Laying performance in hens of two breeds testing soybean meal or rapeseed meal plus peas as protein feed

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Abstract

In hens' feed soybean extracted meal (SBM) was replaced by rapeseed (*Brassica napus*) meal (RSM) solvent extracted plus peas in order to investigate the effects on feed intake, laying performance and composition of eggs. A total of 460 laying hens (230 Lohmann Brown-LB/230 Lohmann Dual-LD) were used in the feeding study. The hens were allocated to four groups of 115 hens each. The hens were kept in pens (23 hens per pen) with five pens per group and fed for six laying months.

The daily feed intake, the number of eggs related to the trial's days (laying intensity) and egg weight of LB hens was significantly higher compared with LD hens. While no effect of substituting SBM through RSM/peas in the diet was seen on laying intensity of all hens, the egg weight was decreased and the feed to egg mass ratio increased. The daily egg mass production was lower in the LB RSM/peas group compared with LB SBM hens and not significantly different between two LD groups. Eggs of LD hens showed a significantly higher percentage of egg yolk and a reduced proportion of egg white. The replacement of SBM by RSM/peas reduced the final body weight of hens. After slaughtering of ten hens per group a statistically higher body weight and proportion of carcass and breast meat of LD hens compared with LB hens was found. The replacement of SBM by RSM plus peas reduced the yield of breast meat in the LD hens. The change of the protein source led in hens to reduced fat content.

Keywords: *Rapeseed meal, peas, hen, layer, dual layer, laying performance, egg composition*

Zusammenfassung

Leistungsentwicklung von Hennen zweier Rassen bei Prüfung von Sojaextraktionsschrot oder Rapsextraktionsschrot plus Erbsen als Proteinfuttermittel

Im Versuch an Legehybriden wurde ein vollständiger Austausch von Sojaextraktionsschrot (SBM) durch Rapsextraktionsschrot (RSM) plus Erbsen im Futter durchgeführt, um den Einfluss auf die Leistungsentwicklung und Eizusammensetzung zu prüfen. Für die Untersuchung wurden 460 Hennen (230 Lohmann Brown-LB/230 Lohmann Dual-LD) in 4 Gruppen mit 115 Hennen in je fünf Abteile aufgeteilt und über eine Versuchsdauer von sechs Legemonaten gehalten.

Die tägliche Futteraufnahme, die Anzahl an gelegten Eiern bezogen auf die Versuchstage (Legeintensität) und das Eigewicht der LB Hennen waren gesichert höher im Vergleich mit den LD Hennen. Während kein Einfluss des Austausches von SBM durch RSM+Erbsen auf die Legeintensität festzustellen war, wurde das Eigewicht gesichert reduziert und der Futterverzehr pro kg produzierter Eimasse stieg an. Die tägliche Eimasseproduktion war gesichert niedriger bei den Hennen der LB RSM/Erbsen Gruppe und nicht signifikant unterschiedlich zwischen den LD Gruppen. Die Eizusammensetzung der LD Hennen ergab einen gesichert höheren Prozentsatz an Eidotter und reduzierten Anteil an Eiklar. Der Austausch der Proteinquelle im Futter reduzierte die Lebendmasse aller Hennen am Ende des Versuches. Die Schlachtung von zehn Hennen pro Gruppe ergab ein gesichert höheres Lebendgewicht und einen höheren Schlachtkörper- und Brustfleischanteil der LD Hennen. Durch den Ausstauch von SBM gegen RSM/Erbsen wurden der Ertrag an Brustfleisch bei den LD Hennen und der Anteil an Abdominalfett bei allen Hennen reduziert.

Schlüsselwörter: *Rapsextraktionsschrot, Erbsen, Henne, Dual-Henne, Leistungsmerkmale, Eibestandteile*

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1 Introduction

Soybean meal (SBM) is the most common protein source in diets of laying hens. The majority of this soybean meal is imported to Germany from non-European countries and often derived from genetically modified varieties. Therefore, the interest has increased to find out alternative protein sources derived from non-genetically modified varieties, such as rapeseed and grain legumes. In Germany, in 2014, rapeseed was grown on 1.39 million ha contrasting with 41.7 thousands ha used for feed peas. As protein feed, 4 million tons of rapeseed meal (RSM) and 4.8 million tons of other oil seed meals, mainly imported soybean meal, were used (UFOP, 2015). Rapeseed feeds and pea feeds are listed in the "German Positive List of Feed Materials" (Normenkommission für Einzelfuttermittel, 2016).

