ray powder diffraction patterns and certain physical characteristics. The X-ray patterns for these zeolites are described below. The composition and density are among the characteristics which have been found to be important in identifying these zeolites.

The basic formula for all crystalline sodium zeolites may be represented as follows:

$$Na_2O \cdot Al_2O_3 \cdot xSiO_2 \cdot yH_2O$$

In general, a particular crystalline zeolite will have values for «x» and «y» that fall in a definite range. The value «x» for a particular zeolite will vary somewhat since the aluminum atoms and the silicon atoms occupy essentially equivalent positions in the lattice. Minor variations in the relative number of these atoms do not significantly alter the crystal structure or physical properties of the zeolite. For zeolite A, the «x» value normally falls within the range 1.85 ± 0.5.

The value for «y» is not necessarily an invariant for all samples of zeolites. This is true because various exchangeable ions are of different size, and, since there is no major change in the crystal lattice dimensions upon ion exchange, the space available in the pores of the zeolite to accommodate water molecules varies.

The average value for «y» for zeolite A is 5.1. The formula for zeolite A may be written as follows:

$$1.0 \pm 0.2\ Na_2O \cdot Al_2O_3 \cdot 1.85 \pm 0.5\ SiO_2 \cdot yH_2O$$

In the formula, «y» may be any value up to 6.

An ideal zeolite A has the following formula:

$$(NaAlSiO_4)_{12} \cdot 27H_2O$$

Among the ways of identifying zeolites and distinguishing them from other zeolites and other crystalline substances, the X-ray powder diffraction pattern has been found to be a useful tool. In obtaining the X-ray powder diffraction patterns, standard techniques are employed. The radiation is the Kα doublet of copper and a Geiger counter spectrometer with a strip chart pen recorder is used. The peak heights, I, and the positions as a function of 2θ where θ is the Bragg angle, are read from a spectrometer chart. From these, the relative intensities, $100\ I/I_o$, where I_o is the intensity of the strongest line or peak and d the interplanar spacing in angstroms (10^{-10} m) corresponding to the recorded lines are calculated.

X-ray powder diffraction data for a sodium zeolite A are given in Table I.

TABLE I

X-RAY DIFFRACTION PATTERN FOR ZEOLITE A

$h^2 + k^2 + l^2$	d (Å) (10^{-10} m)	$\frac{100\ I}{I_o}$
1	12.29	100
2	8.71	70
3	7.11	35
4	6.15	2
5	5.51	25
6	5.03	2
8	4.36	6
9	4.107	35
10	3.895	2
11	3.714	50
13	3.417	16
14	3.293	45
16	3.078	2
17	2.987	55
18	2.904	10
20	2.754	12
21	2.688	4
22	2.626	20
24	2.515	6
25	2.464	4
26	2.414	>1
27	2.371	3
29	2.289	1

TABLE I (continuation)

X-RAY DIFFRACTION PATTERN FOR ZEOLITE A

$h^2 + k^2 + 1^2$	d (Å) (10^{-10} m)	$\frac{100\,I}{I_o}$
30	2.249	3
32	2.177	7
33	2.144	10
34	2.113	3
35	2.083	4
36	2.053	9
41	1.924	7
42	1.901	4
44	2.858	2
45	1.837	3
49	1.759	2
50	1.743	13
53	1.692	6
54	1.676	2
55	1.661	2
57	1.632	4
59	1.604	6

The more significant d values for zeolite A are given in Table II.

TABLE II

MOST SIGNIFICANT d VALUES FOR ZEOLITE A

d Value of Reflection in A (10^{-10} m)
12.2 ± 0.2
8.7 ± 0.2
7.10 ± 0.15
5.50 ± 0.10
4.10 ± 0.10
3.70 ± 0.07
3.40 ± 0.06
3.29 ± 0.05
2.98 ± 0.05
2.62 ± 0.05

Occasionally, additional lines not belonging to the pattern for the zeolite appear in a pattern along with the X-ray lines characteristic of that zeolite. This is an indication that one or more additional crystalline materials are mixed with the zeolite in the sample being tested. Small changes in line positions may also occur under these conditions. Such changes in no way hinder the identification of the X-ray patterns as belonging to the zeolite.

The particular X-ray technique and/or apparatus employed, the humidity, the temperature, the orientation of the powder crystals and other variables, all of which are well known and understood to those skilled in the art of X-ray crystallography or diffraction can cause some variations in the intensities and positions of the lines. These changes, even in those few instances where they become large, pose no problem to the skilled X-ray crystallographer in establishing identities. Thus, the X-ray data given herein to identify the lattice for a zeolite, are not to exclude those materials which, due to some variable mentioned or otherwise known to those skilled in the art, fail to show all of the lines, or show a few extra ones that are permissible in the cubic system of that zeolite, or show a slight shift in position of the lines, so as to give a slightly larger or smaller lattice parameter.

A simpler test described in «American Mineralogist», Vol. 28, page 545, 1943, permits a quick check of the silicon to aluminum ratio of the zeolite. According to the description of the test, zeolite minerals with a three-dimensional network that contains aluminum and silicon atoms in an atomic ratio of Al/Si = 2/3 = 0.67, or greater, procedure a gel when treated with hydrochloric acid. Zeolites having smaller aluminum to silicon ratios disintegrate in the presence of hydrochloric acid and precipitate silica. These tests were developed with natural zeolites and may vary slightly when applied to synthetic types.

