Nutritional manipulation of feeding behaviour of birds

Ubah, E.J, Abeke, F.O. and Madziga, I.I.

National Animal Production Research Institute (NAPRI)/ Ahmadu Bello University (ABU), P.M.B.
1096 Shika, Zaria Kaduna State. **Abstract**

A research to manipulate the feeding behaviour of laying hens from nutritional perspective was conducted with 504 ISA Brown. Seventeen (17) week old ISA brown with weights ranging between 1590 and 1812 g were allocated to six dietary treatments. There were seven replicates per treatment with 12 birds each making a total of 42 pens in all. Experimental diets differed in the levels of energy, levels insoluble Non Starch Polysaccharide (NSP) and the particle sizes of the NSP. Birds had free access to water and feed during which feeding observations with video camera were made to observe and record the feeding behaviour of birds at 17, 21, 25, 29, 33 and 35 weeks of age. A computer software programme called Observer 5.0 was used to analyze the observations by one person for 30 minutes per cage. In order to gain more insight in the feeding behaviour of laying hens, 60 laying hens were used for passage rate experiment using titanium dioxide as an inert marker. Five birds were used for each dietary treatment, and replicated twice. At $t=0$, three titanium capsules were offered to each bird. After five different time points (30, 90, 180, 270 and 360 minutes), these birds were sacrificed and dissected. The gut (titanium) contents from different segments of the GIT (crop, gizzard, ileum, colon and caeca) of each bird were analysed using spectrophotometer at an absorbance of 408 nm. Result from the study indicates that the feeding behaviour of laying hen can be manipulated nutritionally. Bulky diets (10.6 MJ/kg) significantly ($P<0.05$) increased the eating time of laying hens by 15% compared with normal energy content (11.8 MJ/kg) and this led to consumption of more feed (average 2355g) than those of normal energy diets (2175g). Similarly, the separate effect of NSP, NSP coarseness and interaction between low energy, NSP and NSP coarseness influenced the eating behaviour. Feeding layers with low density diet containing a combination of low energy high NSP coarse NSP increased the amount of time birds spent feeding by 32% and consequently increased the feed intake by 11% (average feed intake of 135g) above normal energy low NSP mixture diet (average feed intake of 120g). The passage rate experiment showed that Low energy High non starch polysaccharide coarse (LeHnspcoarse) diet reduces the gut transit time, thus birds quickly feel hungrier after a period of satiety, possibly resulting in a short inter-meal interval. Conclusively, the interaction between low energy, high NSP and NSP coarseness influence birds' feeding behaviour necessitating increase in eating time and faster passage rate via the GIT.

Key words: Laying hen, NSP form, energy level, feeding behaviour and passage rate

Introduction

Fibre plays an important role in the normal structure and functions of the gastrointestinal tract and capable of increasing the time birds devote to eating due to its bulky nature. Fibre is made up of non starch polysaccharide (NSP) and lignin. NSP can be soluble or insoluble.

Soluble NSP increases gut viscosity, increases the time food stays in the gut and decreases gut emptying rate which may reduce feed intake. Monogastric animals attempt to increase feed intake when given diets that contain increasing levels of insoluble NSP and increases in feed intake coincide with decrease in digesta retention

time (Graham and Aman, 1991). This is probably an attempt to maintain the rate of available energy intake. This invariably suggests that providing layers with low energy density diet (dilution) would increase their feed intake and eating time. Coarseness of insoluble fibre can affect the passage rate in the gizzard and the entire gut. The fact that insoluble fibre accumulates in the gizzard may indicate slower passage rate when the level of coarse fibre increased in the diet. This confirms that gizzard is almost like a point of regulation, selectively retaining different feed particles and letting nutrients pass for further digestion. Conceivably, accumulation of coarse insoluble fibre in the gizzard triggers a temporary satiety, but once passed the gizzard; it passes through the gut quickly. This could make the birds feel more satisfied between feeding bouts, but more hungry quickly after gizzard emptying (Hetland and Choct, 2003). Hence it can be imagined that chicken prefer not just fibre but coarse fibre (Van Krimpen *et al.*, 2005) which can increase feeding time

Little or no information is available on the separate effect of low energy, high NSP, NSP coarseness and the interaction between them on the passage rate of consumed feed and eating time (time spent eating). With all these in mind, it can be argued that feeding layers diet with low density diet containing low energy, high NSP and coarse NSP would increase amount of time birds spent during feeding and increase passage rate via the gastrointestinal tract. Therefore, this research is designed to manipulate the feeding behaviour of layers base on the passage rate and the amount of time devoted in feeding. Successful manipulation of birds' feeding behaviour could be a possible solution to certain

misdirected behaviour.