The international relevance of the legumes is underlined by the 68th UN General Assembly declaring 2016 the International Year of Pulses: "The International Year of Pulses represents a unique opportunity to raise awareness on the potential of pulses in the agricultural development sector and provides an additional impulse to increase their production at global level. In addition, pulses can improve soil fertility and increase biodiversity. They reduce the risk of total crop failure in multiple cropping systems improving food security. Pulses are amenable to a diversity of food processing and can be easily stored when dried compared to vegetables and fruits. Finally, they can be sold and therefore generate income making food more accessible. Altogether, pulses reduce dependency on external inputs and improve sustainability of integrated crop - livestock - aquaculture production systems." (FAO, 2016).

In this study, two layer strains, Lohmann Brown hens and the new strain Lohmann Dual were included. In consequence of breeding of approximately 40 million commercially laying hybrids every year, the same number of male chickens is hatched. These male laying-type cockerels or spring chickens cannot be reared economically (Damme and Ristic, 2003; Schäublin et al., 2005; König et al., 2010; Halle et al., 2012; Halle et al., 2015). The routine culling of these day-old male chicks is more and more an ethical problem and to find alternative solutions is a great challenge. The dual-purpose chicken of the Lohmann Tierzucht Company produce eggs and meat. Accordingly, the hatched male chickens are fattened and the females reared to later laying hens. At the moment, by the strongly negative correlation between reproduction and growth the Dual hens do not achieve the high laying performances of the LB hens (Schmutz, 2013).

Objectives of this study were to study the effect of a total replacement of soybean meal by rapeseed meal plus peas in hens' feed on laying performance and egg quality parameters of two strains of hens.

2 Material and methods

A total of 460 laying hens (230 LB/230 LD) were used in this feeding study. The basal diet contained soybean meal. In the treatment diets, soybean meal feed was totally replaced by rapeseed meal and peas (Table 1).

Table 1
Study design (115 hens per group; duration of the trial – six laying month = 168 days)

	LB Hen		LD Hen	
Groups Ingredients (%)	1	2	3	4
Soybean meal	21.6	0	21.6	0
Rapeseed meal	0	12	0	12
Peas	0	35	0	35

Table 2
Ingredient composition and analyzed and calculated nutrients of the diet (g/kg)

Group	LB Hen		LD Hen	
Ingredients	1	2	3	4
Soybean meal	215.62	-	215.62	-
Rapeseed meal	-	120.00	-	120.00
Peas	-	350.00	-	350.00
L-lysine-HCL	0.19	-	0.19	-
DL-methionine	1.37	1.38	1.37	1.38
Corn	213.94	-	213.94	-
Wheat	400.00	346.10	400.00	346.10
Rapeseed oil	40.00	47.44	40.00	47.44
Premix[1)]	10.00	10.00	10.00	10.00
Calcium carbonate	77.60	76.34	77.60	76.34
Di-Calcium-phosphate	12.91	8.82	12.91	8.82
Sodium chloride	3.67	3.69	3.67	3.69
Grass meal	24.70	36.23	24.70	36.23
Dry matter [2)]	891.6	897.0	891.6	897.0
Crude protein [2)]	164.8	162.0	164.8	162.0
ME, MJ/kg [3)]	11.25	11.32	11.25	11.32
Lysine, g/kg [4)]	8.5	9.4	8.5	9.4
Methionine+Cystine, g/kg [4)]	7.1	6.9	7.1	6.9

[1)] Vitamin-mineral premix provided per kg of diet: Fe, 40 mg; Cu, 10 mg; Zn, 80 mg; Mn, 100 mg; Se, 0.25 mg; I, 1.2 mg; Co, 0.21 mg; vitamin A, 10000 IE, vitamin D_3, 2500 IE; vitamin E, 20 mg; vitamin K_3, 4 mg; thiamine, 2.5 mg; riboflavin, 7 mg; pyridoxine, 4 mg; vitamin B12, 20 µg; nicotinic acid, 40 mg; pantothenic acid, 10 mg; folic acid, 0.6 mg; biotin, 25 µg; choline chloride, 400 mg

