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Effect of discarded chickpea (*Cicer arietinum* L.) cooking on the productive response and carcass yield of Japanese quail (*Coturnix coturnix* japonica) at the fattening stage

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In order to study the effect of discarded chickpea cooking on the productive response and carcass yield of the Japanese quail (*Coturnix coturnix* japonica) at the fattening stage, 300 animals (1 d of age and 9.92 ± 0.05 g) were used. The control diet was elaborated with soybean meal and ground corn grain. The discarded chickpea, raw and cooked, replaced at 60 % the soybean meal and the ground corn grain. For the discarded raw chickpea, the feed intake was 77.9 % higher ($P < 0.01$) than for the cooked. It improved ($P < 0.01$) the weight gain (220.10 vs 203.56 and 204.40 g), the slaughter weight (229.85 vs 212.49 and 214.36 g), and the carcass weight (135.77 vs 128.97 and 129.74 g), as compared with the control diet and the diet with discarded cooked chickpea, respectively. There were not differences between the discarded raw chickpea and the cooked chickpea for the feed efficiency and the carcass yield. It was concluded that the inclusion of 60 % of discarded raw chickpea in the diet, as compared with the cooked, enhances the productive response and the carcass weight, not modifying the yield in the Japanese quail at the fattening stage; thus, its boiling is not recommended in this animal category.

Key words: *Cicer arietinum L., quails, fattening*.

Internationally, Mexico occupies the seventh place as chickpea producer, and the first in Latin America (FAO 2010). The chickpea grain, called "café negro" or "forrajero" (*Cicer arietinum* var. fuscum), is grown for swine feeding. The white grain (*Cicer arietinum* L.) is mainly devoted to human intake. The Northwestern region of the country, in which the state of Sinaloa is located, is the most important producing area, with 83 % of the national production (SIAP 2010).

Although most of the chickpea grain is exported but, from 10 to 20 % of the total produced does not have the proper characteristics for export. This percentage is considered as to be discarded and it is devoted to animal feeding (Gómez *et al*. 2003 and Uriarte 2005). The bromatological compoistion of the discarded grain is made up by 20.1 % crude protein (CP), 6.5 % crude fiber (CF), 5.1% ether extract (EE), 3.2 % ashes, and 55.1% nitrogen free extract (NFE) (Uriarte 2005). These characteristics make it an attractive ingredient to be included in non-ruminant diets.

Up to 40 % of discarded grain was included in the feeding of fattening swine at the starter (Uriarte 2005). At finisher (Güémez 2005), up to 60 % was added, not affecting the productive response. However, the available information about its utilization in poultry feeding is contradictory, particularly in respect to its level of inclusion in broiler chicken diets (Farrell *et al*. 1999 and Viveros 2001).

In Japanese quail at fattening, part of the soybean meal and the ground corn grain was substituted by 15, 30, 45, or 60 % of discarded chickpea grain and it was proven that it is possible to include up to 45%, not affecting the productive response and the carcass weight (Portillo *et al*. 2011).

Among the reasons for limiting the use of this ingredient in poultry feeding, there is the low content of sulphur amino acids, such as methionine (Cordesse 1990) and the content of anti-nutritional factors (ANFs). Therefore, their inclusion should be considered in the formulation of the diets.

Lon Wo *et al*. (2002) stated that among the physical treatments to reduce these limitations, the thermal is the most used; specifically, cooking is an adequate and practical method.

The objective was to study the effect of cooking the discarded chickpea grain on the productive response and the carcass yield of Japanese quail (*Coturnix coturnix* japonica) at the fattening stage.

Materials and Methods

Localization and climate. The test of productive response was conducted in the Poultry Unit and in the Laboratory of Feed Analysis in the Veterinary Medicine and Husbandry Faculty of the Autonomous University of Sinaloa, located in the Culiacan city, Sinaloa, Mexico. The test was performed from May to July, with average temperature and relative humidity of 30 °C and 67 %, respectively.

