**Quail egg yield and quality of the *Coturnix coturnix* response to the addition level of agave inulin to the drinking water**

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**Introduction**

The use of prebiotics to improve animal performance and intestinal health is increasing due to the ban on antimicrobial growth promoters in different production systems, such as poultry. Inulin is a water soluble oligosaccharide formed by a linear chain of fructose bond with b2-1 glycoside bonds (Chen et al., 2005a, 2005b; Cieoelik et al., 2005). This oligofructose is a glucide present in various parts of the vegetal (mainly in tubers, leaves or roots), where is stored by accumulation in the cell. The fructan is not digested by the stomach or small intestine enzymes, but the carbohydrate is further fermented to certain extent by the microflora present in the large intestine (Kolida and Gibson, 2007; Park and Park, 2012; Piccolo et al., 2013). Furthermore, inulin similarly to other carbohydrates is a feeding stock for certain lactic acid bacteria, lowering the growth of sensible type of undesired bacteria (Hafany, 2010; Park and Park, 2012).

As mentioned by the previous authors and others (Attia et al., 2013), during the fermentation process, the volatile fatty acids are produced, and this stimulates the growth, and also reduces the pH of the gut content. Also, according to Scholz-Ahrens et al. (2007), this pH reduction increases the solubility of dietary minerals, especially calcium, to be further absorbed in the large intestine and then used by the animal body.

Most of the trials have assessed the effect of inulin-type (from chicory, Jerusalem artichoke) using rapid growth mammals and bone mineralization (Roberfroid et al., 2002; Cashman, 2003). It was also seen in egg producing Leghorn hen by Chen and Chen (2004), who reported that the inulin and the oligo-fructose stimulated egg production and improved feed conversion ratio, without affecting the egg quality. However, Shang et al. (2010) found no effect of the prebiotic inulin on egg production or quality. The same authors also observed an egg cholesterol lowering effect when the inulin was added to the hen feed.

On the other hand, a long type inulin occurs naturally in several *Crassulaceae* acid metabolism plants, for instance the agave which contains approximately 25% of the head weight as inulin. Hence, adding to the drinking water the inulin was added to the drinking water for 6 weeks.

Table 1 presents the composition of the complete diet, formulated to meet the nutrient requirements of Japanese quail (National Research Council, 1994).

**Materials and methods**

This study was conducted at the Animal Production Institute for Sustainable Studies, (Tepatitlán, Jalisco, Mexico). The animals of the experiment were kept, maintained and treated in adherence to accepted standards for the animal welfare.

One hundred, sixty five-days-old *Coturnix coturnix japonica* hens in production which were randomly assigned into 4 groups (25 bird per group, divided in 5 cages containing 5 quails), and fed a sorghum-soybean meal basal diet supplemented with 0 (control), 2, 4, or 6% agave inulin in the drinking water for 6 weeks. Table 1 presents the composition of the complete diet, formulated to meet the nutrient requirements of Japanese quail (National Research Council, 1994).

Water and feed were provided for *ad libitum* and a regimen of 16L:8D was used throughout the experimental period. The birds were housed in quail layer cages (21x20x27 cm), and individual body weight were obtained at the beginning and at the end of the study. Eggs were collected and weighed daily. Daily egg yield (%) and feed intake (g/day) were measured for each treatment during all the experiment. Five eggs from each treatment group were randomly collected every two weeks. These eggs were transported to the laboratory.
to assess egg quality parameters where they were weighed in precision scale (0.01 g accuracy); and then broken to determine the proportions of egg parts relative to the entire egg were mathematically obtained. Eggshells and yolks fresh weighted and then were dried in an oven at 60°C for three days. An egg separator was used to separate the yolk. Albumen weight was calculated by subtracting the fresh yolk and shell weights from the whole egg weight. The albumen weight relative to the individual egg weight was calculated. Particle size of dehydrated egg shell was reduced prior to ashing (600°C for 24 h) in a furnace, according to the methods of the AOAC (1990). The diet and eggshell calcium content was determined by permanganate titration by the molybdate/ana- date method.

The data variance was statistically analysed using the General Linear Model of the SAS package (2002); the threshold for significance was set at 0.05 to declare differences among treatments. The Duncan’s multiple range test was used to separate the means when a significant difference between treatments means was found.

### Table 1. Ingredients and nutrients composition of diet.

| Ingredient                      | g/kg as fed basis |
|---------------------------------|-------------------|
| Sorghum                         | 474.50            |
| Soybean meal                    | 278.81            |
| Rice polishing                  | 90.03             |
| Calcium carbonate               | 65.05             |
| Corn gluten                     | 50.00             |
| Soy oil                         | 16.00             |
| Orthophosphate                  | 14.00             |
| Choline chloride, 70%           | 2.54              |
| Ground salt                     | 2.50              |
| Sodium bicarbonate              | 2.00              |
| D-L Methionine                  | 1.32              |
| L-Lysine                        | 0.91              |
| Vitamin-mineral premix          | 2.50              |