[2)] Analyzed values

[3)] Calculated values according to the equation WPSA(1985) AME_N (kJ/g) = 15.51 Crude protein + 34.31 Crude lipid + 16.69 Starch + 13.01 Sugar (Vogt, 1986)

[4)] Calculated values

The peas were originated from the variety "James". All diets contained a balanced concentration of 16 % crude protein, 0.85 to 0.9 % lysine, 0.7 % methionine plus cystine and 11.2 to 11.3 MJ ME/kg feed. (Table 2, 3). The hens were allocated to four groups of 115 hens each. The hens were kept in pens

(23 hens per pen) with five pens per group. The study commenced when the hens were 22 weeks old and continued until the 6th laying month (168 days). Each hen was offered the respective diet and water ad libitum. Number of eggs laid was recorded daily per pen and the feed consumption monthly. Each month the collected eggs were weighed four times within two weeks. In the 2nd, 4th and 6th laying month, all eggs laid over three consecutive days were collected per pen to measure the yolk weight, albumen weight and shell weight. The color of the egg yolk was read with the Roche-Fan. Body weight of hens was recorded at the start and at the end of the trial. Ten hens of each group (two per pen) were slaughtered at the end of the trial to determine carcass and organ weights. In the feed dry matter (DM), crude protein, ether extract, crude fiber and ash content were determined according to methods of Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten (VDLUFA, 2012). The glucosinolates of rapeseed were determined with the official method of the European Commission (1990); (Rothe et al., 2004) by HPLC (Dionex, Idstein, Germany).

Data were analyzed with a two-way ANOVA: yijk = μ + SCi + Dj + SCDij + eijk, with yijk = observation, μ = general mean, SCi = diet (soybean, rapeseed + peas), Dj = origin of hens (Lohmann Brown, Lohmann Dual), interaction SCDij and eijk = error term (random). Multiple comparisons of means were carried out using the Student-Newman-Keuls Test ($P \leq 0.05$). The statistical analyzes were performed by the SAS, 2002 to 2012 software package (Version 9.4).

3 Results

The peas and the rapeseed extracted meal (RSM) are characterized by their high content of protein (24 %, 34 %; Table 3). The RSM had a higher content of fiber (13.4 %) compared with peas (5.2 %). Crude fiber and thus the content of metabolisable energy (ME) of RSM was only 8.6 MJ/kg compared to peas with 11.8 MJ/kg. The glucosinolates of the RSM amounted to 8.2 mmol/kg.

Table 3
Analyzed compounds and metabolizable energy (ME) calculation of peas and rapeseed meal

Nutrients, g/kg	Pea „James“	Rapeseed meal
Dry matter	875	894
Crude protein	236	340
Crude lipid	17	35
Crude fiber	52	134
Crude ash	30	66
Starch	414	60
Sugar	48	86
Lysine	17	19
Methionine	2	7
Cystine	3	8
Threonine	9	16
ME, MJ/kg [1)]	11.8	8.6
Glucosinolate. mmol/kg	-	8.2

[1)] Calculated values according to the equation WPSA; 1985, see Table 2

Table 4
Laying performance of hens (six laying month)

Treatment	Hen	Feed intake g/day	Laying intensity [1)] %	Egg weight g/egg	Egg mass production g/hen/day	Feed to egg mass ratio, kg/kg
LS means						
1 Soya	LB	127.6 a	92.0 a	63.2 a	58.2 a	2.2 c
2 Rapeseed/peas	LB	125.0 a	92.6 a	61.3 b	56.8 b	2.20 c
3 Soya	LD	110.2 c	82.1 b	58.4 c	47.7 c	2.31 b
4 Rapeseed/peas	LD	115.6 b	83.8 b	57.0 c	47.5 c	2.43 a
Standard error (SE)		7.2	5.9	2.8	2.7	0.14
ANOVA, P-value						
Diet		0.3	0.3	0.002	0.1	0.009
Soya		118.9	87.1	60.8 a	53.0	2.25 b
Rapeseed/peas		120.3	88.2	59.1 b	52.2	2.32 a
Hen		<0.001	<0.001	<0.001	<0.001	<0.001
LB		126.3 a	92.3 a	62.3 a	57.5 a	2.20 b
LD		112.9 b	83.0 b	57.7 b	47.6 b	2.37 a
Diet x Hen		0.003	0.6	0.6	0.2	0.02

