RESEARCH ARTICLE

PARTIAL REPLACEMENT OF SOYBEAN MEAL BY BROAD BEANS OR FIELD PEAS IN JAPANESE QUAILS' DIET

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ABSTRACT

This study was conducted to determine feed formulas specific to the Japanese quail *C. japonica* by partially substituting imported soybean meal with locally produced and cheaper protein-crops. Each formula contained either Entire Broad Beans (EBB), Heat-treated Decorticated Broad Beans (HDBB) or Entire Field Peas (EFP), each one at several replacement levels (10, 20 and 30%) of the whole formula. The results showed that feed containing HDBB led to better growth performances as compared to all the other formulas. Substitution with EFP recorded close effects to the control formula, but its high fiber and average protein contents represent a limitation to its incorporation at higher levels. EBB had adverse impacts, especially on growth performances. HDBB incorporation led to a significant hypoglycemia (batches 20% and 30%) (p=0.0039 and p=0.0049, respectively), and a considerable reduction of uremia (all batches) (p=0.0047, p=0009 and p=0.0227, in that order) with hypercalcemia (batches 20 and 30%) (p=0.0285 and p=0.0208. respectively), hyperphosphatemia (all batches) (p=0.0064, p=0.0163 and p=0.0027. respectively) and normal cholesterolemia, triglyceridemia, proteinemia, serum creatinine, glutamic-oxaloacetic transaminase (GOT) and glutamic-pyruvic transaminase (GTP) amounts. EBB induced a very significant hypoglycemia (at 30% replacement) (P=0.0015), and hypouremia (batch 10%) (p=0.0019) with hypercalcemia (batch 30%) (p=0.0035), hyperphosphatemia (batch 20%) (p=0.0048) and normal cholesterolemia, triglyceridemia, proteinemia, serum creatinine, GOT and GPT. On the other hand, EFP had no effect (p>0.05) on the biochemical parameters of *C. japonica* except a non-significant decrease of uremia in batch 10% (p=0.49). Accordingly, it can be suggested that Field Peas and Treated Broad Beans could be possible substitutes to soybean meal in quails' feed production.

Keywords: Biochemical profile, *Coturnix japonica*, feed formulation, growth performances

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INTRODUCTION

Since their domestication in Japan as singing birds (Hrncar et al., 2014), Japanese quails *Coturnix japonica* have gained an economic importance as agricultural species (Djitie-Kouatcho et al., 2015). They have many distinctive characteristics such as low body weight (80 to 300 g), short generation interval (3 to 4 generations per year), disease resistance, high egg production, rapid sexual maturity and adaptability to several breeding conditions (Nikpiran et al., 2014; Okuliarova et al., 2014).

Because of their high energy and protein contents, corn-soy based diets were considered for a long time as staple feed for birds despite the production type. In poultry, like any other livestock production, feed accounts for almost 60-80% of the total production cost (Olugbenga et al., 2015; Shamna et al., 2013). Thus, nutritionists had attempted to establish feed formulas balanced in energy and proteins at cheapest prices using locally available ingredients. In this context, local protein crops (like broad beans and field peas) can be inexpensive and more available alternatives to soybean meal, which remains the most costly constituent.

Broad bean *(Vicia faba var. minor)* is a leguminous plant that contains relatively high amounts of energy and proteins (25-33% of Dry Matter DM) rich in lysine, but fairly poor in sulfur amino acids and tryptophan. It has also moderate fibercontent (crude fiber: 7-11% DM) (Heuzé et al., 2013).

Field pea *(Pisum sativum)* is an annual herbaceous plant containing two major families of soluble proteins (globulins, soluble in saline buffers and albumins, soluble in water) and 10-15% insoluble proteins. Globulins are the main storage proteins (55–65%) in this crop (Adebiyi and Aluko, 2011; Potter, 1995).

On the other hand, broad beans enclose many anti-nutritional factors (protease inhibitors, lectins, phenolics and especially tannins/ proanthocyanidins) which interfere with digestibility and nutrients' uptake (Kaysi and Melcion, 1992; Kumar et al., 2015) and require appropriate treatments to guarantee a better nutritional use. As well, field peas have fairly low amounts of anti-nutritional factors (protease inhibitors, tannins, alkaloids, lectins, phytic acid, saponins and oligosaccharides) (Hickling, 2003; Konieczka et al., 2014).

In this study, the effects of partial substitution of soybean meal (by entire or heat-treated decorticated broad beans or field peas) on growth parameters and biochemical profiles of Japanese quails were assessed.

MATERIAL AND METHODS

Animals and diets

The trials took place in 2016 at the Institut Technique des Élevages of Constantine (Northeastern Algeria). Fertile quail eggs were incubated, and chicks were started on the same feed under the same conditions prior to being placed on test diets. At 07 days old, about 450 chicks were weighed and allotted to 10 treatment groups (with 03 replicates of 15 chicks for each treatment) in a way to get approximately the same mean body weight and body weight range between all replicates.

Field peas and broad beans (from a local market) were washed, cleared of all impurities then air-dried. Entire broad beans and field peas were then ground, and while treated, broad beans were placed in hot water (80°C) for 30 minutes to facilitate removal of their coats. Next, their almonds were allowed to air dry for one day, after what they were placed in an autoclave at 120°C for about 20 minutes, air dried and finally ground as described by Brufau et al. (1998).

Feed formulations were prepared using Windows User-Friendly Feed Formulation tool (WUFFDA ver. 1.02, 2004) to meet all nutritional requirements of quails (at growth and finishing periods) established by the National Research Council (NRC, 1994).

