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Whole-grain cereal voluntary intake and preference in Japanese quail (*Coturnix coturnix japonica*)

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Abstract

Japanese quail (*Coturnix coturnix japonica*) usually fed on ground or pelleted balanced feeds, while whole grains are supplied in alternative systems. Voluntary intake and preference of four whole-grain cereals (durum wheat, bread wheat, triticale and barley) were assessed in Japanese quails. Two experiments were performed: (i) a trial with five batches of six randomly selected quails (three males, three females) allocated to each treatment consisting of one cereal or a balanced feed (control) in the voluntary intake experiment; and (ii) a trial with four bird batches receiving simultaneously the four cereals in the preference experiment. Three repetitions of each trial were performed. When feedstuffs were provided as a sole feed, voluntary feed intake differed, being the highest in quails fed the balanced feed (20.0 g/d), intermediate for durum wheat (15.0 g/d), bread wheat (15.8 g/d) or triticale (15.6 g/d), and the lowest for barley (12.1 g/d). Voluntary intake did not differ between sexes. Positive correlations existed between voluntary feed intake and live weight of quails, being the highest and very strong for the balanced feed, moderate for durum and bread wheat and barley, and weak for triticale. The preference trial showed that quails preferred durum wheat (7.1 g/d), triticale (4.0 g/d), bread wheat (3.0 g/d) and barley (0.3 g/d) in descending order, independently of sex. Positive correlations existed between daily feed intake and live weight of birds for durum and bread wheat. Strong positive correlation existed between bird live weight and total intake when the four cereals were available simultaneously. Differences in voluntary intake and preference among whole-grain cereals should be take into account when used to feed quails.

Additional keywords: alternative feeding; feed consumption; poultry.

Abbreviations used: CP (crude protein); DM (dry matter); EMM (estimated marginal mean); GLM (general linear model); IU (international unit); LSD (least significant difference); ME (metabolisable energy).

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Introduction

Japanese quail (*Coturnix coturnix japonica*) is a poultry species raised worldwide for several purposes, mainly meat and egg production (Dalmau, 1994; Ayaşan, 2013). In several European countries a hybrid strain is also raised in game farms for release in hunting preserves in order to ensure hunting bags, usually through put-and-take shooting (Puigcerver *et al.*, 2007; Sanchez-Donoso *et al.*, 2012). As a monogastric granivorous species, balanced feeds and rations used to feed quails are formulated with inclusion of at least 50% of cereal grains, mainly corn (Konca & Büyükkiliç, 2013; Kasmani & Mehri, 2015; Mota *et al.*, 2015). Several cereals have been tested as substitutes for corn in feed formulation for growing and laying quails, or to complement corn-based basal rations (Konca & Büyükkiliç, 2013; Ashour *et al.*, 2015). Among other experiments, the use of triticale (Güçlü & Işçan, 2003; Ragab & Namra, 2010; Wahed *et al.*, 2010), barley (Oğuz *et al.*, 2011; Toprak & Yilmaz, 2012; Kianfar *et al.*, 2013), wheat (Sarica *et al.*, 2009; Yasar & Gok, 2014; Mehraei Hamzekolaei *et al.*, 2016), oat (Yasar & Gok, 2014) or rice (Cardoso *et al.*, 2011) has often been cited.