U.S. Patent No. 2 882 243 describes a process for making zeolite A comprising preparing a sodium-aluminum-silicate water mixture having an SiO_2 : Al_2O_3 mole ratio of from 0.5 : 1 to 1.5 : 1, and Na_2O/SiO_2 mole ratio of from 0.8 : 1 to 3 : 1, and an H_2O/Na_2O mole ratio of from 35 : 1 to 200 : 1, maintaining the mixture at a temperature of from 20°C to 175°C until zeolite A is formed, and separating the zeolite A from the mother liquor.

The present invention relates to a method of improving the quality, i.e., the strength of egg shells of layers or laying poultry without deleterious effects on the contents of the egg itself wherein a small amount of zeolite A is added to the feed of the layers, and to a poultry feed composition containing zeolite A.

It has been discovered that the addition of a relatively small amount of zeolite A to a regular or standard feed for laying chickens or hens effectively improves the quality of the egg shell with no significant changes in egg production, egg weight or feed consumption. Zeolite A is preferably added in amounts of from 0.25 percent to 4.00 percent of weight of the total feed.

A typical feed preparation for large scale laying hen operations comprises the following by weight percent:

Corn	62-68
Soy Bean Meal	18-24
Limestone	5- 9
Alfalfa Meal	1
Phosphates	2
Sand	1- 2
Vitamins, Amino Acids Salt and Other Minerals	0- 1

Zeolite A is added to such feed formulation in small amounts by weight percent of up to about four. Greater amounts may be used, but may deprive the layers of the desired amount of nutrients. Greater amounts are also likely to be cost ineffective. A preferred amount of zeolite A is from one-half to two percent by weight of the total feed formulation. A most preferred amount of zeolite A is 0.75 to 1.50 weight percent of the total feed formulation.

The most convenient means of measuring egg shell strength is by measuring the specific gravity of the egg. This is simply done by immersing the egg in solutions of salt water of varying strengths. It is well known in the art that specific gravity correlates with egg shell strength. As specific gravity of the egg is raised, the strength of the shell is increased.

Using Ethyl EZA® zeolite, a commercially available sodium zeolite A, a number of tests were conducted to determine the effect of zeolite on egg shell quality.

EXAMPLE 1

Procedure: 480 hens (Dekalb XL pullets) were divided into eight equal groups and fed one of the following dietary treatments for a minimum of six weeks:

Diet	Calcium (Wt. %)	Zeolite A (Wt. %)
1	4.00	0
2	4.00	0.75
3	4.00	1.50
4	4.00	0.68*
5	2.75	0
6	2.75	0.75
7	2.75	1.50
8	2.75	0.75**

* diet not adjusted for calcium

** zeolite added on top except diet not adjusted for Cl

The diet fed to the hens consisted principally of corn supplemented with a soybean meal (SBM) and limestone. Smaller amounts of alfalfa meal, dicalcium phosphate (diCalP), a synthetic amino acid (DL-methionine), salt, a commercial vitamin and mineral supplement for layers (Micro-Mix). Sand and/or hydrochloric acid (HCl) were added to some diets. Each diet asssured that the hens received all of the required nutrients and minerals.

Diets 1-4 contained 1,238 calories per pound (0,454 kg), 16% protein, 0.55% total sulfur amino acids, 4% calcium and 0.70% total phosphorus.

Diets 5-8 contained 1,292 calories per pound (0,454 kg), 16% protein, 0.55% total sulfur amino acids, 2.75% calcium and 0.70% phosphorus.

All diets were isocaloric and isonitrogenous within treatments and are detailed in Table A.

TABLE A

Experimental Diets for Zeolite Study (Weight Percent)

Diet No.	1	2	3	4	5	6	7	8
	4.00% calcium				2.75% calcium			
Ingredient	0.0	0.75	1.50	0.68 (special)	0.0	0.75	1.50	0.75
Corn	63.80	63.80	63.80	63.80	67.83	67.83	67.83	67.83
SBM	21.41	21.41	21.41	21.41	20.69	20.69	20.69	20.69
Alfalfa meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium Phosphate	2.07	2.07	2.07	2.07	2.03	2.03	2.03	2.03
Limestone	9.14	9.14	9.14	9.14	5.87	5.87	5.87	5.87
DL-methionine	0.01	0.01	0.01	0.01	—	—	—	—
Salt	0.35	0.10	—	0.35	0.35	0.10	—	0.10
Micro-mix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sand	1.72	0.82	—	1.04	1.72	0.82	—	1.23
Zeolite A	—	0.75**	1.50**	0.68*	—	0.75**	1.50**	0.75**
HCl	—	0.40	0.57	0.00	—	0.40	0.57	—
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* 0.68 is the special zeolite. (Diet 4)

** 0.75 and 1.50 is zeolite A.

Tests criteria were as follows:

1. Egg production (weekly)
2. Feed consumption (weekly)
3. Egg specific gravity (weekly)
4. Egg weight (weekly)
5. Shell weight (middle and end of experiment)
6. Serum calcium at termination
7. Body weight at initiation and termination
8. Mortality

All eggs laid during a 3-day period each week of the experiment and the first week prior to the experiment were used for specific gravity and egg weight measurements.