As presented below in Tables 1 and 2, diets were prepared with no substitution of soybean meal (Control diet CTRL) or with partial replacement levels of it (at 10%, 20% and 30% of the whole formula) using either Entire Broad Beans (EBB), Heat-treated Decorticated Broad Beans (HDBB) or Entire Field Peas (EFP).

Birds of each replicate were housed in a separate galvanized-wire cage with feed and water *ad-libitum* and under the same breeding conditions (temperature, relative humidity, lighting program and hygiene).

Table 1 Ingredients and nutrient composition of diets during growth period (from 7th to 21st day)

	Feed formulas	CTRL	EBB			HDBB			EFP		
			10%	20%	30%	10%	20%	30%	10%	20%	30%
Ingredients (%)	Corn	51.25	47.00	45.50	40.50	47.00	45.50	40.50	48.50	43.05	37.95
	Entire beans		10.00	20.00	30.00						
	Treated beans					10.00	20.00	30.00			
	Field Peas								10.00	20.00	30.00
	Wheat bran	8.25	7.00	2.25	2.00	7.00	2.25	2.00	3.35	2.50	1.00
	SBM 44% CP	38.75	34.25	30.5	25.75	34.25	30.50	25.75	36.40	32.70	29.30
	Limestone	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	DCP	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	MV premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Total	100	100	100	100	100	100	100	100	100	100
Nutrient Composition (%)	Dry matter (%)	88.08	88.04	88.00	87.95	88.04	88.00	87.95	88.26	88.42	88.59
	ME (kj/g)	11.63	11.63	11.63	11.63	11.63	11.63	11.60	11.70	11.67	11.63
	Proteins (%)	23.05	23.05	23.06	23.05	23.05	23.06	23.05	23.00	22.99	22.99
	Fat (%)	2.58	2.52	2.49	2.49	2.52	2.49	2.49	2.45	2.32	2.19
	Crude fiber (%)	3.55	3.89	3.94	4.37	1.75	1.77	1.96	3.46	3.70	3.89

CTRL: Control diet.CP: Crude Proteins. DCP: DiCalcium Phosphate. EBB: Entire Broad Beans. HDBB: Heat-treated Decorticated Broad Beans. EFP: Entire Field Peas. ME: Metabolizable Energy.MV: Mineral-Vitamin. SBM: Soybean Meal.

Table 2 Ingredients and nutrient composition of diets during finishing period (from 22nd to 42nd day)

	Feed formulas	CTRL	EBB			HDBB			EFP		
			10%	20%	30%	10%	20%	30%	10%	20%	30%
Ingredients (%)	Corn	58.05	55.00	51.90	48.70	55.00	51.90	48.70	53.65	50.05	46.20
	Entire bean		10.00	20.00	30.00						
	Treated bean					10.00	20.00	30.00			
	Field peas								10.00	20.00	30.00
	Wheat bran	10.00	7.25	4.55	2.00	7.25	4.55	2.00	7.20	3.90	0.92
	SBM 44% CP	29.95	25.75	21.55	17.30	25.75	21.55	17.30	27.15	24.05	20.88
	Limestone	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	DCP	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	MV premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Total	100	100	100	100	100	100	100	100	100	100
Nutrient Composition (%)	Dry matter	88.02	88.98	87.94	87.89	88.98	87.94	87.89	88.19	88.36	88.53
	ME (kj/g)	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.71	11.71	11.71
	Proteins	20.01	20.01	20.01	20.01	20.01	20.01	20.01	20.00	20.00	20.00
	Fat	2.81	2.73	2.64	2.56	2.73	2.64	2.56	2.67	2.54	2.41
	Crude fiber	3.55	3.83	4.12	4.43	1.72	1.85	1.99	3.63	3.67	3.73

CTRL: Control diet. CP: Crude Proteins. DCP: DiCalcium Phosphate. EBB: Entire Broad Beans. HDBB: Heat-treated Decorticated Broad Beans. EFP: Entire Field Peas. ME: Metabolizable Energy. MV: Mineral-Vitamin. SBM: Soybean Meal.

Performances measurement and biochemical analyses

During the experiment, the following data were collected:

- Individual body weights (BW): measured daily before feed distribution early in the morning, and used to calculate average weekly weight of all males, all females separately and of the whole lot along the rising stages.
- Average Daily Body Weight Gain (BWG) (of each batch, all males and all females separately): calculated for the growing and finishing periods and for the entire rearing period.
- Feed Intake (FI) of each batch: recorded daily and used to calculate Feed Conversion Ratio (FCR) during growing, finishing and entire rearing periods.
- Mortality rates (M%): dead birds were counted daily and taken into consideration when calculating FCR and BWG.

By the experiment end, 10 males and 10 females of each group were sacrificed and blood samples taken in heparinized tubes. Plasmas were then harvested by centrifugation at 3000 rpm for 10 minutes to measure glycemia, cholesterolemia, triglyceridemia, proteinemia, uremia, creatininemia, calcemia, phosphatemia,glutamic-oxaloacetic transaminase (GOT) and glutamic-pyruvic transaminase (GPT) amounts, using a Kenza Max-Biolabo Diagnostics® semi-automated spectrophotometer with commercial kits (Spinreact®).

Statistical analysis

Growth parameters were expressed as mean±SE and biochemical ones as median±IQR.

Graph Pad Instat prism 6.04 *(GraphPad Software, Inc., San Diego, CA, USA, 2014)* statistical software was used to compare the growth performances and biochemical profiles of birds of the different batches.