Cereal grains are rich in carbohydrates and have been employed in animal feeding since antiquity. While bread wheat and especially durum wheat are mainly used for human food, other cereals such as barley and triticale are preferably used to feed livestock. About 85% of barley production is dedicated to animal feeding (Feedipedia, 2016). When barley is used in diet formulation for laying quails, crude protein must remain at least at 18% to ensure an adequate egg quality and weight (Toprak & Yilmaz, 2012). Replacing corn with fermented barley or wheat improves growing chicks performance up to three weeks of age (Yasar & Gok, 2014). Wheat efficiency in keeping growing performance in quails when it substitutes corn under high ambient temperature has been described (MacLeod & Dabutha, 1997), and ground wheat permits growing quails to balance nutrients intake when it is supplied along with a concentrate feed (Canoğullari *et al.*, 2004). However, inclusion of wheat in quail rations is subjected to limits because its soluble non-starch polysaccharides content increases the viscosity of digesta (Sarica *et al.*, 2009). Triticale is an artificial alloploid made from hybrids between tetraploid wheat and rye, and later chromosome duplication with colchicine to increase flower fertility. Interest of triticale is increasing in farmers seeking a low input or sustainable agriculture (Palta *et al.*, 2010). It has higher protein content than most cereals and a lysine concentration greater than 30% respect to wheat (FEDNA, 2016). It has been demonstrated that the good nutritional properties of triticale makes it a good alternative to corn in quail grower diets (Ebrahimi *et al.*, 2017). It has been also reported that 40 to 60% triticale can be used to replace corn in balanced feeds without affecting the performance of laying quails (Güçlü & Işçan, 2003).

Cereal grains are generally ground when used in commercial balanced feeds for quails and these are presented as meal or in pelleted form. Moreover, processing of cereals before inclusion in balanced feed improves its nutritive value and quail performance (Kianfar *et al.*, 2013; Yasar & Gok, 2014). However, the use of whole grain in poultry has recently increased to reduce feed processing and transporting costs (Cumming, 1994; Forbes & Covasa, 1995; Svihus, 2001; Bennett *et al.*, 2002), and in response to the demands of consumers for more 'natural' feeding systems (Gabriel *et al.*, 2008). Furthermore, some research point out that feeding whole grains to poultry improves gut health (Ferket, 2000) or even that in free choice feeding experiments, the type or form of the grain do not affect the production performance of birds; however, these may affect intake and the efficiency of utilization of some nutrients (Forbes & Covasa, 1995). There are husbandry practices in which intake and preference of whole cereal grains by quails may be relevant. For instance, in the finishing phase of the game farming of this species to prepare individuals for the transition from the farm to the wild, when birds are provided with variable amounts of whole cereal grains (Dalmau, 1994). To date, voluntary intake and preference of whole-grain cereals have not been investigated in quails, and only the effect of choosing between ground emmer, oat (Konca & Büyükkiliç, 2013) or wheat (Canoğullari *et al.*, 2004; Konca & Büyükkiliç, 2013) and a balanced feed has been studied. In this context, the aim of this study was to assess voluntary intake and preference of four whole-grain cereals (barley, durum and bread wheat, and triticale) in the Japanese quail, as well as the influence of sex and body weight on both feeding patterns.

Material and methods

The research was conducted at the Research and Teaching Farm of the Higher Technical School of Agricultural Engineering (ETSIA) of the University of Seville, Spain (37º 21' 36.3" N, 5º 56' 23.9" W), during February and March of 2015. Bird management and handling were performed according to the Directive 2010/63/EU on the protection of animals used for scientific purposes (European Parliament and Council, 2010). Two experiments were performed, one to investigate the intake level of barley (*Hordeum vulgare* L.), durum wheat (*Triticum turgidum* subsp. *durum* (Desf.) Husn.), bread wheat (*Triticum aestivum* L. subsp. *aestivum*) and triticale (×*Triticosecale* Wittmack) whole-grain cereals, and another to assess preference of quails for these cereals.

Birds and husbandry

Thirty healthy adult (15 males and 15 females) Japanese quails for the voluntary intake experiment and 24 birds (12 males and 12 females) for the preference experiment were used. Average live weight was 139.6±10.9 g for males and 176.6±15.0 g for females. Birds were individually housed in wire-mesh cages (30×30×30 cm) equipped with feeders, drinking cups and plastic trays below the floor to collect excreta and feedstuff leftovers. Quails were subjected to natural lighting regime and maintained at room temperature under static ventilation. Water was available *ad libitum.*

Voluntary intake experiment

To measure voluntary intake of each single feedstuff, a trial with five batches of six randomly selected quails each (three males and three females) was designed. Each treatment consisted of the quails of a batch fed one of the four cereals or a balanced feed (control treatment). A standard feeder (9.5×7.5×6.5 cm) was used in each cage to daily provide an amount of feedstuff (about 100 g) enough to ensure *ad libitum* consumption. Three repetitions of the intake trial were carried out consecutively during February.