The results are summarized in Tables B, C, D, E, F and G as follows:

TABLE B

EGG SPECIFIC GRAVITY *

Diet	No. of Eggs	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Avg. for 8 Weeks
1-4	240	80.24	80.33	80.70	81.03	80.90	80.52	78.21	80.76	80.69	80.39
5-8	240	80.04	78.69	78.32	79.15	78.57	77.75	76.48	78.99	78.80	78.34
1 and 5	120	79.88	78.37	77.63	78.16	77.96	77.14	75.42	77.90	77.74	77.54
2 and 6	120	79.64	79.13	79.47	79.93	79.83	79.43	77.20	80.10	79.51	79.33
3 and 7	120	80.56	80.60	81.14	81.59	80.84	79.87	78.85	80.67	81.15	80.59
4 and 8	120	60.47	79.93	79.79	80.67	80.33	80.08	77.91	80.83	80.58	80.01
1	60	80.27	80.12	79.42	80.30	79.86	79.49	77.59	79.53	79.19	79.44
2	60	79.70	79.03	80.53	81.17	81.27	80.67	78.86	81.01	81.29	80.48
3	60	80.35	81.84	81.96	81.92	81.66	81.53	79.16	81.33	81.91	81.44
4	60	80.64	80.33	80.88	80.73	80.82	80.38	77.22	81.18	80.38	80.24
5	60	79.50	76.63	75.83	76.03	76.06	74.80	73.25	76.28	76.30	75.65
6	60	79.60	79.24	78.41	78.70	78.39	78.20	75.55	79.19	77.73	78.17
7	60	80.77	79.35	80.32	81.26	80.01	78.21	78.54	80.01	80.40	79.76
8	60	80.31	79.54	78.70	80.61	79.83	79.79	78.60	80.47	80.77	79.79

* Divide by 1000 and add 1 to convert to Actual Specific Gravity.

TABLE C

EGG PRODUCTION (Percent Hen Per Day)

Diet	No. of Percent Calculations	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Avg. for 8 Weeks
1-4	240	89.88	86.44	88.59	85.10	87.97	87.87	87.54	86.53	84.46	86.81
5-8	240	90.21	86.59	84.17	81.99	84.65	83.45	82.84	82.58	81.82	83.51
1 and 5	120	90.42	89.25	88.50	85.82	87.86	87.74	85.48	84.82	85.25	86.84
2 and 6	120	90.08	84.55	86.43	84.96	87.13	86.46	86.69	84.67	82.71	85.45
3 and 7	120	89.58	85.12	85.46	81.98	86.32	83.93	85.02	85.65	84.22	84.71
4 and 8	120	90.08	87.14	85.12	81.42	83.93	84.52	83.57	83.09	80.36	83.65
1	60	90.00	90.00	90.07	86.19	90.00	88.33	86.67	84.76	87.38	87.93
2	60	90.00	83.62	85.95	85.39	87.84	88.86	89.10	88.15	82.09	86.38
3	60	89.67	84.76	88.81	84.52	86.90	87.38	86.77	88.46	85.27	86.61
4	60	89.83	87.38	89.52	84.28	87.14	86.90	87.62	84.76	83.10	86.34
5	60	90.83	88.49	86.91	85.45	85.71	87.14	84.29	84.87	83.12	85.75
6	60	90.17	85.48	86.91	84.52	86.43	84.04	84.29	81.19	83.33	84.52
7	60	89.50	85.48	82.12	79.44	85.74	80.48	83.28	82.83	83.17	82.82
8	60	90.33	86.91	80.72	78.57	80.72	82.14	79.52	81.43	77.62	80.95

TABLE D

SHELL WEIGHT (Grams/Egg)

Diet	No. of Eggs	Week 4	Week 8	Avg. for 8 Weeks
1-4	240	5.32	5.23	5.28
5-8	240	5.12	5.08	5.10
1 and 5	120	5.06	5.06	5.06
2 and 6	120	5.22	5.14	5.18
3 and 7	120	5.31	5.23	5.27
4 and 8	120	5.29	5.19	5.24
1	60	5.23	5.20	5.22

TABLE D (continuation)

SHELL WEIGHT (Grams/Egg)

Diet	No. of Eggs	Week 4	Week 8	Avg. for 8 Weeks
2	60	5.37	5.27	5.32
3	60	5.40	5.29	5.35
4	60	5.29	5.18	5.24
5	60	4.89	4.93	4.91
6	60	5.08	5.00	5.04
7	60	5.21	5.17	5.19
8	60	5.29	5.21	5.25

TABLE E

FEED CONSUMPTION (Grams Per Hen Per Day)

Diet	No. of Weighings	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Avg. for 8 Weeks
1-4	240	105.48	108.16	109.76	110.13	112.85	105.64	110.57	115.53	109.76
5-8	240	103.91	101.62	106.01	96.66	107.96	103.42	107.12	112.09	104.85
1 and 5	120	112.06	105.92	109.32	107.44	112.54	106.08	110.57	116.80	110.09
2 and 6	120	101.85	104.96	107.04	105.92	109.13	102.66	108.82	113.69	106.76
3 and 7	120	102.08	105.07	107.99	101.47	110.17	105.25	109.16	112.40	106.70
4 and 8	120	102.78	103.60	107.20	98.76	109.76	104.12	106.84	112.35	105.67
1	60	113.25	109.55	112.98	115.07	117.42	106.76	113.94	119.90	113.61
2	60	99.45	106.05	107.28	110.78	111.20	102.75	109.22	113.21	107.49
3	60	104.65	109.60	111.13	108.85	111.98	107.66	110.73	115.78	110.05
4	60	104.56	107.43	107.65	105.82	110.78	105.38	108.40	113.21	107.90
5	60	110.86	102.30	105.65	99.81	107.65	105.41	107.21	113.69	106.57
6	60	104.24	103.88	106.80	101.05	107.07	102.57	108.42	114.16	106.02
7	60	99.52	100.53	104.85	94.08	108.37	102.83	107.59	109.03	103.35
8	60	101.01	99.77	106.75	91.70	108.74	102.87	105.28	111.48	103.45