Materials and methods

Pre-experimental stage: Six hundred and fifty day old (650) ISA Brown chicks were housed (13 hens per m²) in three groups at the facility house (*De Haar*) of Zodiac, Wageningen Univeristy and managed according to ISA Brown management practice. The birds were not debeaked. In order to encourage foraging behaviour, the floor was covered with wood shavings serving as litter source. Commercial diet with standard energy density (2600 Kcal) was provided from week 1 to week 8 of age after which they were fed low density energy (2500 Kcal) diet at week 8 to week 17 of age. This was done to facilitate the development of gastrointestinal tract of birds.

Experimental stage: At 17 week old, 504 birds were selected based on their weight (between 1590 g and 1812 g) and randomly allotted into six dietary treatments. There were seven replicates per treatment with 12 birds per replicate making a total of 42 pens. The feeding experiment gulped 154 days (22 weeks) but observation of birds with video camera was within 140 days (20 weeks). The diets were all in mash form. Six experimental treatments comprise of different levels of energy, insoluble NSP and NSP coarseness were offered to the birds in the trough *ad libitum*. The treatments (1-6) were designated NeLnspp (Normal energy low NSP), NeHnsppfine (Normal energy high NSP fine), NeHnsppcoarse (Normal energy high NSP coarse), LeLnspp (Low energy low NSP), LeHnsppfine (Low energy high NSP fine) and LeHnsppcoarse (Low energy high NSPcoarse) respectively. Particle sizes of the diets were analyzed according to the dry sieve method. An average size of 0.89 mm

or less was considered fine, whereas an average size of 1.02 mm or higher was considered as coarse diet. Treatment 1 was the control diet without any form of dilution. Treatments 2 and 3 had same normal energy content as treatment 1 except that the NSP content was high in 2 and 3 as a result of 10% oat hulls addition, which was achieved by adjusting the amounts of some ingredients in treatment 1. Treatment 2 and 3 differ in the form of NSP. It was fine in treatment 2 while it was coarse in treatment 3 (Table 1). Treatment 4 was diluted with 10% sand by adjusting some ingredients in treatment 1 resulting in low energy content and low NSP. Treatments 5 and 6 were diluted with 10% oat hulls (NSP source) by changing the quantities of some ingredients in treatment 1, thus the energy levels were low. Treatment 5 differ from 6 in the form of NSP. Treatment 5 had fine NSP in the diet while it was coarse form in treatment 6. Since there were low NSP contents in diets 1 and 4 the form of NSP was not necessary, therefore, the NSP in these diets were neither fine nor coarse form.

Hens were housed in two rooms, both measuring 8.3 x 8.3 metres. The two rooms were designated rooms 1 and 2 and each room contained 21 floor pens respectively. Altogether, there were 42 floor pens measuring 90 x 150 centimetres (1.35 m²) each. The area of the feeding trough was 2 x 100 centimetres (0.2 m²). Excluding the area of the feeding trough, the area is 1.15 m². The pens were made of wires such that hens could see the chickens in the other pens. A laying nest was placed outside of the pen but connected within. Within each pen, there were two perches located at suitable heights. A feeding trough was placed at the long side of the pen, between the laying nest and the perches. Water tube with nipple drinkers was placed at the front