The experimental protocol for the intake trial was as follows. Each of the five treatments was performed feeding the quails during four days with a single cereal or the balanced feed. To prevent birds from becoming accustomed to a particular feedstuff, each batch of birds received a different feedstuff at each repetition of the trial. As the quails were usually fed with a balanced feed, three days before each repetition of the trial, the balanced feed was removed and the correspondent type of cereal was provided *ad libitum* to adapt the birds to the new feedstuff. At the beginning of each trial day, a new and weighted quantity of cereal or the balanced feed was placed in the feeder, and the leftovers in the feeder and on the tray under the cage were removed and weighed.

Preference experiment

To assess preference of quails for cereals, a trial with four batches consisting on six randomly allocated quails (three males and three females) was performed using the same birds from the former intake trial. Each quail batch received the four cereals simultaneously. Four feeders (5×5×5 cm) were used in each cage to daily provide an amount of each cereal (about 35 g) enough to ensure *ad libitum* consumption. Three repetitions of the preference trial were carried out consecutively during March.

The protocol for the preference trial was similar to that of the intake trial. In each repetition of the trial, the cereals were randomly allocated among the four feeders to avoid the preference of birds for a specific place.

Feedstuffs and feedstuff analyses

Whole-grain cereals used in both experiments were a two-row barley (unknown cultivar), durum wheat *cv.* 'Don Isidoro', bread wheat *cv*. 'Trebujena', and triticale *cv*. 'Valeroso'. Feed used as control treatment in the intake experiment was a pelleted balanced commercial feed (A-72; Sandesur, Los Palacios, Spain) meeting the requirements for breeding quails (INRA, 1985). It was composed of corn, wheat, soybean meal, wheat bran, sunflower meal, alfalfa meal, cereal straw (NaOH treated), animal fat, calcium carbonate, dicalcium phosphate, and sodium chloride.

Feedstuff nutrient composition (Table 1) was analysed in two replications. Samples were ground in a Ciclotec 1093 mill (Foss Tecator AB, Höganäs, Sweden) before analysis. AOAC (2005) methods were used to determine dry matter (method 934.01), ash (method 942.05), ether extract (method 920.39), crude fibre (method 978.10), total starch (method 996.11), and N (method 968.06) contents. Total N was determined by the combustion method using a CNS-2000 carbon, N, and sulphur analyzer (Leco CNS-2000, Leco Corporation, USA), and converted to crude protein (CP) by multiplying by a factor of 6.25. Crude fibre was analyzed on a Fibertec M6 1020 (FOSS Tecator AB, Höganäs, Sweden). Fat content was measured by extraction with petroleum ether (boiling point, 40-60 ºC) on a Soxtec System 1040 Extraction Unit (FOSS Tecator AB, Höganäs, Sweden). Starch content was analysed with the Total Starch test kit by the assay procedure of Megazyme (2017), with an UV-Visible Lambda 35 spectrophotometer (Perkin Elmer, Waltham, MA, USA). Total phosphorus was determined following Murphy & Riley (1962) solution method by using an UV-Visible Lambda 35 spectrophotometer (Perkin Elmer, Waltham, MA, USA). Calcium was determined by atomic absorption spectroscopy in an iCE 3500 spectrophotometer (Thermo Scientific, San Jose, CA, USA).