a; b; c; – Means with different letters differ significantly

[1)] Number of eggs in the trial divided through trial's days

There were significant effects of protein source and origin of tested hens on the determined performance parameters (Table 4). The daily feed intake of LB hens was 125.0 to 127.6 g and significantly higher compared with LD hens (110.2 to 115.6 g). During the trial duration of 168 days the laying intensity of LB hens was 92.0 to 92.6 % and 10 % units higher than that of LD hens. While exchanging SBM through RSM/peas in the diet had no effect on laying intensity, the change of the protein source decreased weight of LB hens' eggs from 63.2 g to 61.3 g ($P < 0.01$). The egg weight of LD-hens and egg mass production per day was altogether lower than that of LB hens. The daily egg mass production was lower in the LB RSM/peas group (56.8 g/hen/day) compared with LB soya fed hens (58.2 g/hen/day). LB hens fed the RSM/peas diet did not need more feed per kg egg mass compared with the SBM diet (2.2 kg/kg). The hens of the LD peas/RSM groups had the highest feed to egg mass ratio of 2.4 kg/kg.

Table 5 summarizes egg color, egg weight and the weight percentages of yolk, egg white and shell besides the total egg weight recorded during the 2nd, 4th and 6th laying month. During the complete trial, eggs of LD hens showed a

Table 5
Egg quality

Treatment	Hen	Egg weight g/egg	Yolk %	Egg white %	Egg shell %	Colour of yolk Roche fan
2nd laying month (253 to 315 eggs/per group)						
LS means						
1 Soya	LB	62.4 a	25.3 c	62.6 b	12.1 c	12.8 b
2 Rapeseed/Peas	LB	60.5 b	24.7 d	63.0 a	12.2 c	12.8 b
3 Soya	LD	55.6 c	27.8 a	59.4 d	12.8 a	12.9 b
4 Rapeseed/Peas	LD	54.4 d	27.4 b	60.0 c	12.6 b	13.2 a
SE		4.1	2.0	2.3	1.0	0.7
ANOVA, P-value						
Diet		<0.001	<0.001	<0.001	0.5	<0.001
Hen		<0.001	<0.001	<0.001	<0.001	<0.001
Diet x Hen		0.2	0.6	0.6	0.02	<0.001
4th laying month (n = 256 to 288 eggs per group)						
LS means						
1 Soya	LB	64.6 a	26.2 c	62.0 a	11.9 b	12.9 ab
2 Rapeseed/Peas	LB	62.1 b	25.6 d	62.1 a	12.3 a	12.8 b
3 Soya	LD	60.2 c	29.7 a	58.2 c	12.1 a	12.8 b
4 Rapeseed/Peas	LD	58.7 d	29.2 b	58.5 b	12.3 a	13.0 a
SE		4.6	2.0	2.2	1.0	0.7
ANOVA , P-value						
Diet		<0.001	<0.001	<0.001	<0.001	0.1
Hen		<0.001	<0.001	0.04	0.04	0.4
Diet x Hen		0.06	0.9	0.4	0.05	0.005
6th laying month (n = 204 to 288 eggs per group)						
LS means						
1 Soya	LB	64.4 a	26.2 b	61.5 a	12.2 a	12.6 b
2 Rapeseed/Peas	LB	62.6 b	26.1 b	61.6 a	12.3 a	12.7 b
3 Soya	LD	62.8 b	30.2 a	57.5 b	12.2 a	13.0 a
4 Rapeseed/Peas	LD	61.4 c	30.1 a	57.7 b	12.1 a	12.9 a
SE		4.7	1.9	2.1	1.0	0.6
ANOVA, P-value						
Diet		<0.001	0.3	0.4	0.2	0.6
Hen		<0.001	<0.001	<0.001	0.9	<0.001
Diet x Hen		0.5	0.9	0.5	0.2	0.06

a; b; c; – Means with different letters differ significantly

significantly higher percentage of egg yolk and reduced part of egg white. In the 2nd laying month higher egg shell content was obtained in the LD hens; these differences however were lower in the later laying period. The differences in the yolk color were between 12.6 to 13.2.

The body weight of the hens was significantly different between LB and LD hens both at the start and the end of the trial (Table 6). The exchange of the protein source SEM through peas/RSM reduced the body weight of LB hens (39 g) and LD hens (59 g) ($P < 0.02$).