At first, the distribution of all obtained data was analyzed using the D'Agostino-Pearson test. Disparities between the different batches (including the CTRL one) were analyzed by applying Analysis of Variance (ANOVA) followed by Tukey's multiple comparison test for parametric data, and Kruskal-Wallis test followed by Dunn's multiple comparison test for non-parametric one. As well, the results recorded in males and females of each batch were compared using either Student's *t* test or Mann-Witney's *U* test.

Statistical significance was set at $p<0.05$.

RESULTS

Growth performances

As shown in Table 3, a significant ($p<0.0001$) body weight (BW) increase was recorded in birds of all HDBB batches during the growing and finishing periods; while a significant ($p<0.0001$) BW decrease was observed in all EBB batches throughout the growing phase and only in EBB 10% and 20% batches along the finishing phase, as compared to the CTRL. Quails' BWs of EFP batches were higher than EBB ones. A substantial difference in BW was observed between males and females of all HDBB batches ($p<0.0001$, $p=0.0008$ and $p=0.0012$, respectively). Furthermore, many significant disparities were also observed in BW of quails of different batches as compared to each other.

HDBB batches had displayed a significant increase in feed intake (FI) through the growing ($p<0.0001$) and the finishing periods ($p=0.0007$, $p=0.0013$ and $p=0.0009$, respectively), leading to a sensitive augmentation ($p=0.0005$, $p=0.0017$ and $p=0.0009$, respectively) in their body weight gain (BWG) as compared to CTRL quails. On the other hand, a significant ($p<0.0001$) drop in quails' BWG was noted in all EBB batches along the growing period. Quails of all EBB batches and EFP showed no difference ($p>0.05$) in FI as compared to the CTRL.

Furthermore, a significant increase ($p=0.0056$) was discerned in feed conversion ratio (FCR) of HDBB 20% batch along the growth phase, and it became significant for all HDBB batches in the finishing phase (p=0.0035, p=0.0115 and p=0.0082, respectively). FCR increased also significantly in EBB 20% batch (p=0.0021) in growing period and in EFP 10% and 20% batches in the finishing one (P=0.0008 and p<0.0001, in that order), as compared to the CTRL.

The highest mortality rate during the growing period was recorded in all EBB batches (p=0.0335, p=0.0005 and p=0.0027, respectively), while HDBB fed batches showed relatively low rates compared to the CTRL in the growth and finishing phases (p>0.05).

Table 3 Effect of soybean meal substitution by EBB, HDBB or EFP on growth parameters of *C. japonica* (Mean±SE)

Batch		Growing period					Finishing period				
		BW (g)	**FI (g/d)**	**BWG (g/d)**	**FCR**	**M (%)**	**BW (g)**	**FI (g/d)**	**BWG (g/d)**	**FCR**	**M (%)**
CTRL		61.98 ±6.36	6.28 ±0.78	3.46 ±0.05	1.78 ±0.02	0.00 ±0.00	142.51 ±7.25	18.74 ±1.47	4.01 ±0.04	4.60 ±0.05	2.27 ±1.43
EBB	**10%**	40.41 ±3.93^{*aB}	5.05 ±0.93^{aB}	1.97 ±0.11$^{* a C}$	2.58 ±0.15$^{* B}$	10.68 ±1.66*	122.79 ±9.58^{*aB}	15.82 ±1.94^{*a}	4.11 ±0.08^{a}	4.01 ±0.09^{*ab}	3.03 ±2.13^{a}
	20%	38.74 ±4.49^{*aB}	5.44 ±1.03^{a}	1.87 ±0.11$^{* a C}$	2.99 ±0.19$^{* A C}$	20.38 ±1.35$^{* A B}$	123.37 ±10.59^{*aB}	16.52 ±2.08^{a}	4.27 ±0.11	3.80 ±0.14^{*ab}	0.00 ±0.00^{a}
	30%	41.00 ±3.93^{*aB}	5.51 ±1.04^{a}	2.02 ±0.02$^{* a C}$	2.41 ±0.03$^{* c}$	16.27 ±2.85$^{* B}$	130.78 ±9.92^{aC}	17.89 ±2.38^{aB}	4.48 ±0.10^{C}	3.99 ±0.09$^{* a b C}$	6.66 ±2.35
HDBB	**10%**	91.42 ±4.11^{*A}	11.57 ±1.19^{*A}	5.55 ±0.22$^{* A}$	2.16 ±0.09^{a}	5.55 ±1.95^{a}	180.42 ±8.54^{*A}	26.78 ±2.89^{*A}	4.58 ±0.10^{B}	6.01 ±0.13$^{* A}$	0.00 ±0.00^{a}
	20%	85.36 ±4.85^{*A}	11.93 ±1.07^{*A}	5.07 ±0.07$^{* A}$	2.35 ±0.03$^{* a}$	0.00 ±0.00$^{a b}$	177.14 ±8.59^{*A}	26.45 ±2.71^{*A}	4.59 ±0.18^{B}	5.77 ±0.23$^{* A}$	3.03 ±2.13^{a}
	30%	86.07 ±4.26^{*A}	11.24 ±1.25^{*A}	5.21 ±0.16$^{* A}$	2.16 ±0.08 ^{a}	5.80 ±2.05	177.41 ±10.33^{*A}	26.61 ±3.11^{*A}	4.76 ±0.11^{B}	5.83 ±0.14$^{* A}$	0.00 ±0.00^{a}
EFP	**10%**	59.51 ±6.89^{ab}	6.29 ±0.51^{a}	3.16 ±0.05$^{a B c}$	1.98 ±0.03$^{a b c}$	2.77 ±1.95$^{a b}$	143.38 ±9.76^{ab}	14.50 ±1.56^{*ab}	4.29 ±0.10	3.43 ±0.08$^{* a B c d}$	5.55 ±3.92
	20%	52.64 ±4.53^{ab}	6.79 ±0.45^{ab}	2.94 ±0.13$^{a c}$	2.32 ±0.11^{*c}	7.40 ±5.23^{b}	152.16 ±7.79^{abc}	14.55 ±1.37^{*ab}	4,97 ±0.15$^{* A C}$	2.92 ±0.03$^{* a B c D}$	0.00 ±0.00^{a}
	30%	51.62 ±4.82^{ab}	6.97 ±0.51$^{a b}$	3.83 ±0.14$^{a b c}$	2.03 ±0.07$^{a c}$	8.33 ±2.94^{b}	136.90 ±7.07^{a}	16.26 ±1.84^{a}	3.78 ±0.13$^{b c}$	4.31 ±0.15^{ad}	19.04 ±3.36$^{* A}$
ANOVA (p-value)		0.0001	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001	0.0005	0.0001	0.0091