Determination of the bromatological composition of the discarded chickpea grain. The discarded chickpea grain, byproduct from the harvest devoted to human consumption, was bought at the Grain Marketing Enterprise, located in the agricultural valley of Culiacan, Sinaloa. Out of the total volume, two kilograms were selected as representative sample and divided into two subsamples. The first was ground with Willey equipment (Model 4, Thomas Scientific, Swedosboro, NJ, USA) up to particle size of 2 mm. An analytical sample of 100 g was obtained by reducing the samples through the quarter method (García 2006), being an analytical sample of 100 g and determing DM, CP, ash, OM, CF, EE and

NFE was calculated by difference (AOAC 1995).

The second subsample was soaked in water for 24 h. It was boiled at 99.8 ± 1.5 ºC for 1 h and 20 min. Later, it was dried during four days through exposure to the sun rays and subject to the previously described procedure, to know the effect of cooking on the bromatological values. The content of metabolizable energy (ME) of the discarded chickpea grain was calculated by the formula of Moir *et al*. (1980): ME MCal/kg = 3.75 x CP + 8.09 and expressed as MJ/kg x EE – 6.95 x CF + 3.94 x NFE.

Preparation of the experimental diets. The bromatological composition and the nutritional supply of the experimental diets are shown in table 1. The diets were formulated from the nutritional requirements of the Japanese quail to be fattened (NRC 1994). The treatments were: 1) control diet, 2) diet with partial replacement, 60 %, of the ground corn grain and the soybean meal by discarded raw chickpea grain, 3) diet with partial replacement, 60 %, of the ground corn grain and soybean meal by cooked discarded chickpea grain. The content of ME of the experimental diets was ca*lculated by the formula of Moir et al. (1980).*

Animals and management. The feeding test lasted for 35 d. Three hundred quail chicks were used, They were non-sexed and they were one-day old (9.92 ± 0.05 g). The chicks were distributed randomly into 15 metallic cages, of 90 cm x 90 cm x 60 cm, at 60 cm above the floor (20 birds per cage). They were provided heat (35 to 38°C) through incandescent lamps the first three days, from 32 to 35 °C up to the seventh day. Since the second week, temperature was reduced, at a rate of 5°C (Lucotte 1990).

In order to ensure the birds had an adequate environment, paper litter was provided in the cages. The walls and roofs were covered with plastic canvas during the first 10 d. These devices were removed gradually as the age of the birds was increased. During the first three days, in each cage, a plate-type feeder of 25 x 18 x 2.5cm was put, as well as a semi-automatic drinker, with capacity for 3.8 L. Since the fourth day there was one trough with semi-automatic floor of 25 x 17.5 x 25 cm and an automatic water supplier, of 20 x 12 cm. In order to favor the animal welfare, the cages were put in a conventional shed, equipped with canvas curtains, fit to height according to the environmental temperature, the air flows and the sun rays.

The feed was given at 7:00 a.m. and the amount was recorded. At the end of the week, the feed intake per bird was calculated (offer minus the feed wastes divided by the amount of animals). Throughout the experiment, weekly weigthings were performed, at days 1, 8, 15, 22, 29, and 35, to record the weight gain (initial weight minus final weight) and the feed efficiency (weight gain divided by the feed intake).

Every day, the death rate was calculated and recorded. The dead birds and/or rejected were not replaced. During

Table 1. Bromatological composition of the treatments and nutritional contribution calculated

Ingredients (%)	Treatments		
	Control	Discarded raw chickpea grain	Discarded cooked chickpea grain
Discarded chickpea	0.00	60.00	60.00
Ground corn	55.00	13.57	13.57
Soybean	35.00	15.50	15.50
Fish meal	7.00	7.00	7.00
Safflower oil	1.55	2.35	2.35
Common salt	0.30	0.30	0.30
DL - Methionine	0.00	0.13	0.13
Lime	0.90	0.90	0.90
Premixture of vitamins and minerals[2]	0.25	0.25	0.25
Total	100.00	100.00	100.00
Crude protein, %	24.30	24.40	23.50
Metabolizable energy, MJ / kg DM	12343	12472	11853
Crude fiber, %	3.71	5.45	6.90
Lysine, %	1.40	1.58	1.58
Methionine, %	0.66	0.66	0.66

[1]Calculated values of NRC (1994), except for discarded raw and cooked chickpea grain, to which values of the feed laboratory of the FMVZ-UAS were assigned.