TABLE F

BODY WEIGHT (Grams per Hen)

Diet	No. of Weighings	Week 0	Week 1
1-4	240	1,538.58	1,550.63
5-8	240	1,518.58	1,520.00
1 and 5	120	1,526.25	1,565.00
2 and 6	120	1,528.00	1,542.00
3 and 7	120	1,515.58	1,492.00
4 and 8	120	1,544.50	1,542.25
1	60	1,541.67	1,579.33

TABLE F

BODY WEIGHT (Grams per Hen)

Diet	No. of Weighings	Week 0	Week 1
2	60	1,525.83	1,543.17
3	60	1,518.67	1,507.00
4	60	1,508.17	1,573.00
5	60	1,510.83	1,550.67
6	60	1,530.17	1,540.83
7	60	1,512.50	1,477.00
8	60	1,520.83	1,511.50

TABLE G

EGG WEIGHTS (Grams per Egg)

Diet	No. of Weighings	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Avg. for 8 Weeks
1-4	240	59.04	59.87	59.98	60.06	60.33	59.95	59.88	60.19	60.19	60.05
5-8	240	58.85	59.38	59.45	59.59	59.84	59.81	59.51	59.60	59.97	59.64
1 and 5	120	58.58	59.12	59.49	59.53	59.64	59.77	59.59	60.14	60.22	59.69
2 and 6	120	58.93	59.96	59.91	59.84	60.13	59.88	59.64	59.97	60.09	59.93
3 and 7	120	58.95	59.72	59.80	59.86	60.26	59.77	59.81	59.72	60.01	59.87
4 and 8	120	59.31	59.69	59.67	60.06	60.31	60.08	59.73	59.76	59.99	59.91
1	60	58.74	59.66	60.03	60.03	60.33	59.81	60.13	60.70	60.77	60.18
2	60	59.21	60.28	59.98	60.05	60.37	60.56	59.93	60.39	60.23	60.22
3	60	58.94	59.62	60.26	60.00	60.57	59.56	59.92	59.88	60.13	59.99
4	60	59.26	59.92	59.66	60.17	60.05	59.85	59.54	59.78	59.61	59.82
5	60	58.42	58.59	58.95	59.03	58.95	59.73	59.04	59.58	59.66	59.19
6	60	58.66	59.64	59.84	59.64	59.90	59.20	59.34	59.54	59.96	59.63
7	60	58.96	59.83	59.34	59.72	59.95	59.97	59.71	59.56	59.89	59.75
8	60	59.35	59.46	59.70	59.96	60.56	60.32	59.93	59.75	60.36	60.01

A review of the test data in Table B shows that zeolite A provided a definite benefit on shell quality, and had no significant effect on the other qualities studied except possibly for shell weight. Two concentrations (0.75%, 1.5%) were evaluated because of sodium limitations and for those levels, the data showed a linear relationship with concentration.

In Table C zeolite A had no significant effect on production (% hen day). However there is some indication that a slight reduction occurred, particularly with Diet 8 in the 2.75% Ca series (i.e. low-Ca).

In Table D there appears to be an indication of some benefits from zeolite A.

Previous indications that feed consumption was reduced without any reduction in egg or body weight or in egg production could not be substantiated by the statistical data. As shown in Table E 1.5% zeolite A reduced feed consumption, relative to baseline, at both Ca levels in Weeks 1 and 4. However this did not occur in the other six weeks of the trial. Thus if we look at the results for the 8th week:

% Ca	Run No.	Feed Cons. (g/hen/day)
2.75	1	113.69
2.75	2	114.16
2.75	3	109.03
2.75	4	111.48

The reduced value is most likely attributable to a palatability consideration. Laying hens usually eat more than they need. Any factor, such as feed dustiness, can reduce intake by up to 5% without an adverse effect.

Tables F and G show no significant benefits for body and egg weights.

EXAMPLE II

Procedure: 480 hens were divided into eight equal groups and fed one of the following dietary treatments for a minimum of three months.

Diet	TSAA (Wt.%)	Zeolite A (Wt.%)
9	0.51	0
10	0.51	0.75
11	0.51	1.50
12	0.51	0.68*
13	0.61	0
14	0.61	0.75
15	0.61	1.50
16	0.61	0.68*

* special zeolite - 10.43% Ca and 0.52% Na.

All diets were isocaloric and isonitrogenous and are detailed in Table H.

Tests criteria were the same as in Example I.

The components of the diets were also similar as those of Example I.

Diets 9-12 contained 1237 calories per pound (0,454 kg), 17% protein, 0.61% TSAA (Total Sulphur Amino Acids), 3.75% calcium and 0.70% phosphorus.

Diets 13-16 contained 1262 calories per pound (0,454 kg), 14.78% protein, 0.51% TSAA, 3.75% calcium and 0.70% phosphorus.