side of the pen, between the laying nest and the feeding trough. Each pen had four nipple drinkers. Hens had 10 hours of light per day. The hens only received artificial light since the windows were covered with black plastic material. The light period was extended by one hour every week by switching on the light one hour earlier until they (hens) had 16 hours of light per day at the age of 22 weeks. Initially, the light intensity was approximately 10 lux using bulbs (8 light bulbs of 25 Watt). The first light adjustment was increased by 10 lux when the hens were 18 weeks old, thus 20 lux (60 Watt bulbs) in total. At 20 week old, it was increased to 30 lux (100 Watt bulbs). This was marked with an outbreak of cannibalism. Consequently, the light intensity was reduced to 20 lux at 21 week old and maintained until the end of the trial. Every week, sand which served as the litter source was turned over to transport dryer sand to places within each pen where most droppings fell. The laying nests were vacuum cleaned, as was the situation for the rest of the room. Twice daily check-up was done to control the status (health) of the hens. The temperature was set at 20°C the optimal requirement throughout the duration of the experiment. The temperature and air humidity were checked and recorded twice daily. During the experimental period, all pens were individually assigned a marked bucket with a lid, containing weighed feed. This was done in order to differentiate between experimental treatments and the amount of feed for a particular pen. Every week, the feeding troughs were emptied into buckets and the remnant weighed. Thereafter, new feed was put into each bucket and weighed again. Feed and water were provided *ad libitum*. The percentage number of dead birds from 1st week through 20th week when we observed the eating behaviour of the

birds was 28. Diets were chemically analyzed according to standard procedures (Table 1).

Behavioral observation with video

Behavioral observation to measure the amount of time laying hens devoted to eating (eating time) was measured per pen using video. Video observations were made at the age of 17, 21, 25, 29, 33 and 36 weeks. The video was positioned at the top of the cage so as to capture when birds were eating. For this observation, the day was divided into three blocks: from 9.00 am to 11.00 am, 11.30 am to 1.30 pm and 2.00 pm to 4.00 pm. In each block, eight cages were observed using four cameras. Each observation lasted for one hour in the pen. Within this observation period, the number of hens eating (between 0 and 12) was recorded continuously until the end of each observation. A computer software programme called Observer 5.0 was used to analyze the observations made by video camera at the pen by one person for 30 minutes per pen. Since the observation was done for 60 minutes per cage, 15 minutes adjustment time was allowed before the actual reading with the observer. This was done to re-establish the birds' feeding habit and correct for environmental disturbance created when the video was placed. Eating time was defined as the time when one or more than one hens put their head in the feeding trough to eat during 30 minutes. Based on the video observations, the total number of hens per cage and by duration of observation period was calculated. This number was divided by the number of hens per cage and by the duration of observation period, resulting in average percentage of time spent on feed intake (eating time) per cage. Eating minutes was calculated as 16 hours daylight by 60 minutes by eating time (%). Eating rate (g feed intake/eating time)

was calculated as feed intake in grams divided by eating time in minutes.

Statistical analysis

Statistical analyses were performed using Genstat software package (Genstat Committee, 2002) to test the effects of (a) energy and NSP levels, (b) the interaction between energy*NSP levels, interaction between NSP levels*NSP coarseness, interaction between energy*NSP levels*NSP coarseness on eating behaviour of layers. Since the observation was not orthogonal (not balanced). Residual (or restricted) maximum likelihood (REML) was used to test for significant of main effect and interaction. The dependent eating behaviour variable determined were eating time (%) and eating rate (g/min).

$$Y = \mu + E_i + N_j + (E*N)_{ij} + (N*C)_k + (E*N*C)_{ik} + \epsilon_{ijkm}$$

Where Y is the eating time or eating rate, μ the mean, E_i the energy effect (i = low, normal energy), N_j NSP effect (j = low, high NSP), $(E*N)_{ij}$ interaction between energy and NSP level, $(N*C)_k$ interaction between NSP and NSP coarseness $(E*N*C)_{ik}$ interaction between energy level, NSP level and NSP coarseness, and ϵ_{ijkm} the error term.

Passage rate experiment

In order to determine the dietary effect of energy and NSP levels, interaction between energy*NSP level, interaction between NSP level*NSP coarseness and interaction between energy*NSP level*NSP coarseness on passage rate along the gastro-intestinal tract with possible effect on the feeding behaviour, a passage rate experiment was conducted on the birds' gastro-intestinal tract. The parts considered were crop, gizzard, ileum, colon and caecum. The same birds that were used for

the behavioral observation were used. Sixty (6 dietary treatments x 5 birds/pen x 2 replicates) laying hens were given titanium capsules. Each marked birds were given 3 titanium capsules (TiO_2) administered sequentially. To facilitate intake of the titanium capsules, each capsule was dissolved in water. The mouth of the bird was opened and turned upside down, immediately the dissolved TiO_2 were poured accordingly. The birds were slaughtered and dissected after five different time points: 30, 90, 180, 270 and 360 minutes after capsules were given

when the birds were 37 week old. The gut contents from different segments of the gastro intestinal tract (crop, gizzard, ileum, colon and caecum) of each bird were removed using hand and collected into cleaned labeled plastic containers and sealed for determination of dry matter and passage rate respectively using titanium dioxide as an inert marker with the aid of ultra violet (UV) visible spectrophotometer at an absorbance of 408nm. To facilitate the determination of the samples, standard calibration was made.