Metabolisable energy (ME) level of balanced feed was estimated using the prediction equation of Sibbald *et al.* (1980): ME (kcal/kg DM) = 3951+54.4 ether extract (%DM)–88.7 crude fibre (%DM)–40.8 ash (%DM). For the cereal grains, the prediction equations used were as follows: for barley, ME (kcal/kg DM) = 2213+18.0 starch (%DM)–22.1 ash (%DM) (CVB, 1999); for wheats, ME (kcal/kg DM) = 4337–202.0 crude fibre (%DM)–156.8 ether extract (%DM) (Borges *et al.*, 2003); and for triticale, ME (kcal/kg DM) = 1374+33.6 starch (%DM) (Flores *et al.*, 1994).

Measurements and calculations

Individual daily intake of cereals and control feed were calculated for both trials as the difference between the weight of feedstuff provided, and the weight of the leftovers remaining in the feeders and the weight of the drop in the trays below the cages. Preference among cereals was assessed by means of the difference in the amounts consumed. Feedstuffs and quail weights, measured in grams, were recorded using a digital precision balance (Vicon Vic-3101, Acculab, Sartorius Group, Göttingen, Germany).

Statistical methods

Daily intake of each feedstuff (grain or balanced feed) was analysed as dependent variable in both

Table 1. Nutrient composition of cereals and balanced feed provided to quails (as feed basis).

Item	Barley	Durum wheat	Bread wheat	Triticale	Balanced feed[2]
Dry matter, %	90.29	91.94	91.54	91.04	91.97
Crude protein, %	9.88	16.87	12.87	11.52	23.69
Crude fibre, %	2.89	2.31	2.34	2.46	6.11
Crude fat, %	2.15	2.15	2.04	1.89	3.91
Starch, %	50.14	49.26	44.99	49.13	33.61
Ash, %	1.98	2.01	1.95	2.18	8.86
Calcium, %	0.016	0.014	0.018	0.016	1.567
Total phosphorus, %	0.268	0.261	0.346	0.343	0.536
ME[1], kcal/kg	2854	3183	3191	2901	2943

[1]Metabolisable energy (ME). [2]Vitamin-mineral premix per kg of the balanced feed contains: vitamin A (retinyl acetate): 10,000 IU/kg; vitamin D_3 (cholecalciferol): 2,500 IU/kg; copper (cupric sulphate pentahydrate): 8.16 mg/kg; iron (ferrous sulfate monohydrate): 40.00 mg/kg; manganese (manganese oxide): 69.44 mg/kg; selenium (sodium selenite): 0.10 mg/kg; and zinc (zinc oxide): 58.50 mg/kg.

trials using the univariate general linear model (GLM) procedure with sex (two levels) and feedstuff (five levels in the intake trial and four levels in the preference trial) as fixed effects. Interaction between factors (feedstuff × sex) was also analysed. Live weight of quails was considered as a covariate. Fisher's least significant difference (LSD) *post hoc* tests were used to separate means among feedstuff levels and interaction (feedstuff × sex) levels. In both trials, Pearson correlation coefficients between bird live weight and feedstuff consumption were calculated. Results are expressed as estimated marginal means, and pooled standard error of the mean was also calculated. The analyses were performed using SPSS 15.0 (SPSS Inc., 2006).

Results

Feedstuffs voluntary intake

Table 2 shows the whole grain cereals and the balanced feed voluntary intake by quails when each feedstuff was provided as the sole feed. There were differences (p<0.001) in the amount of feedstuff consumed. Feed intake was the highest in quails fed the balanced feed (control), it was intermediate when durum wheat, bread wheat or triticale was provided, and it was the lowest when barley was administered to the birds. No differences (p>0.05) were found between sexes in the feedstuff intake. However, there was an interaction (p=0.001) between feedstuff and quail sex, characterised by the fact that females consumed higher amount of balanced feed than males, while the intake of each whole grain cereal was the same in both sexes.

Positive linear correlations (p<0.001) were found between daily feed intake and live weight of quails for all the tested feedstuffs (Table 3). These correlations were very strong for the balanced feed, moderate for durum and bread wheat and barley, and weak for triticale.