TABLE H

Experimental Diets for Zeolite Study (Weight Percent)

Diet No.	9	10	11	12	13	14	15	16
	1.50% TSAA				0.61% TSAA			
Ingredient Name	0.00%	0.75%	1.50%	0.68 (special)	0.00%	0.75%	1.50%	0.68 (special)
Corn	67.65	67.65	67.65	67.65	62.07	62.07	62.07	62.07
SBM (48%)	18.19	18.19	18.19	18.19	23.81	23.81	23.81	23.81
Alfalfa (17%)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium Phosphate (18.5%)	2.12	2.12	2.12	2.12	2.01	2.01	2.01	2.01
Limestone	8.47	8.47	8.47	8.29	8.50	8.50	8.50	8.31
DL-methionine	—	—	—	—	0.04	0.04	0.04	0.04
Salt	0.35	0.10	—	0.35	0.35	0.10	—	0.35
Micro-mix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sand	1.72	0.82	—	1.22	1.72	0.82	—	1.23
Zeolite	—	0.75	1.50	0.68	—	0.75	1.50	0.68
HCl	—	0.40	0.57	—	—	0.40	0.57	—
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The results of the tests are summarized in Tables P, J, K, L, M and N.

TABLE P

EGG SPECIFIC GRAVITY *

Diet	No. of Eggs	Week 0	Week 1	Week 2	Week 3	Week 4	Week 6	Week 7	Week 8	Avg. for 8 Weeks
9-12	240	89.24	90.54	88.87	88.53	90.05	87.80	88.47	87.18	88.34
12-16	240	89.86	91.24	88.84	89.30	90.19	88.38	88.06	87.87	89.22
9 and 13	120	89.34	89.93	87.90	87.94	88.88	86.81	87.67	86.66	88.14
10 and 14	120	89.38	90.85	89.01	88.60	89.93	88.25	88.43	87.03	88.94
11 and 15	120	90.44	92.07	90.13	90.01	91.29	89.40	88.88	88.57	90.10
12 and 16	120	89.06	90.71	88.40	89.11	90.40	87.89	88.06	87.84	88.93
9	60	89.27	89.25	87.83	87.46	88.36	86.14	88.09	86.49	87.86
10	60	89.16	90.89	89.76	87.78	90.48	88.08	88.68	86.40	88.90
11	60	90.04	91.73	89.92	90.00	91.23	89.27	89.07	88.07	88.92
12	60	88.50	90.31	87.99	88.89	90.16	87.71	88.04	87.78	88.67
13	60	89.41	90.61	87.97	88.43	89.39	87.48	87.24	86.83	88.42
14	60	89.60	90.81	88.27	89.41	89.39	88.41	88.21	87.66	88.97
15	60	90.83	92.41	90.33	90.02	91.35	89.53	88.69	89.07	90.28
16	60	89.62	92.12	88.80	89.33	90.64	88.08	88.09	87.91	89.20

* Divide by 1000 and add 1 to convert to Actual Specific Gravity.

TABLE J

EGG PRODUCTION (Percent Hen Per Day)

Diet	No. of Percent Calculations	Week No. 1	2	3	4	5	6	7	8	9	10	11	12	Avg. for 12 Weeks
9-12	240	57.26	69.54	78.04	80.82	84.93	87.00	85.83	89.24	88.33	87.81	81.55	87.87	81.52
13-16	240	53.41	69.40	81.83	87.13	89.39	89.92	89.18	89.92	87.53	88.76	84.13	88.24	83.24
9 and 13	120	53.73	71.31	82.12	85.19	87.94	87.86	86.34	89.48	89.22	87.63	82.06	85.29	82.35
10 and 14	120	60.23	71.31	75.71	76.47	82.74	89.22	89.52	91.19	88.69	90.12	86.19	90.60	82.58
11 and 15	120	5.93	64.32	78.01	85.01	87.65	89.17	85.76	88.61	86.73	88.86	83.31	87.59	81.41
12 and 16	120	55.43	70.95	83.89	89.25	90.31	88.60	88.40	89.04	87.06	86.52	79.79	88.74	83.16
9	60	55.00	70.48	80.24	81.67	85.48	87.14	82.86	88.34	88.81	87.14	77.82	84.76	80.79
10	60	60.95	70.95	70.48	67.86	76.43	85.24	88.34	91.43	89.76	89.29	85.48	89.76	80.50
11	60	56.72	70.08	81.75	87.88	88.15	88.18	83.41	87.94	87.04	88.92	83.28	89.57	82.57
12	60	56.35	66.67	79.68	85.87	89.66	87.43	88.71	89.26	87.70	85.90	79.81	89.39	82.20
13	60	52.46	72.14	83.99	88.71	90.40	88.57	89.82	90.63	89.63	88.12	86.51	85.82	83.90
14	60	59.53	71.67	80.95	85.07	89.05	91.19	90.71	90.95	87.62	90.95	86.91	91.43	84.67
15	60	47.14	58.57	74.28	82.14	87.14	90.17	88.10	89.29	86.43	88.81	83.33	87.62	80.25
16	60	54.52	75.24	88.10	92.62	90.95	89.76	88.10	88.81	86.43	87.15	79.76	88.10	84.13

TABLE K

SHELL WEIGHT (Grams/Egg)

