Full-fat silkworm-based diets for laying quails: impact on egg fatty acid profile

Yazavinder Singh[1], Marco Cullere[1], Silvia Cappellozza[2], Antonella Dalle Zotte[1]

[1]*Department of Animal Medicine, Production and Health - MAPS, University of Padova, Agripolis, Viale dell'Università 16, Legnaro, 35020 Padova, Italy*

[2]*Sericulture Laboratory, Council for Agricultural Research and Economics, Research Centre for Agriculture and Environment (CREA–AA), Via Eulero 6a, 35143 Padova, Italy*

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI MEDICINA ANIMALE, PRODUZIONI E SALUTE

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Silkworm (*Bombyx mori* L.) pupae

Authorised by the EU for use as a processed animal protein in aquaculture, poultry and pigs

- ✓ Pupae are the major **by-product** of the **silk industry/sericulture**
- ✓ **Excellent source** of **nutrients** (CP: 37.8% and lipids: 29.2%), fatty acids (FA), and **energy** (25.2 MJ/kg) **for livestock**
- ✓ **Valuable** insect species to replace some **conventional feedstuffs** for **livestock species**

Main FA classes (% FAME)	
Total SFA	28.4
Total MUFA	33.6
Total PUFA	37.8
n-6	8.06
n-3	29.7
n-6/*n*-3	0.27

Japanese quail (*Coturnix japonica* L.)

✓ Species of growing **economic interest** for meat & egg **production** in different areas of the **world**, due to:

- Early sexual maturity
- Rapid growth
- Short generation interval
- Limited feed & space requirements per bird
- Tradition

Research studies on the utilisation of silkworm by-products (pupae and oil) in monogastric livestock production

Total no. of studies	44

Poultry	30

Layer	8

Broiler	22

Rabbit	8

Pig	6

Egg Quality

Sensory

Digestibility

Microbiome & Microbiota

Performance

Meat Quality

Blood & Serum traits

Source (10 August '24): Scopus; Google Scholar

OBJECTIVE

To test different full-fat silkworm meal (SWM) inclusion levels (0%, 4%, 8%, and 12%)

into laying quails' (*Coturnix japonica*) diet and evaluate egg proximate and FA profile

A total of 240, 31-day-old female Japanese quails were randomly assigned to four dietary groups (12 replicates/treatment; 5 quails/replicate)

The experiment started when the oviposition rate was 81% (63 days of age)

Experimental diets			
Control (0% SWM)	**SWM4 (4% SWM)**	**SWM8 (8% SWM)**	**SWM12 (12% SWM)**
			

Diets were isonitrogen and isoenergy

Experiment layout

- Trial duration: 8-weeks
- Feed and water: *ad libitum*
- The average temperature and relative humidity were 21 °C and 76%, respectively
- The adopted photoperiod was 18L:6D

Egg collection, sample preparation, proximate and FA profile analyses

- During the 8th week of trial, 7 eggs/cage collected & pooled to 1 sample (12 pooled samples/treatment)

Statistical analysis

- Data were analysed using 1-way ANOVA with the experimental diets as a fixed effect, unit: pooled samples

Proximate composition (g/100 g whole egg) of eggs collected during the 8th week of trial

	Experimental groups				Significance
	C	SWM4	SWM8	SWM12	
Moisture	72.9	72.9	73.0	73.0	ns
Protein	13.1	13.1	13.0	13.2	ns
Lipids	11.5	11.6	11.4	11.2	ns
Ash	0.97	1.00	0.99	0.99	ns

ns: not significance

FA classes (% FAME) of eggs collected during the 8th week of trial

	Experimental groups				Significance	
	Control	SWM4	SWM8	SWM12		
Lipids, g/100 g	11.5	11.6	11.4	11.2	ns	
Total SFA	36.3^{ABa}	36.6^{A}	35.2^{Bb}	35.3^{Bab}	*	
Total MUFA	36.8^{C}	37.9^{C}	43.8^{A}	40.2^{B}	*	
Total PUFA	25.7^{A}	23.4^{B}	20.1^{C}	23.6^{B}	*	
***n*-6**	23.3^{A}	19.7^{B}	15.1^{Cb}	16.6^{Ca}	*	
***n*-3**	2.37^{D}	3.71^{C}	5.05^{B}	7.03^{A}	*	**X 4.7**
***n*-6/*n*-3**	9.82^{A}	5.32^{B}	2.99^{C}	2.36^{D}	*	

ns: not significance; ^{A,B}Different superscript letters differ for P<0.01; ^{a,b}Different superscript letters differ for P<0.05.