Cereal preference

Preference of whole cereal grains consumption by quails is shown in Table 2. There were differences (p<0.001) in the amount of grain consumed when the four tested cereals were provided simultaneously. Quails preferred durum wheat, triticale, bread wheat and barley in descending order, with average intakes progressively decreasing from 4.0 to 0.3 g/d, respectively. No differences (p>0.05) were found between sexes in the preference of cereals. An interaction (p=0.001) was found between cereal and quail sex, indicating that barley intake was nil in females compared to males, while the intake of each one of the other whole grain cereals was the same in both sexes.

Table 3 shows positive linear correlations between daily feed intake and live weight of birds for durum (weak; p<0.001) and bread wheat (very weak; p<0.01), while no correlation was found for barley and triticale. Moreover a strong positive linear correlation (r=0.710; p<0.001) existed between bird live weight and total intake when the four cereals where available simultaneously in the preference trial.

Discussion

To our knowledge, literature on whole-grain cereal voluntary intake and preference in quails is scarce. In fact, this is the first work that undertakes this assessment simultaneously for the four studied cereals: durum and bread wheat, triticale and barley.

Table 2. Average daily intake (EMM[1], g/d) by quails in the voluntary intake trial of whole-grain cereals and balanced feed, and in the preference trial of whole-grain cereals.

	Voluntary intake trial[3]		Preference trial[7]	
Feedstuff	n[4]		n[8]	
Barley	72	12.1[c]	288	0.3[d]
Durum wheat	72	15.0[b]	288	7.1[a]
Bread wheat	72	15.8[b]	288	3.0[c]
Triticale	72	15.6[b]	288	4.0[b]
Balanced feed	72	20.0[a]		
Sex	n[5]		n[9]	
Male	180	15.3	576	3.7
Female	180	16.0	576	3.4
Feedstuff × sex	n[6]		n[10]	
Barley × male	36	12.4[d]	144	0.9[d]
Barley × female	36	11.7[d]	144	0.0[e]
Durum wheat × male	36	15.1[c]	144	6.6[a]
Durum wheat × female	36	15.0[c]	144	7.5[a]
Bread wheat × male	36	15.3[c]	144	3.4[b,c]
Bread wheat × female	36	16.2[b,c]	144	2.5[c]
Triticale × male	36	15.8[c]	144	4.1[b]
Triticale × female	36	15.4[c]	144	3.9[b]
Balanced feed × male	36	18.0[b]		
Balanced feed × female	36	22.0[a]		
SEM[2]		0.20		0.13
p				
Feedstuff		<0.001		<0.001
Sex		0.316		0.416
Feedstuff × sex		0.001		0.011

[1]EMM = Estimated marginal mean. [2]SEM = Pooled standard error of the mean. [3]Each feedstuff supplied separately. [4]n = 3 repetitions × 6 quails per feedstuff × 4 recording days. [5]n = 3 repetitions × 3 quails per feedstuff × 5 feedstuffs × 4 recording days. [6]n = 3 repetitions × 3 quails per feedstuff × 4 recording days. [7]All cereals supplied simultaneously. [8]n = 3 repetitions × 4 quail batches × 6 quails per batch × 4 recording days. [9]n = 3 repetitions × 4 quail batches × 3 quails per batch × 4 cereals × 4 recording days. [10]n = 3 repetitions × 4 quail batches × 3 quails per batch × 4 recording days. [a,b,c,d,e]Values in the same column with different superscript letters are significantly different ($p<0.05$).

Regarding the lower intake of whole-grain of barley in both experiments (especially in the preference trial), it should be taken into account that barley is the only hulled cereal of this study. Barley hull consists mainly of cellulose, hemicellulose, and lignin. Therefore crude fibre content is higher, and the digestible energy of barley is lower compared to the remaining cereals (of hulled or naked kernel) in this work. Hull may also act as a diluent of available nutrients or by physically or chemically inhibiting nutrient digestion and absorption (Sharifi *et al.*, 2012).