Diet	No. of Eggs	Week 1	Week 2	Avg. for 2 Weeks
9-12	240	5.58	5.54	5.56
13-16	240	5.67	5.63	5.65
9 and 13	120	5.52	5.60	5.56
10 and 14	120	5.59	5.55	5.57
11 and 15	120	5.68	5.60	5.64
12 and 16	120	5.70	5.59	5.65
9	60	5.45	5.54	5.49

TABLE K (continuation)

SHELL WEIGHT (Grams/Egg)

Diet	No. of Eggs	Week 1	Week 2	Avg. for 2 Weeks
10	60	5.60	5.54	5.57
11	60	5.63	5.53	5.58
12	60	5.64	5.54	5.59
13	60	5.60	5.65	5.62
14	60	5.59	5.56	5.57
15	60	5.73	5.64	5.70
16	60	5.76	5.64	5.70

TABLE L

FEED CONSUMPTION (Grams Per Hen Per Day)

Diet	No. of Weighings	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Avg. for 12 Weeks
9-12	240	48.46	99.99	109.73	119.50	122.02	124.81	121.58	120.55	119.90	116.19	127.07	126.87	113.06
13-16	240	46.83	99.44	108.18	115.65	117.85	120.77	118.26	118.37	118.88	115.16	123.32	127.25	110.89
9 and 13	120	50.38	102.66	111.29	119.56	122.97	122.55	121.86	120.09	119.88	114.09	126.58	127.97	113.41
10 and 14	120	51.39	97.54	106.64	115.63	121.17	123.85	120.33	120.67	120.22	117.38	127.20	128.18	112.52
11 and 15	120	40.78	95.91	106.74	116.19	116.49	120.14	115.64	115.23	115.71	112.91	123.17	123.68	108.55
12 and 16	120	48.02	102.77	111.14	118.91	119.03	124.61	121.86	121.83	121.32	117.33	125.82	128.41	113.42
9	60	55.36	107.40	116.61	123.85	126.99	124.25	126.59	124.45	121.78	115.12	127.93	129.53	116.66
10	60	50.04	94.97	102.57	115.92	121.49	126.62	122.74	123.44	122.81	118.76	130.94	129.54	113.32
11	60	41.59	96.84	109.08	117.39	116.79	120.14	225.64	113.21	115.28	111.69	123.85	121.46	108.58
12	60	46.84	100.76	110.66	120.83	122.83	128.23	121.34	121.08	119.75	119.21	125.55	126.94	113.67
13	60	45.40	97.91	105.97	115.27	118.95	120.85	117.12	115.74	117.97	115.06	125.23	126.42	110.16
14	60	52.74	100.10	110.72	115.33	121.04	121.08	117.92	117.90	117.63	115.99	123.47	126.82	111.73
15	60	40.00	94.98	104.39	115.00	116.20	120.14	115.63	117.25	116.14	114.14	122.50	125.90	108.52
16	60	49.20	104.78	111.62	116.99	115.22	121.00	122.39	122.58	122.90	115.46	126.08	129.88	113.17

TABLE M

BODY WEIGHT (Grams per Hen)

Diet No.	No. of Weighings	Difference
9-12	240	218.00
13-16	240	219.46
9 and 13	120	228.25
10 and 14	120	219.50
11 and 15	120	205.33
12 and 16	120	221.83
9	60	239.50

TABLE M

BODY WEIGHT (Grams per Hen)

Diet No.	No. of Weighings	Difference
10	60	228.33
11	60	179.67
12	60	224.50
13	60	217.00
14	60	210.67
15	60	231.00
16	60	219.17

TABLE N

EGG WEIGHTS (Grams per Egg)

Diet	No. of Weighings	1 Week	2 Weeks	3 Weeks	4 Weeks	6 Weeks	8 Weeks	10 Weeks	12 Weeks	Avg. for 12 Weeks
9-12	240	51.42	51.86	53.42	54.07	55.48	56.49	57.57	58.72	58.88
13-16	240	52.57	53.90	55.04	55.94	57.21	57.88	58.79	59.82	56.39
9 and 13	120	52.05	53.10	54.82	55.18	56.38	57.19	58.35	59.30	55.80
10 and 14	120	52.24	52.38	53.18	54.36	56.24	57.29	58.37	59.29	55.42
11 and 15	120	51.28	52.31	54.13	55.04	56.18	56.87	57.53	59.00	55.29
12 and 16	120	52.43	53.73	54.78	55.45	56.59	57.39	58.48	59.48	56.03
9	60	51.30	52.08	54.25	54.49	55.39	56.71	57.71	59.08	55.11
10	60	51.72	51.05	52.06	53.10	55.54	57.00	58.01	59.20	54.79
11	60	51.31	51.81	53.95	54.35	55.38	56.09	56.65	58.38	54.74
12	60	51.36	52.50	53.51	54.36	55.62	56.18	57.91	58.21	54.96
13	60	52.79	54.11	55.49	55.87	57.37	57.68	58.99	59.53	56.48
14	60	52.76	53.71	54.30	55.62	56.93	57.58	58.74	59.37	56.13
15	60	51.25	52.82	54.32	55.74	56.98	57.64	58.41	59.62	55.85
16	60	53.51	54.96	56.05	56.53	57.566	58.60	59.04	60.75	57.12

A review of the test data in Tables P and J through N shows that substantially the same results were obtained as those in Tables B through H.