BW: Body Weight. BWG: Daily Body Weight Gain. CTRL: Control. EBB: Entire Broad Beans. EFP: Entire Field Peas. FI: Daily Feed Intake. FCR: Feed Conversion Ratio. HDBB: Heat-treated Decorticated Broad Beans. M: Mortality rate.*: significant difference compared to CTRL. Letters within the same column indicate significant differences at p<0.05 probability level by Tukey test: means labelled by an upper-case letter are significantly different from those labeled by the same lower-case letter. There are no significant differences between means that share the same upper-case or the same lower-case letter.

Biochemical parameters

The biochemical traits of the different batches are summarized in Table 4. A significant decrease in glycemia was observed in HDBB 20% and 30% groups (p=0.0039 and p=0.0049, respectively) and in EBB 30% group, as compared to the CTRL (p=0.0015). However, we did not record any serum cholesterol variations in our batches except a significant difference (p=0.0079) between males and females in the control group, in favor of females. Furthermore, no disparities ($p>0.05$) in protein levels were observed in the different batches as compared to the CTRL; nevertheless, differences were noticed in favor of EBB and EFP batches compared to HDBB ones. In addition, blood urea decreased in EBB batch 10% significantly ($p=0.0019$), and in EFP 10% batch, but in a non-significant way ($p=0.49$). This decrease was very significant in HDBB 10%, 20% and 30% batches ($p=0.0047$, $p=0009$ and $p=0.0227$, in that order), as compared to the CTRL. On the other hand, creatinine levels were unaffected by dietary changes ($p>0.05$), in contrast with calcemia that increased in a significant manner in HDBB 20% and 30% ($p=0.0285$ and $p=0.0208$, respectively) and EBB 30% batches ($p=0.0035$) in comparison to CTRL. Phosphatemia of all HDBB groups ($p=0.0064$, $p=0.0163$ and $p=0.0027$, respectively) and EBB 20% ($p=0.0048$) was higher than the CTRL. Finally, the partial replacement of soybean meal by EBB, HDBB and EFP had no impact on plasma GOT and GPT amounts.

Table 4 Effect of soybean meal substitution by EBB, HDBB and EFP on the biochemical profile of the Japanese quail (Median±IQR)

Batch		Glucose (g/l)	Cholesterol(g/l)	Triglycerides(g/l)	Total Proteins(g/l)	Urea (g/l)	Creatinine(g/l)	GOT(U/l)	GPT(U/l)	Calcium (mg/l)	Phosphate(mg/l)
CTRL		3.63 ±0.43	2.35 ±1.52	1.20 ±0.87	27.05 ±9.49	0.10 ±0.05	5.45 ±0.77	280.00 ±177.80	25.50 ±6.75	75.00 ±21	64.70 ±10.75
EBB	10%	2.83 ±0.41	2.05 ±0.88	0.78 ±0.41	34.45 ±6.55^{a}	0.03 ±0.03^{*a}	4.75 ±1.14	252.00 ±78.80	34.50 ±15.75	81.00 ±11.25^{a}	83.50 ±21.00
	20%	3.51 ±1.10^{a}	2.22 ±0.75	1.44 ±1.24	36.25 ±5.42^{ab}	0.07 ±0.02	4.45 ±0.65	247.00 ±85.20	44 ±35.25	88.5 ±13.50	93.75 ±32.50*
	30%	1.66 ±0.55^{*A}	2.08 ±0.42	0.74 ±0.78	28.20 ±5.38	0.10 ±0.03^{A}	5.70 ±3.40	218.00 ±36.50	39.50 ±17.75^{a}	100.00 ±6.30*	80.00 ±20.39
HDBB	10%	3.05 ±0.23	2.17 ±0.36	1.21 ±0.80	19.45 ±6.37^{A}	0.05 ±0.02^{*a}	4.85 ±2.30	157.50 ±87.00	15.50 ±17.50	117.00 ±10.50^{A}	115.00 ±51.70^{*A}
	20%	2.81 ±0.51*	2.56 ±0.89	1.90 ±1.50	22.95 ±10.53^{B}	0.04 ±0.03^{*aB}	6.20 ±1.47	165.00 ±24.00	37.00 ±20.50	125.00 ±55.30^{*A}	109.00 ±49.50^{*B}
	30%	2.83 ±0.28*	2.20 ±1.04	1.21 ±0.84	21.75 ±17.60	0.05 ±0.02*	5.40 ±0.87	162.00 ±99.50	34.00 ±11.75	142.00 ±81.50^{*A}	119.30 ±15.90^{*C}
EFP	10%	3.94 ±0.51^{a}	1.88 ±0.43	1.36 ±0.36	27.70 ±6.65	0.06 ±0.03	4.25 ±0.72	245.50 ±90.00	18.50 ±12.00	88.0 ±11.50	64.40 ±21.00^{ac}
	20%	3.18 ±0.48	2.41 ±0.74	1.25 ±0.39	26.85 ±5.70	0.08 ±0.02^{b}	5.83 ±0.28	268.50 ±135.00	15.50 ±4.75^{A}	85.00 ±13.50^{a}	67.80 ±5.43^{ac}
	30%	3.19 ±0.32	2.23 ±0.39	0.98 ±0.74	39.65 ±6.90^{ab}	0.07 ±0.03	3.95 ±3.30	240.00 ±58.70	46.00 ±47.00	85.50 ±20.75^{a}	53.00 ±29.30^{abc}
Kruskal-Wallis (p-value)		0.0001	0.58	0.15	0.0001	0.0001	0.009	0.029	0.0006	0.0001	0.0001