Table 6
Body weight and number of hens (n = 115 hens per group at the start of the trial)

Treatment	Hen	Body weight, start point g/hen	Number of hens, end of trial	Final body weight, g/hen
LS means,				
1 Soya	LB	1774 b	111	1911 c
2 Rapeseed/Peas	LB	1781 b	114	1872 c
3 Soya	LD	1880 a	114	2108 a
4 Rapeseed/Peas	LD	1853 a	114	2049 b
SE		183		217
ANOVA, P-value				
Diet		-	-	0.02
Hen		<0.001	-	<0.001
Diet x Hen		-	-	0.6
a; b; c; – Means with different letters differ significantly				

The mortality during the 6-month trial was 1.5 % without differences between the groups.

Slaughtering showed for LD hens a statistically higher body weight and a larger part of carcass (76.8 to 79.0 %), breast meat (10.6 to 11.8 %) and abdominal fat (3.0 to 3.4 %) compared with LB hens (71.4 to 72.9 %; 8.6 to 8.9 %; 2.1 to 3.1 %; Table 7). The exchange of SES through RSM/peas in the LD hen diet reduced the yield of breast meat ($P < 0.05$). LB hens showed a higher part of gizzard (1.84 %) and thyroid weight (0.17 to 0.21 g) than the LD hens (1.34 to 1.43 %, 0.14 g). The replacement of SBM by RSM plus peas led in both hen breeds to reduced fat content.

4 Discussion

Rapeseed and its oil are the basis for European biodiesel production besides their use for food and feed. Therefore, after extraction, rapeseed meal is increasingly available as protein and energy component for animal feed (UFOP, 2015). Whereas meals consisting "00-rapeseed" cause no problems in the feeding of ruminants, there is a maximum content of 10 % rapeseed meal and 5 % rapeseed cake in the feed for hen breeds laying white eggs (Spiekers and Südekum, 2004; Jeroch and Dänicke, 2013). For some brown-egg laying hen breeds, their inability to metabolise trimethylamin (TMA) originating from the bacterial degradation of rapeseed sinapine in the large intestine, results in "fishy taint" eggs (Butler and Fenwick ,1984). The Lohmann Tierzucht Company identified the gene which is responsible for the inability of some hens to metabolise TMA and hens carrying this gene were eliminated from breeding. Thus, Lohmann Tierzucht announced that all commercial laying hens of Lohmann and H&N origin hatching from January 2007 onwards are free of the mentioned genetic defect and may receive diets containing rapeseed products (Pottgüter, 2006). In 2014, the rapeseed monitoring published the analytical results of

Table 7
Slaughtering of hens at the end of the trial (n = ten hens per group, two per pen)

Treatment	Hen	Body weight, g	Carcass, %[1)]	Breast meat, g	Breast meat, %	Legs, g	Legs, %[1)]	Liver, %[1)]	Heart, %[1)]	Gizzard, %[1)]	Fat, %[1)]	Thyroid weight, g
LS means												
1 Soya	LB	1900 b	71.4 b	163.5 c	8.6 c	342.0 b	18.0	1.77	0.36	1.84 a	3.12 a	0.17 ab
2 Rapeseed/Peas	LB	1886 b	72.9 b	167.8 c	8.9 c	337.9 b	17.9	1.81	0.35	1.88 a	2.11 b	0.21 a
3 Soya	LD	2089 a	79.0 a	247.8 a	11.8 a	374.1 a	17.9	1.76	0.38	1.34 b	3.37 a	0.14 b
4 Rapeseed/Peas	LD	2071 a	76.8 a	220.5 b	10.6 b	358.3 ab	17.3	1.95	0.37	1.43 b	3.02 a	0.14 b
SE		72	4.8	24.4	1.1	23.6	1.1	0.2	0.04	0.3	0.9	0.04
ANOVA, P-value												
Diet		0.5	0.9	0.1	0.2	0.2	0.3	0.2	0.5	0.5	0.02	0.1
Hen		<0.001	<0.001	<0.001	<0.001	0.001	0.3	0.4	0.08	<0.001	0.04	0.001
Diet x Hen		0.9	0.5	0.05	0.04	0.4	0.5	0.4	0.9	0.8	0.2	0.3

a; b; c; – Means with different letters differ significantly

[1)] Relative to the final body weight

rapeseed samples (n = 65) (UFOP, 2015). Rapeseed meal then contained 8.8 (0.8 to 14.9) mmol glucosinolates/kg dry matter (89 %), 27 (4 to 46) g crude fat/kg, crude fiber 108 (93 to 123) g/kg, crude protein 342 (312 to 371) g/kg and 7.4 (6.8 to 8.1) MJ ME/kg. These values are well comparable with the rapeseed meal in the presented hen trial (Table 4).