In a preliminary study of a relatively few laying hens with one percent zeolite in the diet it was indicated that the relative ranks of zeolites in improving shell strength were as follows:

Rank	*Shell Strength*
1	Zeolite A
2	Synthetic Mordenites
3	Synthetic Zeolite X
4	Natural Erionite
5	Natural Clinoptilolite
6	Synthetic Zeolite Y

In shell strength, the controls were inferior to or equal to the poorest of all the zeolites.

The later studies clearly show that zeolite A is effective in increasing shell strength. Some increase in shell strength using mordenite should also be expected.

The term poultry includes all domestic fowl, namely chickens, turkeys, ducks, geese, and the like.

Corn is the principal diet for most laying poultry. A feed formulation comprising by weight percent the following is desirable:

	Weight Percent
corn	50-75
soybean meal	10-30
calcium carbonate	4-10
zeolite A	0.25-4.0

Calcium carbonate is usually in the form of natural limestone ground to a suitable particle size, but sometimes oyster shells which have also been suitably ground are used.

It can be appreciated that a wide variety of nutrients or foods may be included in the diets of layers or poultry laying hens. In a controlled environment, the hens are only exposed to desired foods or food products. A typical laying ration composition contains the following:

		Weight Percent
crude protein	- not less than	16.0
crude fat	- not less than	2.5
crude fiber	- not more than	7.0
calcium (as Ca)	- not less than	3.1
calcium (as Ca)	- not more than	4.1
phosphorus (P)	- not less than	0.5
iodine (I)	- not less than	0.0001
salt (NaCl)	- not less than	0.3
salt (NaCl)	- not more than	0.9

The foregoing composition is obtained from or included the following ingredients:

Grain and processed grain by-products. Includes corn, corn hominy, corn germ meal, barley, millet, oats, rice, rice hulls, rye, sorghum, wheat and wheat shorts. These are among the energy ingredients, mostly carbohydrates with some proteins.

Plant protein products. Includes soybean oil meal, barley malt sprouts, conconut meal, corn distillers grain, corn gluten meal, cottonseed meal, pea seed, potato meal, peanut meal, rape seed meal, sunflower meal, wheat germ meal, brewer's yeast. All of these are proein sources.

Roughage or fiber. Includes dehydrated alfalfa, alfalfa hay, alfalfa leaf meal and pasture grasses. These are all fiber sources.

Animal and fish by-products. Includes blood meal, blood flour, dried buttermilk, dried whey, dried casein, fish meal, dried fish solubles, liver meal, meat meal, meat meal tankage, bone meal and dried skim milk. Anchovies, herring and menhaden are sources of fish meal.

Minerals and synthetic trace ingredients. Includes vitamins such as B-12, A, pantothenate, niacin, riboflavin, K, etc., DL methionine, choline chloride, folic acid, dicalcium phosphate, magnesium sulfonate, potassium sulfate, calcium carbonate (limestone, oyster shells), salt, sodium selenite, manganous oxide, calcium iodate, copper oxide, zinc and D activated animal sterol.

Molasses and animal fats are added to improve palatability and to increase or balance the energy levels.

Presevatives are also added such as, Ethoxyquin™ and sodium sulfite.

In general, a feed composition for poultry laying hens should preferably contain by weight percent the following:

		Weight Percent
crude protein	- at least about	14
crude fat	- at least about	2
crude fiber	- not more than about	7
calcium	- about	2.7 to 4.1
phosphorus	- at least about	0.05
iodine	- at least	0.0001
sodium	- about	0.1 to 0.4
chlorine	- about	0.1 to 0.5
zeolite	- about	0.25 to 4.0

US-A-3 271 161 discloses the increase of egg production with thicker egg shells by addition of diatomaceous earth to conventional poultry feed nutrients. In virtue of the substantial differences in the chemical composition and the structure between diatomaceous earth and zeolite A it could not be derived that zeolite A has an effect of increasing the quality of the egg shell.

Claims

1. A method of increasing the quality of the egg shell of a poultry laying hen characterized in that a small amount of zeolite A is added to the feed of the hen.

2. The method as claimed in claim 1 in which the amount of zeolite A is added up to 4 weigth percent of the feed.

3. The method as claimed in claim 1 in which the amount of zeolite A added to the feed is from 0.25 percent to three percent by weight.

4. The method as claimed in claim 1 in which the amount of zeolite A added to the feed is 0.75 weight percent.

5. The method as claimed in claim 1 in which the amount of zeolite A added to the feed is 1.5 weight percent.

6. A feed formulation for laying poultry comprising principally corn, characterized in that from about 0.25 to about 4.00 percent by weight of zeolite A is added to the formulation.

7. The feed formulation of claim 6, wherein said zeolite A is added thereto in an amount of about 0.75 to about 1.5 weight percent.

8. A feed formulation for laying poultry comprising by weight percent, 50-75 percent corn, 10-30 percent soybean meal and 4-10 percent calcium carbonate, characterized in that about 0.25 percent to about 4.0 percent by weight of zeolite A is added to the formulation.