Table 1 Composition of the experimental diets

Ingredients (%)	Dietary treatments					
	1	2	3	4	5	6
Maize	38.34	38.34	38.34	34.51	34.51	34.51
Wheat	20.48	4.00	4.00	18.42	18.42	18.42
Soya bean meal extract	13.79	10.89	10.89	12.41	12.41	12.41
Peas CP<22%	8.46	9.18	9.18	7.61	7.61	7.61
Grit stones	7.24	7.20	7.20	6.52	6.52	6.52
Rapeseed extract CP<38%	3.00	0.00	0.00	2.70	2.70	2.70
Soya bean heated	2.50	11.60	11.60	2.25	2.25	2.25
Soya oil	2.33	2.50	2.50	2.10	2.10	2.10
Grit	2.00	2.00	2.00	1.80	1.80	1.80
Monocalcium phosphate	0.81	0.90	0.90	0.72	0.72	0.72
Minerals	0.50	0.50	0.50	0.45	0.45	0.45
Salt	0.37	0.37	0.37	0.33	0.33	0.33
DL-Methionine	0.16	0.20	0.20	0.14	0.14	0.14
L-Lysine	0.04	0.00	0.00	0.04	0.04	0.04
Palm oil	0.00	2.32	2.32	0.00	0.00	0.00
Oat hulls (NSP source)	-	10.00	10.00	-	10.00	10.00
Sand	-	-	-	10.00	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00
Determined Nutrients(g/kg)						
Dry matter	887.42	896.79	896.79	897.89	890.59	890.59
Moisture	112.58	103.21	103.21	102.11	109.41	109.59
Ash	127.19	132.31	132.31	204.43	120.43	120.43
Crude protein	155.00	151.27	151.27	143.14	144.04	144.04
Fat	49.57	90.00	90.00	46.28	46.28	46.28
Crude fibre	31.66	56.84	56.84	28.49	57.49	57.49
Neutral detergent fibre	95.78	150.45	150.45	86.20	156.20	156.20
Acid detergent fibre	40.28	74.27	74.27	36.25	75.65	75.65
Acid detergent lignin	5.40	3.41	3.41	4.86	6.06	6.06
Calcium	38.00	38.00	38.00	34.21	34.38	34.38
Phosphorus	5.19	4.90	4.90	4.70	4.68	4.68
Energy MJ/kg	11.80	11.80	11.80	10.62	10.77	10.77
Non starch polysaccharide	144.24	188.32	188.32	129.79	194.80	194.80
Average particle size (mm)	0.89	0.89	1.08	0.87	0.86	1.02
NSP coarse (no unit)	Irrelevant	Fine	Coarse	Irrelevant	Fine	Coarse

Results and discussion

Naturally, birds would spend roughly ± 60 % of their daily activities on feeding and foraging; feeding (± 29 %) and foraging (± 22 %) (Aerni *et al.*, 2000). Comparing this aforementioned values with the result of the present study in control and LeHnspcoarse diets groups, the amount of time spent feeding were ± 15 % and ± 22 % respectively. The difference between Aerni *et al.* (2000) and our result could be breed difference as Lohman selected Leghorns hybrids were used for the latter while ISA Brown breed was used for our study. It can also be difference in definition of eating time and the time allocated for observation. The time allowed for observation in the author's experiment was 30 seconds per individual and feeding time started and recorded when birds had had more than 5 feeding pecks while in this experiment it was 30 minutes per hens in each pen. As would normally be expected, the feed intakes (g) of all laying hens fed dietary treatments from periods 17, 21, 25, 29, 33 and 36 weeks of age (Figure 1) increased with time, somewhat curvilinear and this (the increase) was more for the birds fed diets containing low energy content (10.70 MJ/kg) than those on normal energy content (11.80 MJ/kg). Similarly, increase feed intake corresponded with increase percentage eating time and vice versa (Figure 2). However, there was a change in this pattern after week 25 (age of bird) and this negatively affected the amount of feed consumed. The sudden decrease in feed intake was probably health related since the birds were affected with mites and this possibly limited the bird's appetite for feed consumption.