[2]Proportional premixture of vitamins and minerals per kg of diet: 3,75 mg retinol, 112 µg cholecalciferol, 30 mg acetate of tocopherol, 3 mg menadione-sodium bisulphate ® te, 1.5 mg thiamine, 6 mg riboflavin, 3 mg pyridoxine, 15 µg cyanocobalamin, 1,5 mg folic acid, 55 mg niacin, 15 mg Ca panthotenate,180 µg biotin, 600 mg coline, 75 mg Mn, 75 mg Zn, 75 mg Fe, 900 µg Mo, 750 µg Co, 900 µg 1,6 mg Cu, 105 µg Se, 120 mg Banox (BHA +BHT).

the first two weeks, the feed and the birds were weighed with digital scales (OhausMR, capacity of 2 610 g and precision of 0.1 g). After this period, the quails were weighed on digital scales (TorreyMR), with capacity of 20 kg and precision of 5 g. In order to know the carcass weight and the yield in percentage, five animals were slaughtered at 35 d of age, based on the procedures established by the Official Mexican Standard (NOM-033-ZOO-1995). They were processed according to the protocol of Genchev and Mihaylov (2008).

Statistical analysis. Analysis of variance was used for the chemical composition of the raw and cooked chickpea. The results of the variables of the carcass and the productive performance were analyzed through completely randomized design, with three treatments and five repetitions, of 20 animals each, respectively. When necessary, the comparison of the averages was conducted through the test of Tukey, reported by Steel and Torrie (1988), with maximum α level of 0.05. The SAS statistical software was used, Version 8.1 (2002) on Windows.

Results and Discussion

Bromatological analysis of discarded raw and cooked chickpea. The results of the bromatological analyses of the discarded material of raw and cooked chickpea are shown in table 2. The bromatological values of the raw and the cooked discarded chickpea were within the ranges published by Reddy *et al*. (1984), Williams *et al*. (1987) and Chavan *et al*. (1989).

The concentration of CF was increased in 2.4 percentage units in the discarded cooked chickpea. The reaction to the heat increased the presence of several carbohydrates, due to the appearance of reactions of the Maillard type, supposing a condensation between the carbonyl group from a sugar with the free amino group from an amino acid or a protein (McDonald *et al*. 1995).

The cooking temperature has great influence on the speed with which this reaction is produced, which is 9 000 times faster at 70 ºC than at 10 ºC, affecting particularly the lysine, which is more susceptible, and produces oxidized forms of this amino acid and of the sulfurous (methionine and cystine). This provokes lower bioavailability and lower protein quality of the cooked chickpea grain (Sawar *et al*. 2005). There were not differences for the CP indicator. There were evidences of color change during the process, from cream to coffee, and to dark coffee (McDonald *et al*. 1995). This could be attributed to the brown color or the dark brown color in overheated feed when the Maillard reaction occurrs. The ashes were reduced, maybe as a result from their loss in the cooking process.

The value of EE diminished in 0.9 percentage units, as the ME decreased in 1021 MJ/kg for the discarded cooked chickpea grain. As to Herrera *et al*. (1986), this latter fraction quantifies the lipids, the carotenes, pigments of large number of carbons in their molecule, and other related compounds. It tends to be considered as the energy fraction of the sample. This could have been influenced on the low energy content that was obtained.

Productive response of the Japanese quail under fattening. Table 3 shows the productive response of the Japanese quail, fed during the fattening with the cooked or raw discarded chickpea. The lowest final weight in the quails fed the control diet and the one containing discarded cooked chickpea, compared with those fed discarded raw chickpea ($P < 0.01$), can be explained by their performance at the time of the intake, because there is a direct relationship between both indicators (Forbes 2007).