CTRL: Control. EBB: Entire Broad Beans. EFP: Entire Field Peas. GOT: glutamic-oxaloacetic transaminase. GPT: glutamic-pyruvic transaminase. HDBB: Heat-treated Decorticated Broad Beans.

*: significant difference compared to CTRL. Letters within the same column indicate significant differences at $p<0.05$ probability level by Dunn test: medians labeled by an upper-case letter are significantly different from those labeled by the same lower-case letter. There are no significant differences between medians that share the same upper case or the same lower-case letter.

DISCUSSION AND CONCLUSION

The disparities recorded in quails' weights of our several batches, could be related to variations in nutrients' contents, others than energy and proteins, of the various used formulas. Furthermore, the higher content of EFP and EBB (to a less extent) in antinutritional factors, as described by Hickling (2003), negatively affected weights of birds fed on them, as compared with those fed on HDBB.

Differences in BW between males and females may be related to sexual dimorphism. This same observation was made by Aytac and Karabayir (2012) and Ojedapo and Amao (2014).

FI noted in our CTRL was similar to the one reported by Guluma and al. (2014) in their CTRL and may be linked to similarities in used quail strains and rearing conditions (Ipek et al., 2007). The increase in feed consumption is consistent with the work of Magoda and Goss (2011), in laying hens fed on dehulled broad beans, and it was related to the absence of antinutritional factors after shelling and to an unidentified deficiency that incited birds to consume more in order to get enough nutrients. However, it is believed that shelling and even autoclaving do not eliminate all antinutritional factors since the thermostable α-galactosides found in the bean almonds will persist. Higher organisms, like birds, do not possess α-galactosidase and the presence of these sugars results in digestive discomfort (flatulence and diarrhea). This can diminish FI and glucose absorption, and leads to hypoglycemia and accelerated intestinal transit (Cunha and Freire, 1993; Kaysi and Melcion, 1992). Therefore, and in order to compensate for the limiting element (glucose), feed consumption increased. In addition, the elimination of tannins with a major part of other antinutritional factors by treating broad beans has positive effects on the improvement of palatability. According to Gemede and Ratta (2014), tannins are known to be responsible for decreasing feed consumption, dietary efficiency and protein digestibility. They are also the cause of decreased palatability and reduced growth rate. Moreover, Kanyinji and Moonga (2014) reported that the increase in consumption index might have been due to spillage, while its reduction could be related to increased fiber content.

The effect of antinutritional factors would be the cause of the FCR increase observed during growing period in EBB and EFP batches. These factors are known to cause growth retardation, reduced feed efficiency and protein digestibility in animals (Gemede and Ratta, 2014). To this, we can also associate the effect of fibers contained in EBB and EFP. The decreased FCR in EBB batches in the finishing period can be explained by the fact that quails probably became more resistant to its antinutritional factors.

The high mortality recorded in EBB batches may be attributed to the adverse effects of antinutritional factors as observed in the work of Koivunen et al. (2014), and the fact that HDBB- fed batches showed relatively less mortalities supports the idea that heat treatment of broad beans eliminates a big amount of them.

The nutrient profile of broad bean shows a high content of thiamine (5.5mg/kg), compared to soybean meal and field peas (1.7 and 1.8mg/kg, respectively). This vitamin is known to play a fundamental role in the metabolism of carbohydrates and the production of ATP within cells. Thus, it can be suggested that its high content in broad bean was probably the cause of the hypoglycemia observed in quails that fed on it. However, it is worth noting that the animal organism does not store thiamine, and the excess is excreted in urine or feces (Mc Dowell, 2000). Furthermore, diurnal variations in blood glucose levels had been well documented in terms of rapid ingestion cycle effect and its interference with internal rhythms (Scholtz et al., 2009). Another hypothesis that may explain the hypoglycemia observed in broad bean batches is related to the presence of α-galactosides, as previously explained. In the literature, there are also similar observations that are still normal for the Japanese quail glycemia standards noted by Sholtz et al. (2009) and Tufan et al. (2015).

The difference in blood glucose between males and females may be due to increased steroid hormones secretion with birds aging in preparation for laying period (Ali et al., 2012). Elnagar and Abd-Elhady (2009) reported that reproductive and pre-sexual development led to 13-15% reduction in glycemia during sexual maturity and peak production, respectively.