Furthermore, when comparing voluntary intake by Japanese quails among feeds including different cereals, Yasar & Gok (2014) observed that feed intake of diets including fermented barley was significantly reduced in comparison to diets including fermented wheat. This agrees with the lower feed intake of barley grain in the present study in comparison to wheat grains (Table 2). Yasar & Gok (2014) explain this effect on the basis of differences in chemical composition and physical texture of both cereal grains that would lead to different nutrient digestibility. In particular, they found that these intake differences were highly correlated with the reduced total dietary fibre, non-starch polysaccharides, and β-glucan contents of the diet that included wheat compared to that of barley. In fact, most part of barley soluble fibre consists in β-glucans and pentosans, and average β-glucans content in this cereal is higher than

Table 3. Correlation between daily feed intake of whole-grain cereals or balanced feed and live weight of quails in the voluntary intake trial and in the preference trial.

Feedstuff	Voluntary intake trial		Preference trial	
	r	*p*	r	*p*
Barley	0.414	<0.001	-0.080	0.177
Durum wheat	0.596	<0.001	0.294	<0.001
Bread wheat	0.432	<0.001	0.157	0.007
Triticale	0.352	<0.001	0.039	0.510
Balanced feed	0.829	<0.001		

r: Pearson correlation coefficient.

in wheat and triticale (FEDNA, 2016). Therefore, the higher crude fibre content of barley compared to wheat and triticale (Table 1; FEDNA, 2016) may partially explain the lower barley voluntary intake and preference (Table 2) recorded in the present trial, compared to the remaining tested cereals.

Regarding hardness of the cereal kernel, durum wheat has been considered the cereal of highest hardness value, producing coarse and vitreous particles when milling. On the contrary, a soft kernel produces a floury, opaque and fine particle when milling (Evers & Millar, 2002). Wheat hardness depends on the presence of a compound named puroindoline and polar lipids on the starch granule surface (Pauly *et al.*, 2013). Barley and bread wheat must have an intermediate hardness, while triticale is considered a soft grain with approximately half of the kernel hardness of wheat and barley (Van Barneveld, 2002). According to our results, kernel hardness did not influence the intake by the quails. In fact, the preference test showed that durum wheat was, by far, the most consumed cereal. Although unusual in animal feeding, a study by a Canadian group proved durum wheat to be a good grain to feed broilers, with a high apparent metabolisable energy and a low digesta viscosity (Silversides, 1999). As summarised by Sarica *et al.* (2009), wheat has a limited use in commercial quail and poultry diets because of its content of soluble non-starch polysaccharides (predominantly arabinoxylans) in the endosperm cell wall (Mathlouthi *et al.*, 2003). It is known that the water-soluble arabinoxylans of wheat, and the β-glucans and pentosans of barley binds variable amounts of water and increases the digesta viscosity in the small intestine (Salobir *et al.*, 1995; FEDNA, 2016). The presence of these compounds reduces voluntary intake and nutrient digestion in the foregut by slowing the passage of digested nutrients to the gut wall and exposure time of digesta to digestive enzymes (Sarica *et al.*, 2009; FEDNA, 2016). For this reason, the inclusion of these cereals in poultry feed is limited to 20-30% for wheat, 30-40% for triticale and 25-45% for barley, depending on poultry production type (broilers, layers, breeders; FEDNA, 2016).

Despite its anti-nutritional factors content, several authors (Sethi *et al.*, 2006; Yasar & Gok, 2014) observed that feed intake of quails fed diet with partial replacement of corn by wheat was not reduced in comparison to control corn-based diets. This finding explains the relatively good performance of wheat grain when used in quail feed formulation and manufacturing and it agrees with the higher voluntary intake (Table 2) and preference (at least for the durum wheat; Table 2) found in the present research. In fact, wheat is considered a palatable cereal in all species (FEDNA, 2016).