The feed consumed per bird was inferior ($P < 0.01$), only for the diet containing discarded cooked chickpea, compared with the control and the diet with discarded raw chickpea grain. This could be due to the higher content of CF in the diet with discarded cooked chickpea (6.90 %), as compared with that including discarded raw chickpea and the control (5.45 and 3.71%, respectively). According to Savón (2005), there is inverse relationship between the intake and the time of DM retention in the upper parts of the digestive tract, when including

Table 2. Means of the bromatological analysis of the discarded chickpea used in the fattening of the Japanese quail

Nutrients (%)	Discarded raw chickpea grain	Discarded cooked chickpea grain	SE±
Humidity	8.0	7.4	0.2
CP	20.1	18.6	0.4
CF	6.8[a]	9.2[b]	0.5*
Ashes	3.3[a]	2.6[b]	0.2*
EE	6.3[a]	5.4[b]	0.2*
NFE	54.7	56.7	0.8
ME, MJ/kg DM	12460	11439	

[ab]Different letters in the same row show statistical difference.

* ($P < 0.05$). CP: crude protein; CF: crude fiber; EE: ether extract; NFE: nitrogen free extract; ME: metabolizable energy.

Table 3. Productive response fo the Japonese quail fed discarded raw and cooked chickpea

Variable	Treatments			
	Control	Discarded raw chickpea grain	Discarded cooked chickpea grain	SE±
Initial weight, g/bird	10.02	9.79	9.94	0.05
Final weight, g/bird	213.58[a]	229.85[b]	214.36[a]	2.7**
Feed intake, g/bird	549.18[a]	565.62[a]	487.72[b]	11.0**
Weight gain, g/bird	203.56[a]	220.10[b]	204.40[a]	2.7**
Feed efficiency	0.371[a]	0.390[ab]	0.420[b]	0.007**

[ab] Different letters in the same row show statistical difference according to Tukey
** (P < 0.01)

Table 4. Carcass yield of the Japanese quail fed discarded raw and cooked chickpea

Variable	Treatments			
	Control diet	Discarded raw chickpea grain	Discarded cooked chickpea grain	SE±
Live weight, g/bird	213.58[a]	229.85[b]	214.36[a]	2.7**
Hot carcass weight, g/bird	128.97[a]	135.77[b]	129.74[a]	1.23*
Yield, %	61.14	59.23	60.92	0.39

[ab] Different letters in the same row show statistical difference according to Tukey
* (P < 0.05) ** (P < 0.01)

roughages to diets for monogastric animals. Apparently, the discarded cooked chickpea remains longer time in the gizzard than the raw, thereby decreasing this indicator. As to this previous statement, the quails fed discarded raw chickpea grain had superior weight gain (P < 0.01) as compared with the control, and with those fed discarded cooked chickpea.

The feed efficiency was lower in the diet including discarded cooked chickpea compared with the group of birds fed the control (table 3). This could be explained according to the compensatory feed intake (López *et al*. 2005), because the birds in relation to their body weight have higher feed intake, which is translated into better feed efficiency.

Carcass weight and yield. Table 4 shows the weight and carcass yield results in the Japanese quail, fed discarded raw and cooked chickpea. When comparing the averages between treatments, the fresh carcass weight was superior (P < 0.05) in 6.80 and 6.03 percentage units in the quails fed discarded raw chickpea, compared with those fed the control and those fed discarded cooked chickpea grain, respectively. This can be related to the higher slaughter weight of the birds fed discarded raw chickpea grain (table 3).

In the Japanese quail under fattening, fed corn grain and soybean mail, and slaughtered at 42 d of age, Bonos *et al*. (2010) noted similar carcass weight at 42 d (131.58). However, Alkan *et al*. (2010) recorded lower weights than those in this experiment (120.58 g) in different lines, thus, it can be stated that this input is an alternative that should be considered in the feeding of this type of birds.

The carcass yield was similar between treatments, with average value of 60.43 % (table 4). The values were in the range reported by different authors in Japanese quail, subject to different feeding systems (Lomelí 2005, Castro *et al*. 2010 and Portillo *et al*. 2010). These outcomes permit stating that the ingredient under study, whether cooked or raw, does not affect the indicator.