Generally, birds on low energy diets significantly ($P < 0.05$) spent more time (15% extra time) feeding (average 20 % compared with 17 % for those on normal

energy levels) and thus consumed more feed (average 2355g) than those of normal energy diets (average 2175g). The increased time spent in eating was aided by the low energy content of the diet. Increase feed intake and time spent eating would be the price paid for energy dilution of the diet, as birds would continue to feed and spend more time eating until their energy demand is met. This is in line with the result obtained. Possibly, in order to meet nutritional requirement for physiological response, birds continued to eat and spend more time feeding. The average eating rate (expressed as the amount of feed consumed per minute) for birds on low energy diets was 0.76 and 0.85g/min for normal energy diets (Figure 3). This indicates that birds on low energy diets would consume low amount of feed (0.76g) in 60 seconds (more eating frequency and longer spread) compared with normal energy diets (0.85g). Rapid consumption of feed is an indication of quick satiety, less time devoted in eating leading to low feed consumption (Hartini *et al.*, 2003). Invariably, given same amount of time (with different diet combinations), birds with high energy (less bulky diet) will consume 1g of feed quickly and get bored of eating, and may thus warrant engaging in other activities like feather pecking compared with birds with low energy diets with high levels of bulking agents. Possible explanation for this could be differences in specific gravity between the dietary treatments necessitating quick satiety. Another possible explanation could be that unlike birds on less bulky diet, those on bulky diet (low energy high NSP coarse NSP combination) could be searching or selecting feed particles or foraging without actually feeding at all time (Aerni *et al.*, 2000; Sedlackova *et al.*, 2004). Fright arising from presence of attendants during egg collection and other routine activities

could also be a possibility preventing some group housed birds from feeding, consequently, affecting feed consumption per time. The effect of NSP proportion is evident in both low and high diets. The mean percentage eating time was significantly ($P < 0.05$) higher (+15%) for high NSP (20%) diet than low NSP (17%). Similarly, the interaction effect between NSP proportion and NSP structure shows that diet containing high NSP and coarse NSP (21%) is more preferred to diets with either low NSP (17%) or High NSP and fine NSP (20%). This suggest that chicken prefer not just NSP but coarse NSP (Van Krimpen *et al.*, 2005). Nonetheless, energy effect seems to have a greater effect irrespective of diet form. This is because when there is a sensation to maintain birds'

energy requirement, birds continue to consume less energy dense diet(s) until the energy is met. Although there was no significant difference ($P > 0.05$) in the interaction effect in feed intake, percentage eating time and eating rate, but numerical difference exist. Feeding layer diet containing a combination of low energy, high NSP and coarse NSP would increase the amount of time birds spend during feeding and consequently increase the feed intake (average feed intake of 135g LeHnspcoarse) than normal energy low NSP mixture (average feed intake of 120g NeLnsP). Birds possibly have a preference for low energy high NSP coarse diet than any other combinations. This is in accordance with the hypothesis of this study.

Figure 1 feed intake (g) of laying hens fed dietary treatments

Passage rate result (Figure 4) shows that at 30 minutes after titanium ingestion most of the feed consumed by the treated birds was found at the crop and gizzard segments (except diet 4). The amount of time necessary to process food in the gizzard

segment differs between dietary treatments. Birds fed low energy diets (especially diets 5 and 6) had more feed in their gizzard compared with normal diets. The accumulation of diets in this segment indicates that the rate of digesta passage of

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high insoluble NSP was slower than other diets at 30 minutes. This is because the high insoluble NSP and coarse form (diet 6) would cause the gizzard to work harder. Within the first 90 minutes, less than 50% of the feed consumed remained in the first two segments (crop and gizzard) and other proportion distributed unevenly to other segments (more in ileum than in colon and caeca). This indicates the regulating mechanism of the gizzard in releasing food

passed from the crop to other segments. Moreover, at 90 minutes, coarse diet (treatment 6) had the lowest amount of gut content reaching the ileum compare to other dietary treatments, indicating a longer stay in the gizzard due to the coarseness of the diet before emptying into the next segment, ileum. And once in the ileum gut emptying rate increases as evident in the colon of diet 6 with highest accumulation of gut content in the colon after 90 minutes.