**Chemical composition**

| Nutrient          | %       |
|-------------------|---------|
| Dry matter        | 90.10   |
| Crude protein      | 20.63   |
| Crude fat          | 5.17    |
| Crude ash          | 11.56   |
| Crude fibre        | 3.04    |
| Methionine         | 0.41    |
| Lysine             | 1.06    |
| Methionine + cystine| 0.71   |

**Metabolizable energy kcal/kg**

| Source                  | kcal/kg |
|-------------------------|---------|
| Corn gluten, 60%        | 2800    |
| Sorghum                 | 474.50  |
| Soybean meal            | 278.81  |

**(Chemical composition of the diet was calculated based on National Research Council (1994) feed composition tables.)**

### Table 2. Effects of the addition of agave inulin on the egg production and quality (mean±SEM).

| Intake, g/day | 0       | 2       | 4       | 6       |
|---------------|---------|---------|---------|---------|
| Yolk          | 28.62±0.70 | 28.11±0.71 | 26.75±0.69 | 24.97±0.71 |
| Laying rate, %| 67.51±2.37 | 77.28±2.35 | 77.10±2.30 | 78.48±2.30 |
| Egg mass, g/day| 8.73±0.30 | 9.36±0.31 | 9.71±0.20 | 8.92±0.29 |
| Feed conversion ratio | 3.28±0.16 | 3.28±0.15 | 3.49±0.16 | 3.12±0.15 |
| Egg weight, g    | 13.02±0.12 | 11.90±0.13 | 13.29±0.12 | 12.14±0.12 |

**Yolk**

| Weight, g         | 4.14±0.15 | 4.16±0.26 | 4.83±0.25 | 3.82±0.23 |
| EGG, %            | 31.68±1.14 | 34.92±1.90 | 36.69±1.91 | 31.49±1.74 |
| Eggshell, %       | 14.27±0.46 | 15.51±0.77 | 13.31±0.76 | 13.53±0.70 |
| Ash content       | 48.68±1.42 | 42.96±2.38 | 51.53±2.36 | 52.47±2.17 |
| Calcium           | 18.16±1.06 | 17.01±1.64 | 23.52±1.84 | 19.95±1.50 |

**Albumen**

| Weight, g         | 7.03±0.23 | 5.90±0.38 | 6.64±0.37 | 6.67±0.35 |
| EGG, %            | 54.54±1.19 | 49.57±2.00 | 50.00±2.10 | 54.98±1.82 |

**Results and discussion**

The average individual feed intake (27.13 g/day) was reduced by 1.90, 6.64, and 12.85% with the addition of 2, 4, and 6% of agave inulin in the drinking water, respectively (P<0.05; Table 2). Abdelqader et al. (2013) using hens found no effect of inulin supplementation to the diet on feed consumption. But, water consumption augmented as the inulin addition to the water increased (63.32, 67.45, and 72.45 ml/day with 0, 2, 4, and 6% agave inulin respectively).

Laying rate average 75% and was increased as the agave inulin addition to the water augmented (P<0.05; Table 2). The egg weight was similar among treatments (average 12.70 grams). Yildiz et al. (2006) reported no effect of dried Jerusalem artichoke as source of inulin added to the diet of hen on performance and intake. This observation also coincides with the reported findings of Świątkiewicz et al. (2010), Abdelqader et al. (2013), and Sritawatthai et al. (2013), who found no significant effect of the addition of chicory inulin on the hen productivity. Nevertheless, Hanafy (2010) reported an improvement in egg weight and productivity of laying hens with the use of inulin in the feed. Also, Park and Park (2012) using artichoke inulin and laying hens fed a soybean-corn diet increased the egg yield.

The eggshell ash content was higher (P<0.05) in 4 and 6% supplemented group (Table 2) in respect of 2%; however all groups that received agave inulin showed no differences in respect of the control group. Chen and Chen (2004) found similar results to the findings of the present study; they reported that supplementation of 1% oligofructose or chicory inulin to the diet significantly increased eggshell percentage. Abdelqader et al. (2013) using 1% of chicory in the diet observed an increase in the eggshell percentage. The calcium in the diet was 1.52% and the concentration in the eggshell of the present trial varied with the level on the agave inulin in the drinking water (P<0.05).

The author Świątkiewicz et al. (2010) with chicory (Chicorium intybus) and Sritawatthai et al. (2013) with artichoke (Helianthus tuberosus) inulin observed no effect of adding the oligosaccharide to the feed on the eggshell of hens. As observed in Table 2, adding agave inulin to the drinking water had no significant effect neither on yolk weight, and content of ash (P>0.05) nor on the albumen weight and content (P>0.05). Park and Park (2012) using artichoke inulin and laying hens fed a soybean-corn diet observed a slight increase in the yolk weight.

The findings in the present experiment as well as those of other authors, showed that inulin, disregarding of the source, has limited effect on the absorption and deposition of minerals, especially calcium, although some controversial studies are found with different source of the fructan.

### Conclusions

The results of this study indicate that agave inulin as water additive for producing quails, fed a sorghum-soybean meal based diet with a
normal level of calcium, increases the production but had minor effect on production and egg quality.

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