9. A feed composition for poultry laying hens comprising by weight percent the following:

crude protein	at least 14
crude fat	at least 2
crude fiber	not more than 7.0
calcium	about 2.7 to 4.1
phosphorus	at least 0.4
iodine	at least 0.0001
sodium	about 0.1 to 0.4
chloride	about 0.1 to 0.5
zeolite A	about 0.25 to 4.0

10. A feed composition for poultry laying hens comprising by weight percent the following:

crude protein	at least 16
crude fat	at least 2.5
crude fiber	not more than 7.0
calcium	about 3.1 to 4.1
phosphorus	at least 0.5
iodine	at least 0.0001
sodium	about 0.1 to 0.3
chloride	about 0.1 to 0.3
zeolite A	about 0.25 to 4.00

Patentansprüche

1. Verfahren zur Erhöhung der Qualität der Eierschale bei Geflügelzuchthennen, dadurch gekennzeichnet, dass man dem Hühnerfutter eine geringe Menge Zeolith A beifügt.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass eine Menge des Zeoliths A bis zu 4 Gewichtsprozent (Gew.-%) des Futters beigefügt wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Menge des beigefügten Zeoliths A von 0.25 bis 3 Gew.-% des Futters beträgt.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Menge des zum Futter beigefügten Zeoliths A 0,75 Gew.-% beträgt.

5. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die zum Futter beigefügte Menge des Zeoliths A 1,5 Gew.-% beträgt.

6. Futterzubereitung für eine Legegeflügelzucht, enthaltend im wesentlichen Mais, dadurch gekennzeichnet, dass man etwa 0,25 bis etwa 4 Gew.-% Zeolith A zur Zubereitung beifügt.

7. Futterbereitung nach Anspruch 6, dadurch gekennzeichnet, dass man den Zeolith A in einer Menge von etwa 0,75 bis etwa 1,5 Gew.-% beifügt.

8. Futterzubereitung für eine Legegeflügelzucht, enthaltend, in Gewichtsprozenten, 50 bis 75% Mais, 10 bis 30% Sojabohnenmehl und 4 bis 10% Calciumcarbonat, dadurch gekennzeichnet, dass man etwa 0,25 bis etwa 4,0 Gew.-% Zeolith A der Zubereitung beifügt.

9. Futterzusammensetzung für Legehennen einer Geflügelzucht, enthaltend, in Gewichtsprozent, folgende Bestandteile:

Rohprotein	mindestens 14
Rohfett	mindestens 2
Rohfaserstoffe	nicht mehr als 7,0
Calcium	etwa 2,7 bis 4,1
Phosphor	mindestens 0,4
Jod	mindestens 0,0001
Natrium	etwa 0,1 bis 0,4
Chlorid	etwa 0,1 bis 0,5
Zeolith A	etwa 0,25 bis 4,0

10. Futterzusammensetzung für Legehennen einer Geflügelzucht, enthaltend, in Gewichtsprozent, folgende Bestandteile:

Rohprotein	mindestens 16
Rohfett	mindestens 2,5
Rohfaserstoffe	nicht mehr als 7,0
Calcium	etwa 3,1 bis 4,1
Phosphor	mindestens 0,5
Jod	mindestens 0,0001
Natrium	etwa 0,1 bis 0,3
Chlorid	etwa 0,1 bis 0,3
Zeolith A	etwa 0,25 bis 4,00

Revendications

1. Procédé pour améliorer la qualité de la coquille des oeufs d'une volaille pondeuse, caractérisé en ce qu'une petite quantité de zéolite A est ajoutée à la nourriture de la volaille.

2. Procédé suivant la revendication 1, dans lequel la quantité ajoutée de zéolite A va jusqu'à 4% en poids de la nourriture.

3. Procédé suivant la revendication 1, dans lequel la quantité de zéolite A ajoutée à la nourriture va de 0,25 à 3% en poids.

4. Procédé suivant la revendication 1, dans lequel la quantité de zéolite A ajoutée à la nourriture est de 0,75% en poids.

5. Procédé suivant la revendication 1, dans lequel la quantité de zéolite A ajoutée à la nourriture est de 1,5% en poids.

6. Formulation pour l'alimentation de volailles pondeuses, comprenant principalement du maïs, caractérisée en ce qu'une proportion d'environ 0,25 à environ 4,00% en poids de zéolite A est ajoutée à la formulation.

7. Formulation alimentaire suivant la revendication 6, dans laquelle la zéolite A est ajoutée en une proportion d'environ 0,75 à environ 1,5% en poids.

8. Formulation pour l'alimentation de volailles pondeuses, comprenant en poids, 50 à 75% de maïs, 10 à 30% de farine de soja et 4 à 10% de carbonate de calcium, caractérisée en ce qu'une proportion d'environ 0,25 à environ 4,0% en poids de zéolite A y est ajoutée.

9. Composition pour l'alimentation de volailles pondeuses, comprenant, en % en poids, les composants suivants:

protéine brute	au moins 14
matière grasse brute	au moins 2
fibre brute	pas plus de 7,0
calcium	environ 2,7 à 4,1
phosphore	au moins 0,4
iode	au moins 0,0001
sodium	environ 0,1 à 0,4
chlorure	environ 0,1 à 0,5
zéolite A	environ 0,25 à 4,0

10. Composition pour l'alimentation de volailles pondeuses, comprenant, en % en poids, les composants suivants:

protéine brute	au moins 16
matière grasse brute	au moins 2,5
fibre brute	pas plus de 7,0
calcium	environ 3,1 à 4,1
phosphore	au moins 0,5
iode	au moins 0,0001
sodium	environ 0,1 à 0,3
chlorure	environ 0,1 à 0,3
zéolite A	environ 0,25 à 4,00