Fibers contained in whole seeds contribute in cholesterol absorption decrease in the intestine (Potter, 1995). Additionally, in birds, most of the circulating cholesterol is transported by HDL and LDL. The effect of legume (including *Vicia faba*) proteins on serum cholesterol is related to their amino acid composition that reduces the number of LDL particles available for cholesterol transport in the plasma (Kingman et al., 1993). In preparation and during the laying period, hepatic synthesis of triglycerides, phospholipids and cholesterol is increased in quails (Walzem et al., 1999).These lipids are incorporated in lipoproteins of blood and ovary oocytes. This makes females, especially the laying ones, to have extraordinarily high blood cholesterol concentrations, unlike males (König et al., 2007).This is in concordance with our CTRL records.

Proteinemia of our CTRL is consistent with those described in previously published works (Ali et al., 2012; Nazifi and Asasi, 2001; Tufan et al., 2015). Nevertheless, it is important to note that a passive and transient hyperproteinemia can occur following dehydration (Hochleithner, 1994).

It is known that hypouremia can be caused by the antinutritional factors present in the broad beans, especially the tannins (concentrated mainly in the teguments), in addition to trypsin and chymotrypsic inhibitors, lectins and saponins that reduce the digestibility and use of nitrogen (Cunha and Freire, 1993). This may explicate the decrease in blood urea remarked in EBB and EFP batches.

Plasma creatinine levels of our study did not vary between the batches, and they are very similar to those of Scholtz et al. (2009).

Serum calcium values of CTRL quails are consistent with Coenen et al. (1994) records. The hypercalcemia observed in HDBB and EBB batches is, interestingly, close to those recorded in CTRL batches of previous studies (Nazifi and Asasi, 2001; Vali, 2010). Unfortunately, we could not find any explanation to this increase, except that in female birds, the formation of woven medullary bone is stimulated by the actions of oestrogens and androgens concomitantly with the maturation of the ovarian follicles. Resorption of this medullary bone provides 40% of the calcium required for shell formation, which explains the increase in blood calcium at the onset of spawning (Dacke et al., 1993; Thorp et al., 1993). In fact, we have observed an early sexual maturity in broad bean batches.

Increase in phosphoremia of HDBB and EBB groups can be physiological, as concluded by Hassan (2010) who attributed it to estrogens. Indeed, at the beginning of the laying period, this increase is due to higher calcium and phosphorus requirements, that lead to in-kidney vitamin D activation and bone resorption increase to meet the quails'needs (Proszkowiec-Weglarz and Angel, 2013).

Finally, the plasma amounts of GOT and GPT of our birds are still analogous to those obtained in CTRL quails of other studies (Babazadeh et al., 2011; Mahmoud et al., 2012).

To sum up, our feeding trials demonstrated that entire broad beans should not be incorporated in feed formulas for Japanese quails, especially during the growing period because of their richness in antinutrient factors; however, treated broad beans and field peas could be potential alternatives to solve the soybean-meal importation problem in Algeria and elsewhere. Nevertheless, the extensive studies are needed to determine up to which amounts these crops can be used.

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CONFLICT OF INTEREST

None.

CONTRIBUTIONS

AB: Data Collection and Processing; Analysis and Interpretation of the Data; Literature Review; Writing.AA: Conception; Design; Supervision; Analysis and Interpretation of the Data; Critical Review.

REFERENCES

Adebiyi AP, AlukoRE. 2011. Functional properties of protein fractions obtained from commercial yellow field pea (Pisum sativum L.) seed protein isolate. Food Chem, 128(4), 902-8. https://doi.org/10.1016/j.foodchem.2011.03.116

Ali M, Hmar L, Inaotombi DL, Prava M, Lallianchhunga MC,Tolenkhomba TC. 2012.Effect of age on the haematological and biochemical profile of Japanese quails (Coturnix coturnix japonica). Int Multidiscip Res J, 2(8), 32-5.

Aytac S,Karabayir A. 2012.The effect of the floor differences in cages on the incubation results and live weight of Japanese quail.J Anim Vet Adv, 11(8), 1204-7.http://dx.doi.org/10.3923/javaa.2012.1204.1207

Babazadeh T, Vahdatpour H, Nikpiran H, Jafargholipour MA, Vahdatpour S. 2011.Effects of probiotic, prebiotic and synbiotic intake on blood enzymes and performance of Japanesequails (Coturnix japonica).Indian J Anim Sci, 81(8), 870-4.

Brufau J, Boros D, Marquardt RR. 1998.Influence of growing season, tannin content and autoclave treatment on the nutritive value of near-isogenic lines of Fababeans (Vicia faba L.) when fed to leghorn chicks. Br Poult Sci, 39(1), 97-105.https://doi.org/10.1080/00071669889457

Coenen TM, Enninga IC, Cave DA. 1994. Hematology and serum biochemistry of Japanese quail fed dietary tri-n-butyltin oxide during reproduction. Arch Environ Contam Toxicol, 26(2),227-33. https://doi.org/10.1007/BF00224809

Cunha LF,Freire JP. 1993.Effet de la substitution totale ou partielle du tourteau de soja par Vicia fabaBenghalensissur la digestibilité, la caecotrophie et le bilan azoté chez le lapin adulte.World Rabbit Sci, 1(1),31-6.https://doi.org/10.4995/wrs.1993.193

Dacke CG, Arkle S, Cook DJ, Wormstone IM, Jones S, Zaidi M,Bascal A. 1993.Medullary bone and avian calcium regulation. J Exp Biol, 184(1), 63-4.https://doi.org/10.1242/jeb.184.1.63

Djitie-Kouatcho F, Kana JR, Ngoula F, Nana NF,Teguia A. 2015.Effect of dietary crude protein level on growth parameters and carcass characteristics of quail (Coturnix sp.) at finisher stage in Western Highlands of Cameroon. LRRD, 27(8), 1-10.