The laying intensity of the LB hens showed in this trial, no dependence on the protein source in the diet. Replacement of 22 % SBM by 12 % RSM plus 35 % peas did not influence the daily feed intake nor number of laying eggs in the first six laying months. The egg weight was decreased by 3 % ($P < 0.05$) and the daily egg mass production by 2.5 % ($P = 0.1$) after totally changed protein source. The reduction of the egg weight after feeding RSM was described in the literature (Rodehutscord et al., 2012; Halle and Schöne, 2013). Studies of Roth-Maier and Kirchgessner (1995) and Jeroch et al. (1999) with laying hens and a diet with 15 % rapeseed showed no difference in the laying parameters (feed intake, laying intensity, egg mass production) compared with the control groups without rapeseed feeds. Richter et al. (1996) measured negative effects (feed intake, laying intensity, egg weight) due to feeding of only 5 % dietary rapeseed. After a combined chemical and hydrothermal treatment of the rapeseed or rapeseed cake to reduce antinutritive compounds a higher percentage of rapeseed (22.5 %) or rapeseed cake (30 %) could be fed without negative impact on the laying performance (feed intake, laying intensity, egg mass production) (Jeroch et al., 1995; 1999; 2008). Jeroch et al. (2008) conclude that the inclusion of the rapeseed feeds into compound feeds, i.e. their maximum level in the diets, is particularly determined by the glucosinolate content. Fixing maximum glucosinolate content in the laying hen feed is not possible through, as specific studies these difficulties are missing.

Legumes – peas, field beans and lupines are important protein feedstuffs. Studies of Igbasan and Guenter (1997), Richter (2004) and Halle (2005) with laying hens and diets with up to 40 % peas showed no differences in laying performance (feed intake, laying intensity, egg mass production) compared with control groups. Perez-Maldonado et al. (1999) concluded that 25 % peas per kg hen feed could be fed without negative impact on the laying performance. The influence of micronisation, dehulling, and enzyme supplementation on the nutritional value of peas in a diet with 60 % peas was studied with hens (Igbasan and Guenter, 1997). Only the laying performance of the hens with a diet containing 60 % peas after micronisation showed no negative effect compared with controls. Kraft et al. (2013) studied the replacement of SBM by a mixture of concentrated pea protein, RSM and sunflower extracted meal in the hen diet during a period of 52 weeks. A replacement of 50 % did not change laying performance of hens while a total replacement of SBM caused decreased laying performance and increased feed to egg mass ratio.

The LD breed combines good laying performance of hens with an acceptable meat gain of males. Dual hens laid up to 250 eggs in twelve laying months (wk. 20 to wk. 68) and achieved a highest peak production of 85 % at 29 weeks of age (Schmutz, 2013; Icken et. al., 2013). The mean laying performance of the LD hens in this six laying month's trial was 83 % and it was not affected by the diet. The feed to egg mass ratio of the RSM/peas hens was 2.4 and significantly higher compared with SEM hens (2.3) (Table 4). The results after slaughtering of LD hens showed that the feeding of RSM/peas as protein source in their feed decreased the body weight, the breast meat weight and the abdominal fat (Table 6, 7).

Heavier thyroids of the LB hens may results from higher laying performance based on higher metabolic activity and showed a tendency to increase thyroid mass after feeding RSM. This confirms the results obtained by Schöne et al. (2013) showing that the feeding of rapeseed cake led to increased thyroid mass in hens.

The trial's results allow the conclusion that a total replacement of soybean meal with rapeseed meal plus peas in feed of LB hens had no effect on laying intensity but reduces the egg weight and increased the feed to egg mass ratio of LD hens.

Acknowledgment

Union for the Promotion of Oil and Protein Plants e.V. (UFOP), Germany supported this work financially.

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