The fact that quails consumed a lower amount of barley and the highest amount of durum wheat compared to other cereals, can be explained because quails, like most poultry species, can match their protein intake closely to their requirements when supplied two feeds to choose between them. This has been observed in growing quails by Canoğullari *et al.* (2004) when birds received ground wheat and concentrate feed simultaneously as a choice, and by McLeod & Dabutha (1997) in birds allowed to choose between a low-energy, soya-based, high protein mixture and a high-energy, wheat-based, low protein mixture under several ambient temperatures. Toprak & Yilmaz (2012) also reported feed intake reduction in quails fed barley-based deficient diets. In general, cereal consumption decreased as protein intake decreased. In fact, protein content of barley was the lowest of the tested cereals, while the one of durum wheat was the highest (Table 1).

Except for barley, cereal daily intake recorded in the preference trial for each single grain, particularly durum wheat, was near to that recorded for wheat (6.03 g/d) in an experiment carried out by Canoğullari *et al.* (2004) on growing quails when offered ground wheat and concentrate feed simultaneously as a choice. Moreover, choice feeding did not change feed intake when total daily intake of the four whole grain cereal supplied together recorded in the preference trial (14.3±0.21 g) was compared to daily intake of each single cereal when available alone (12.1 to 15.6 g; Table 2). This result also agrees with findings by Canoğullari *et al.* (2004) when offering ground wheat and concentrate feed simultaneously to growing quails, compared to supplying only concentrate.

Although adult female Japanese quails are heavier than males (Vali, 2009), in the present study no differences between sexes were found in relation to cereal intake and preference when sex was considered as a factor because bird weight was included as a covariate in the statistical analysis. This fact agrees with previous findings reporting similar feed intake in quails of both sexes (Vali, 2009; Chin *et al.*, 2013). However, females are more sensitive than males to undernutrition (Chin *et al.*, 2013), something that could explain the interactions between sex and feedstuff factors found in the present research (Table 2), in the sense that: i) balanced feed intake was higher for females than males; ii) males preferred barley in a higher degree compared to females. This could be explained because barley has the lowest nutritive value compared to the other tested cereals, and the cereals have lower (unbalanced) nutritive value than the balanced feed.

Positive correlations found, in general terms, between bird live weight and feed consumption in the intake trial (Table 3) agree with previous studies reporting increasing feed intake with increasing body weight (Marks, 1993; Vali, 2009), because maintenance needs grow as bird body mass increases (Marks, 1991). The weak (or lack of) correlation between quail live weight and each cereal consumption found in the preference trial (Table 3) might be due to the fact that the four tested cereals were offered simultaneously, thus leading to a greatly different single cereal consumptions by each bird. Therefore, birds seemed to be able to adjust and counterbalance their total intake by selecting and combining different amounts of each single cereal, as a way to equilibrate total intake to better fit the maintenance needs (Pousga *et al.*, 2005). This also explains the strong positive linear correlation between quail live weight and the total intake when the four cereals where available simultaneously in the preference trial.

This research may contribute useful information to feed manufacturing and management in production systems in which the use of whole-grain cereals is common. Thus, in rural small-scale poultry production the use of whole grain not only save grinding and mixing cost but it has also demonstrated increased efficiency of diet utilisation (Pousga *et al.*, 2005). Whole-grain cereals are also given to quails in the finishing phase of the game farming of this species, with the aim of preparing birds for the transition from the balanced feed that receive in the farm to the food that will eat in the wild, where they may also find cereal grains (Dalmau, 1994).

In summary, results from the two trials in the current study suggest that diet formulation and manufacturing with whole-grain cereals taking into account preferences of Japanese quails might have nutritional relevance. Japanese quails in these trials chose those cereals that better fit their nutritional requirements. Voluntary intake of durum and bread wheat and triticale was higher than that of barley, and intake of each cereal grain was lower compared to the balanced feed. When given as a choice, quails preferred, in decreasing order, durum wheat, triticale, bread wheat, and barley. These differences in voluntary intake and preference among whole-grain cereals, that did not show any differences between sexes, were attributable to differences in their chemical composition, physical texture, and nutritive value.

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