Figure 2 Eating time (%) of the laying hens fed dietary treatments

Figure 3 Eating rate (g/min) of the laying hens fed dietary treatments

The processing mechanism of the coarse diet by the gizzard leading to longer stay in the gizzard is the price paid for temporary satiety. In addition, the coarseness of diet probably increased the capacity of the gizzard to house coarse diets for a longer period of time than normal, thus temporarily reducing the flow of gut content to other segments. Furthermore, the effect of insoluble fibre (NSP) in maintaining the normal structure and functioning of gastrointestinal tract cannot be over emphasized and this (insoluble fibre) has been suggested in poultry rations (Aerni *et al.*, 2000; Savory, 1995; Hartini *et al.*, 2003; Van Krimpen *et al.*, 2005). Coarse insoluble fibre accumulates in the gizzard and may trigger temporary satiety, but once passed the gizzard after a temporary storage time in the gizzard, it passes through the gut rapidly, thus making bird feel hungrier and spending more time eating (Van Krimpen *et al.*, 2005 and Blokhuis and Arkes 1984). It is therefore necessary that food is always in the trough when the sensation for hunger emerges to avoid misdirection. The low proportion of the total gut content after 90 minutes in the high NSP coarse diet i.e diet 6 (80.6%) compared with high NSP fine i.e diet 5 (90.7%) may signify quick passage rate as a result of excretion. The low gut content of diet 6 (35.6%) at time 180 minutes compared with diet 5 (65.6%) in the last three segments (ileum, colon and caeca) may also imply that passage rate is faster in coarse diet than fine. Hartini *et al.* (2003) and Blokhuis (1986) noted that insoluble NSP serves as bulking agent and as a result birds will feel hungry quicker and therefore spend more time eating if nutrient disappear faster from the lumen and digesta moving through gut quickly. The continuous feeding may necessitate decrease gut transit time and increase gut-emptying rate due to limited access to

digestive enzymes and microbial action. In this present study the low accumulation of digesta in the ileum during 90 minutes in diet 4 (46.2%) as against diet 1 (68.2%) may be an indication of quick passage rate and this could be attributed to differences in energy content. After 180 minutes, nearly all the titanium would have been excreted and the birds would continue or resume feeding. However, the low amount of titanium content at 360 minutes for dietary treatment 5 (5.8%) and 6 (6.6%) may also suggest rapid passage rate of these diets due to their bulky nature (low energy high NSP). Consequently, the interaction between the low energy, high amount of NSP and NSP coarseness increased the eating time and this perhaps was associated with increase emptying or passage rate. This mechanism could be the possible explanation for reduced mortality and low feather score (less feather pecking) observed in Van Krimpen *et al.* (2006) study.

The result obtained in this study is expected, however, the low amount of food found in the crop segment of dietary treatment 4 at 30 minutes was below our expectation. This variation could be explained by differences between individual laying hens since it was assumed that all birds placed on same dietary treatments would have same effect. Another possible reason could be the differences in the amount of digesta collected at the crop and gizzard segments. Other potential source of variation could be differences in weight of titanium capsules given to the birds for the determination of passage rate. This was assumed to be same; nevertheless, we found significant differences between titanium content of every capsule.

Conclusion and Recommendation

Conclusively, feeding behaviour of laying

hens can be manipulated nutritionally by increasing the time devoted to eating leading to increase feed intake. And this can be achieved by giving birds diets with low energy or high NSP or Coarse NSP. Importantly, the interaction between low energy, high NSP and NSP coarseness

influence birds' feeding behaviour necessitating increase in eating time and faster passage rate via the GIT, thus birds feel hunger sensation after gizzard emptying.

Figure 4 Passage rates of test diets in laying hens' gut segments

% Titanium (Ti) for time 30 & 90 minutes = Segment Ti content mg/Total segment Ti * 100
 % Titanium (Ti) for time > 90 minutes = Segment Ti content mg/Average total Ti * 100
 Number of samples= 260; number of replicates= 2 (except for diet 6 which was 1).

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