Elnagar SA,Abd-Elhady AM. 2009.Exogenous estradiol: Productive and reproductive performance and physiological profile of Japanese quail.Int JPoul Sci, 8(7),634-41.http://doi.org/10.3923/ijps.2009.634.641

GemedeHF,Ratta N. 2014.Antinutritional factors in plant foods: Potential health benefits and adverse effects.Int J Food Sci Nutr, 3(4),284-9.https://doi.org/10.11648/j.ijnfs.20140304.18

Guluma LY, Madaki YA, Machido H, Dantayi RJ,Kulokom S. 2014.Growth performance and carcass evaluation of quails fed graded levels of watersoaked Sweet Orange Peel Meal (SOPM).Adv Life SciTechnol, 20, 1-6.

Hassan HA. 2010.Variations in egg performance and plasma constituents at different ages of females Japanese quail.Egypt Poult Sci J, 30(2), 565-81.

Heuzé V, Tran G, Delagarde R, Lessire M, Lebas F. 2018. Faba bean (Vicia faba). Feedipedia, a program by INRA, CIRAD, AFZ and FAO. https://www.feedipedia.org/node/4926 (accessed17.7.18).

Hickling D.2003. Canadian Feed Peas Industry Guide. 3rded (pp.10-14).Winnipeg MB, Canada:Pulse Canada.

Hochleithner M.1994. Biochemistries. In:Ritchie BW, Harrison GJ,Harrison LR (Eds), Avian medicine: Principles and application(pp.1-23).Lake Worth Florida, USA: Wingers Publishing Inc.

HrncarC, Hanusova E,Hanus A,Bujko J. 2014.Effect of genotype on egg quality characteristics of Japanese quail (Coturnix japonica). Slovak J Anim Sci, 47(1), 6-11.

Ipek H, Avci M, Yerturk M, Iriadam M, Aydilek N. 2007. Effects of ascorbic acid and vitamin E on performance and hematological parameters of Japanese quails under high ambient temperature in Sanliurfa. Arch Geflugelkd, 71(3), 130-4.

Kanyinji F,Moonga M. 2014.Effects of replacing maize meal with rumen filtrate-fermented cassava meal on growth and egg production performance in Japanese quails (Cortunix japonica).J Adv Vet Anim Res, 1(3), 100-6.http://doi.org/10.5455/javar.2014.a19

KaysiY,Melcion JP. 1992.Traitements technologiques des protéagineux pour le monogastrique: exemples d'application à la graine de féverole.INRA Prod Anim, 5(1), 3-17.https://doi.org/10.20870/productions-animales.1992.5.1.4217

Kingman SM, Walker F, Low AG, Sambrook IE.1993. Comparative effects of four legume species on plasma lipids and faecal steroid excretion in hypercholesterolaemic pigs. Brit J Nut, 69(2), 409-21.https://doi.org/10.1079/BJN19930043

Koivunen E, Tuunainen P, Valkonen E, Rossow L, Valaja J. 2014.Use of Fababeans (Vicia faba L.) in diets of laying hens.Agric Food Sci, 23(3), 165-72.https://doi.org/10.23986/afsci.41329

Konieczka P, Smulikowska S, Czerwiński J, Mieczkowska A. 2014. Raw vs extruded coloured-flower pea as an ingredient in broiler diets: effects on performance, ileal digestibility, gut morphology, and intestinal microbiota activity. J Anim Feed Sci, 23(3), 244-52.https://doi.org/10.22358/jafs/65687/2014

König B, Kluge H, Haase K, Brandsch C, Stangl GI, Eder K. 2007. Effects of clofibrate treatment in layinghens. Poultry Sci. 86(6),1187-95.https://doi.org/10.1093/ps/86.6.1187

Kumar AN, Prasad N, SinhaSK. 2015. Nutritional and antinutritional attributes of Faba bean (Vicia faba L.) germplasms growing in Bihar, India. Physiol Mol Biol Plants, 21(1),159-62. https://doi.org/10.1007%2Fs12298-014-0270-2

Magoda SF,Gous RM. 2011. Evaluation of dehulled Fababean (Vicia faba cv. Fiord) as a protein source for laying hens.S Afr J Anim Sci, 41(2), 87-92.http://doi.org/10.4314/sajas.v41i2.71011

Mahmoud HM, Haggag AM, El-Gebaly HS. 2012. Toxicological studies of malathion on Japanese quail (Coturnix Japonica).Life Sci J, 9(3), 1725-32.

Mcdowell LR.2000.Vitamins in animal and human nutrition. 2nd ed (p.812). Ames, USA: Iowa State University Press.

NRC.1994. Subcommittee on poultry nutrition, National Research Council, Nutrient Requirements of Poultry. 9th ed (p.176). Washington DC, USA:National Academy of Science Press.

NazifiS,Asasi K. 2001.Hematological and serum biochemical studies on Japanese quails (Coturnix coturnixjaponica) feddifferent levels of furazolidone.Rev Med Vet, 152(10), 705-8.

Nikpiran H, Vahdatpour T, Babazadeh D, Tabatabaei SM, Vahdatpour S. 2014.Effects of functional feed additives on growth influenced hormones and performance of Japanese quails (Coturnix japonica).Green J Biol Sci, 4(2),39-44. https://doi.org/10.15580/GJBS.2014.2.021014096

Ojedapo LO,Amao SR. 2014.Sexual dimorphism on carcass characteristics of Japanase quail (Coturnix coturnix japonica) reared inderived savanna zone of Nigeria.Int JSci Environ Technol 3(1),250-7.