Differences in main classes attributable to variation in single fatty acids (% FAME)

	Experimental groups				Significance	
	C	SWM4	SWM8	SWM12		
SFA						
Palmitic acid (C16:0)	24.4^{B}	24.9^{A}	25.3^{A}	24.9^{AB}		*
Stearic acid (C18:0)	10.9^{Aa}	10.4^{Ab}	8.70^{B}	9.19^{B}		*
MUFA						
Palmitoleic acid (C16:1)	3.09^{B}	3.10^{B}	3.43^{A}	4.41^{B}		*
Oleic acid (C18:1 *n*-9)	32.1^{C}	32.9^{C}	35.8^{A}	37.6^{B}		*
PUFA						
Linoleic acid (C18:2 *n*-6)	19.9^{A}	16.9^{B}	15.1^{C}	13.4^{D}		*
α-Linolenic acid (C18:3 *n*-3)	0.89^{D}	1.76^{C}	3.05^{B}	4.86^{A}	X 4	*
Arachidonic acid (C20:4 *n*-6)	2.84^{A}	2.28^{B}	1.41^{C}	1.24^{C}		*
Docosahexaenoic acid (C22:6 *n*-3)	1.40^{B}	1.80^{A}	1.74^{A}	1.86^{A}		*

^{A,B}Different superscript letters differ for P<0.01; ^{a,b}Different superscript letters differ for P<0.05.

Dietary inclusion of full-fat silkworm pupae meal on quails eggs:

- **proximate composition remained comparable among the groups**
- **omega-3 FA proportion linearly increased with the SWM inclusion level**
- **omega-3 FA increased by ≈4.7 times in SWM12**
- **improved n-6/n-3**

SWM12 is suitable to feed laying quails for improving the nutritional value of the egg

live performances?.....

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI MEDICINA ANIMALE, PRODUZIONI E SALUTE

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Thank you very much for you attention!

ACKNOWLEDGEMENTS

- This research was supported by the University of Padova (Italy) funds (2019 - Prot. BIRD193891)
- Authors acknowledge the Laboratory LabCNX (MAPS) for the analyses, and the Sericulture Laboratory of the CREA (Padova) for providing the dried silkworm cocoons

Chemical composition (g/100 g as is), mineral content (mg/kg, as is), 1-Deoxynojirimycin content (1-DNJ: µg/g), gross energy content (GE: MJ/kg) of SWM and the experimental diets

	SWM	Experimental diets			
		C	SWM4	SWM8	SWM12
DM	93.5	90.9	91.1	90.8	91.4
CP	37.8	21.5	21.8	21.0	21.2
Lipids	29.2	6.71	4.40	3.67	4.81
Ash	4.89	9.78	10.8	10.6	13.1
Starch	-	32.2	30.2	31.4	27.2
Chitin	1.46	0.00	0.02	0.05	0.10
Ca	-	25.1	25.1	25.0	25.0
P	-	3.51	3.51	3.50	3.50
1-DNJ	0.76	-	0.25	0.43	0.91
GE	25.2	12.2	12.2	12.2	12.2

Source: Singh et al., 2023

FA classes (% FAME) of SWM and experimental diets

	SWM	Experimental diets			
		C	SWM4	SWM8	SWM12
Lipids, g/ 100 g	29.2	6.71	4.40	3.67	4.81
Total SFA	28.4	17.5	22.1	26.8	28.0
Total MUFA	33.6	24.0	27.7	31.4	32.0
Total PUFA	37.8	58.0	49.6	41.1	39.4
***n*-6**	8.06	52.3	39.6	26.6	21.0
***n*-3**	29.7	5.70	9.97	14.5	18.4
***n*-6/*n*-3**	0.27	9.17	3.97	1.84	1.14

Single fatty acids (%) of the SWM and experimental diets

	SWM	Experimental diets			
		C	SWM4	SWM8	SWM12
Palmitic acid (C16:0)	21.6	12.7	16.6	21.0	22.1
Stearic acid (C18:0)	5.75	3.49	4.07	4.27	4.63
Palmitoleic acid (C16:1)	0.91	0.09	0.30	0.52	0.61
Oleic acid (C18:1)	32.5	23.8	27.2	30.7	31.2
Linoleic acid (C18:2 *n*-6)	7.88	52.2	39.5	26.5	20.8
α-Linolenic acid (C18:3 *n*-3)	29.6	5.70	9.94	14.4	18.3

Performances and production

	Experimental diets				Significance
	C	SWM4	SWM8	SWM12	
N. of cages	12	12	12	12	
FCR (Week1-8)	2.74^{B}	3.00^{AB}	3.13^{A}	3.24^{A}	*
Egg production (Week1-8), %	84.1^{Bb}	86.3^{AB}	86.8^{ABa}	87.0^{A}	*
Egg weight (Week1-8), g	13.6	13.8	13.9	13.5	ns

ns: not significance; ^{A,B}Different superscript letters differ for P<0.01; ^{a,b}Different superscript letters differ for P<0.05.

Source: Singh et al., 2023

Egg health indexes

	Experimental Groups				Significance
	C	SWM4	SWM8	SWM12	
Atherogenicity index (AI)	0.41^{ABb}	0.43^{Aa}	0.42^{ABab}	0.41^{B}	*
Thrombogenicity index (TI)	1.18^{ABa}	1.22^{A}	1.13^{Bb}	1.16^{ABab}	*
Peroxidability index (PI)	45.5^{A}	44.7^{A}	39.0^{B}	43.0^{A}	*
Hypocholesterolemic/ Hypercholesterolemic index (hH)	2.31^{AB}	2.21^{C}	2.23^{BC}	2.34^{A}	*

^{A,B}Different superscript letters differ for P<0.01; ^{a,b}Different superscript letters differ for P<0.05.