The inclusion in the diet of 60 % of discarded raw chickpea as compared with the cooked improves the productive response and the carcass weight, not modifying the yield in the Japanese quail at the fattening stage. Therefore, cooking through boiling is not recommended for the discarded chickpea grain to be used in this animal category.

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References

Alkan, S., Karabag, K., Galic, A., Karsli, T. & Balcioglu, M.S. 2010. Determination of body weight and some carcass traits in Japanese quails (*Coturnix coturnix* japonica) of different lines. Kafkas Univ. Vet. Fak. Derg. 16:277

AOAC. 1995. Official methods of analysis. 15th Ed. Off. Anal. Chem. Washington, D.C. pp. 777-881

Bonos, E.M., Christaki, E.V. & Florou-Paneri, P.C. 2010. Performance and carcass characteristics of Japanese quail as affected by sex or mannan oligosaccharides and calcium propionate. South Afr. J. Anim. Sci. 40:173

Castro, T.C., Bátiz, Z.Z., Cabrera, V.JA., Del Valle, M., Portillo L.J.J. & Ríos, R.F.G. 2010. Respuesta productiva y composición de la canal de codorniz japonesa en engorde separada por sexo de 14 a 35 d de edad. III Congreso

Internacional de Producción Animal Tropical. La Habana, Cuba. pp. 1 648-1 653

Chavan, J.K., Kadam, S.S. & Salunkhe, D.K. 1989. Chickpea. In: D.K. Salunkhe and S.S. Kadam (Eds). CRC Handbook of World Food Legumes: Nutritional Chemistry Processing Technology and Utilization. Vol I. CRC Press, Inc. Boca Raton, Florida, USA. Pp. 247-288

Cordesse, R. 1990. Value of chickpea as animal feed. Options Méditerranéennes. Pp. 9:127

FAO. 2010. Food and Agriculture Organization of United Nation Stat. Base de datos. Available: <http//www.fao.org>[Consulted: September 9, 2010]

Farrell, D. J., Pérez-Maldonado, R.A. & Mannion, P.F. 1999. Optimum inclusion of field peas, faba beans, chick lupins in poultry diets. II. Broiler experiments. Br. Poultry Sci. 40:674

Forbes, J. M. 2007. Voluntary food intake and diet selection in farm animals. Animal and Environmental Factors. Ed. CABI Head Office. Ucrania. 310 pp.

García, P.A. 2006. Muestreo y envío de muestras. Departamento de Nutrición y Bioquímica. Facultad de Medicina Veterinaria y Zootecnia. Universidad Nacional Autónoma de México. Ciudad Universitaria, Coyoacán, México, D.F. 6 pp.

Genchev, A. & Mihaylov, R. 2008. Slaughter analysis protocol in experiments using Japanese quail (Coturnix japonica). Trakia J. Sci. 4: 66

Gómez, R.M., Gómez, L. & Salinas, R. 2003. Blanco Sinaloa-92, variedad de garbanzo blanco para exportación. Instituto Nacional de Investigaciones Forestales y Agropecuarias. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. Culiacán, Sinaloa, México. Folleto Técnico No. 24. 20 pp.

Güémez, H. R. 2005. Desempeño productivo y características de la canal de cerdos en finalización alimentados con rezaga de garbanzo. Bachelor Thesis. Universidad Autónoma de Sinaloa, México. 35 pp.

Herrera, R.S., González, S., García, M., Ríos, C. & Ojeda, F. 1986. Análisis químico del pasto. In: Los pastos en Cuba. Tomo I. Segunda Edición. Ed. Instituto de Ciencia Animal. La Habana, Cuba. Pp. 701-751

Lomelí, J.J. 2005. Efecto de niveles descendentes de proteína en la dieta en la respuesta productiva de codorniz japonesa en engorde. Bachelor Thesis. Universidad Autónoma de Sinaloa. México. 30 pp.