Okuliarova M, Kankova Z, Bertin A, Leterrier C, Mostl E, Zeman M. 2014. Maternally derived egg hormones, antibodies and antimicrobial proteins: common and different pathways of maternal effects in Japanese quail. PLoS One, 9(11), e112817.https://doi.org/10.1371/journal.pone.0112817

Olugbenga SO, Abayomi OO, Oluseye AA, Taiwo AT. 2015. Optimized nutrients diet formulation of broiler poultry rations in Nigeria using linear programming. J NutrFood Sci, S14, 1-6http://dx.doi.org/10.4172/2155-9600.S14-002

Potter SM.1995. Overview of proposed mechanisms for the hypo-cholesterolemic effect of soy. JNutr, 125 (3 Suppl), 606S-611S. https://doi.org/10.1093/jn/125.3_Suppl.606S

Proszkowiec-Weglarz M,Angel R. 2013. Calcium and phosphorus metabolism in broilers: Effect of homeostaticmechanism on calcium andphosphorus digestibility. J Appl Poult Res, 22(3),609-27. https://doi.org/10.3382/japr.2012-00743

Scholtz N, Halle I, Flachowsky G, Sauerwein H. 2009.Serum chemistry reference values in adult Japanese quail (Coturnix coturnix japonica) including sex related differences. Poultry Sci, 88(6),1186-90.https://doi.org/10.3382/ps.2008-00546

Shamna TP, Peethambaran PA, Jalaludeen A, Joseph L, Muhammad-Aslam MK. 2013.Broiler characteristics of Japanese quails (Coturnix coturnix japonica) at different levels of diet substitution with Azolla pinnata.Anim Sci Rep, 7(2),75-80.

Thorp BH, Wilson S, Rennie S, Solomon SE. 1993.The effect of a bisphosphonate on bone volume and eggshell structure in the hen. Avian Pathol, 22(4), 671-82.https://doi.org/10.1080/03079459308418955

Tufan T, Arslan C, Durna Ö, Önk K, Sari M, Erman H. 2015. Effects of chito-oligosaccharides and L-carnitine supplementation in diets for Japanese quails on performance, carcass traits and some blood parameters.ArqBrasMed Vet Zootec, 67(1), 283-9.http://doi.org/10.1590/1678-7507

Vali N.2010. Comparison difference levels of phytase enzyme in diet of Japanese quail (Coturnix japonica) and some blood parameters. Asian J Poultry Sci, 4(2), 60-6. http://doi.org/10.3923/ajpsaj.2010.60.66

Walzem RL, Hansen RJ,Williams DL, Hamilton RL.1999. Estrogen induction of VLDL assembly in egg-laying hens.J Nutr, 129(2S Suppl),467S–72S.https://doi.org/10.1093/jn/129.2.467S

WUFFDA. 2004. Windows User-Friendly Feed Formulation V.1.02. Available athttps://secure.caes.uga.edu/extension/publications/files/html/RB438/WUFFDA-English.html (accessed 4.7.23)

DJELOMIČNA ZAMJENA OBROKA OD SOJE SA BOBOM ILI GRAŠKOM U PREHRANI JAPANSKIH PREPELICA

SAŽETAK

Cilj istraživanja jeste odrediti prehrambene formule specifične za Japansku prepelicu *C. japonica* djelomičnom zamjenom uvoznog sojinog obroka sa lokalno proizvedenim i jeftinijim proteinskim žitaricama. Svaka formula je sadržavala ili cjeloviti bob (EBB), toplotom oguljeni bob (HDBB) ili cjeloviti grašak (EFP) sa različitim udjelima (10, 20 i 30%) u cjelokupnoj formuli. Rezultati su pokazali da je prehrana koja sadrži HDBB imala bolje performanse rasta u odnosu na sve druge formule. Zamjena sa EFP-om je pokazala učinke slične kontrolnoj formuli, ali je visok sadržaj vlakana i proteina u njoj predstavljao ograničenje za dodatno povećanje udjela u ukupnoj formuli. EBB je pokazao negativne učinke, posebno na performanse rasta. Dodavanje HDBB-a je izazvalo signifikantnu hipoglikemiju (serije 20% i 30%) (p=0.0039 i p=0.0049) i znatno smanjenje uremije (sve serije) (p=0.0047, p=0009 i p=0.0227, tim redoslijedom) sa hiperkalcemijom (serije 20 i 30%) (p=0.0285 i p=0.0208), hiperfosfatemijom (sve serije) (p=0.0064, p=0.0163 i p=0.0027) i normalnom holesterolemijom, trigliceridemijom, proteinemijom, serumskim kreatininom, glutamat oksalacetatnom transaminazom (GOT) i glutamat piruvatnom transaminazom (GTP). EBB je izazvao veoma signifikantnu hipoglikemiju (pri zamjeni od 30%) (P=0.0015) i hipouremiju (serija 10%) (p=0.0019) sa hiperkalcemijom (serija 30%) (p=0.0035), hiperfosfatemijom (serija 20%) (p=0.0048) i normalnom holesterolemijom, trigliceridemijom, proteinemijom, serumskim kreatininom, GOT i GPT. S druge strane, EFP nije imao učinka (p>0.05) na biohemijske parametre *C. japonice*, osim nesignifikantnog smanjenja uremije u seriji 10% (p=0.49). Prema tome, može se zaključiti da grašak i tretirani bob mogu biti korišteni kao zamjene za obroke od soje u proizvodnji prepelica.

Ključne riječi: Biohemijski profil, *Coturnix japonica*, formula, performanse rasta