Lon-Wo, E., Beltrán, M., Camps, D.M., Rodríguez, B. & Dieppa, O. 2002. Extrusion, toasting or sun-drying of tropical legume grains. Technical note. Cuban J. Agric. Sci. 36:143

López, C.C., Menocal, A.J. & Ávila, G.E. 2005. Mitos y realidades del sistema digestivo y sus implicaciones sobre la productividad. Available: < http://www.wpsa-aeca.com/img/informacion/13_07_21_Mitos_y_realidades_del_sistema_digestivo.pdf.> [Consulted: October 22, 2008]

Lucotte, G. 1990. Cría de los pollos de codorniz. La Codorniz: Cría y Explotación. Segunda Edición. Ed. Mundi-Prensa. Madrid, España. pp. 59-66

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. & Morgan, C.A. 1995. Nutrición Animal. Capítulo 4. Proteínas, ácidos nucleicos y otros compuestos nitrogenados. Quinta Edición. Ed. Acribia. Zaragoza, España. pp. 45-59

Moir, K.W., Yule, W.J. & Connor, J.K. 1980. Energy losses in the excreta of poultry: a model for predicting dietary metabolizable energy. Aust. J. Exp. Agric. Anim. Husb. 20:151

NOM-033-ZOO-1995. Sacrificio humanitario de los animales domésticos y silvestres. Secretaría de agricultura, ganadería, desarrollo rural, pesca y alimentación. Norma Oficial Mexicana. México, D.F. 17 pp.

NRC. 1994. National Research Council. Nutriment Requirements of Poultry. Nutrient Requirements of Ring-Necked Pheasants, Japanese Quail, and Bobwhite Quail. 9th Rev. Ed. National Academy Press. Washington, DC. pp. 44-45

Portillo, L.J., Bojórquez, Z.S., Castro, T.C.B., Ríos, R.F.G. & Zazueta, T.B.A. 2010. Composición corporal de hembras y machos de codorniz japonesa sacrificada a diferentes edades. III Congreso Internacional de Producción Animal Tropical. La Habana, Cuba. pp. 1 741-1 746

Portillo, L.J., Castro, T.C.B., Obregón, J.F., Plascencia, J.A., Ríos, R.F.G. & Suárez, G.D. 2011. Sustitución parcial de harina de soja y grano de maíz molido por garbanzo de descarte en la respuesta productiva y rendimiento en canal de codorniz japonesa. Rev. Cient. Vet. LUZ. XXI: 162

Reddy, N.R., Pierson, M.D., Sathe, S.K. & Salunkhe, D.K. 1984. Chemical nutritional and physiological aspects of dry bean carbohydrates. A Review. Food Chem. 13:25

SAS. 2002. Proprietary Software Version 9.00 (TS M0). Licensed to Suny at stony brook, Site 0013402001. Copyright by SAS Institute Inc. Cary, NC. USA

Savón, L. 2005. Tropical roughages and their effect on the digestive physiology on monogastric species. Cuban J. Agric. Sci. 39:463

Sawar, G.C., Cockell, K.A. & Sepehr, E. 2005. Effects of antinutritional factors on protein digestibility and amino acid availability in foods. J. AAOC. Int. 88:967

SIAP. 2010. Sistema de información agropecuaria y pesquera. Secretaría de agricultura, ganadería, desarrollo rural, pesca y alimentación. Análisis estadístico de la información agrícola. México. Available: < http://www. siap.gob.mx. > [Consulted: September 9, 2010]

Steel, R.D. & Torrie, J.H. 1988. Bioestadística: principios y procedimientos. Segunda Edición. Ed. McGraw-Hill. México, D.F. 622 pp.

Uriarte, J. M. 2005. Comportamiento productivo de cerdos en crecimiento alimentados con rezaga de garbanzo en sustitución de maíz y pasta de soya. Bachelor Thesis. Universidad Autónoma de Sinaloa. México. 30 pp.

Viveros, A., Brenes, A., Elices, R., Arija, I. & Canales, R. 2001. Nutritional value of raw and autoclaved Kabuli and Desi chickpeas (*Cicer arietinum* L.) for growing chickens. Br. Poult. Sci. 42:242

Williams, P.C. & Singh, U. 1987. The Chickpea nutritional quality and evaluation of quality in breeding programmers. In: The Chickpea. Ed. M.C. Saxena and K.B. Singh. Wallingford, Oxon, UK: CAB, Int.

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