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Black soldier fly (BSF) meal as an alternative protein source in aquaculture & poultry feeding

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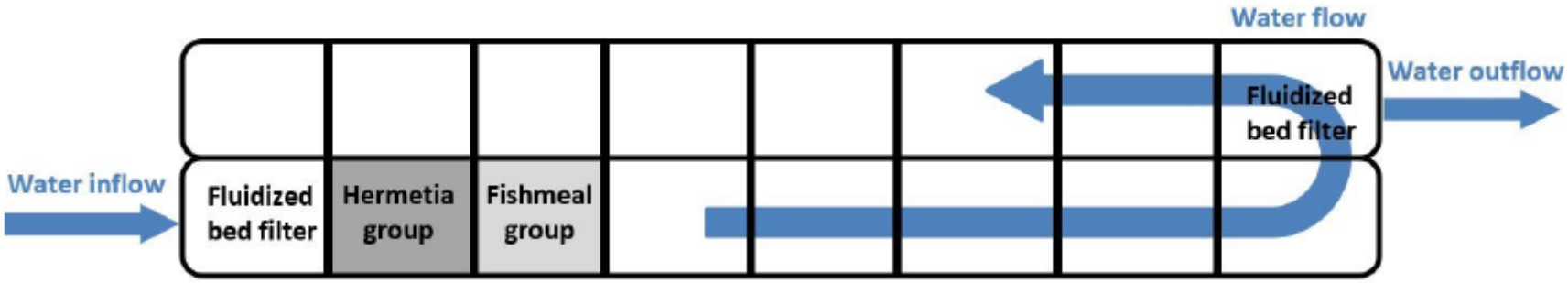
Objective of this presentation

Overview on three feeding trials (fish and poultry) with BSF larvae meal – *is BSF meal equivalent to conventional protein sources?*

BSF meal as fish meal replacement for rainbow trout – on farm

Experimental setup:

- 2 diets with 3 replicates (compartments) each
- ~2874 rainbow trout per 65 m^3 compartment (2.9kg/m^3)
- Water flow: 200 l/sec (10% water exchange per day)
- Feeding 3x per day (1.13 - 1.59% of BW, depending on size & water temperature)
- 7 weeks feeding phase



Evaluated parameters:

- **Feed, protein & lipid utilization**
- **Growth**
- **Organoleptic properties (post slaughter)**

Stadtlander *et al.*, 2017
Journal of Insects as Food & Feed

Rainbow trout feeding trial: experimental diets

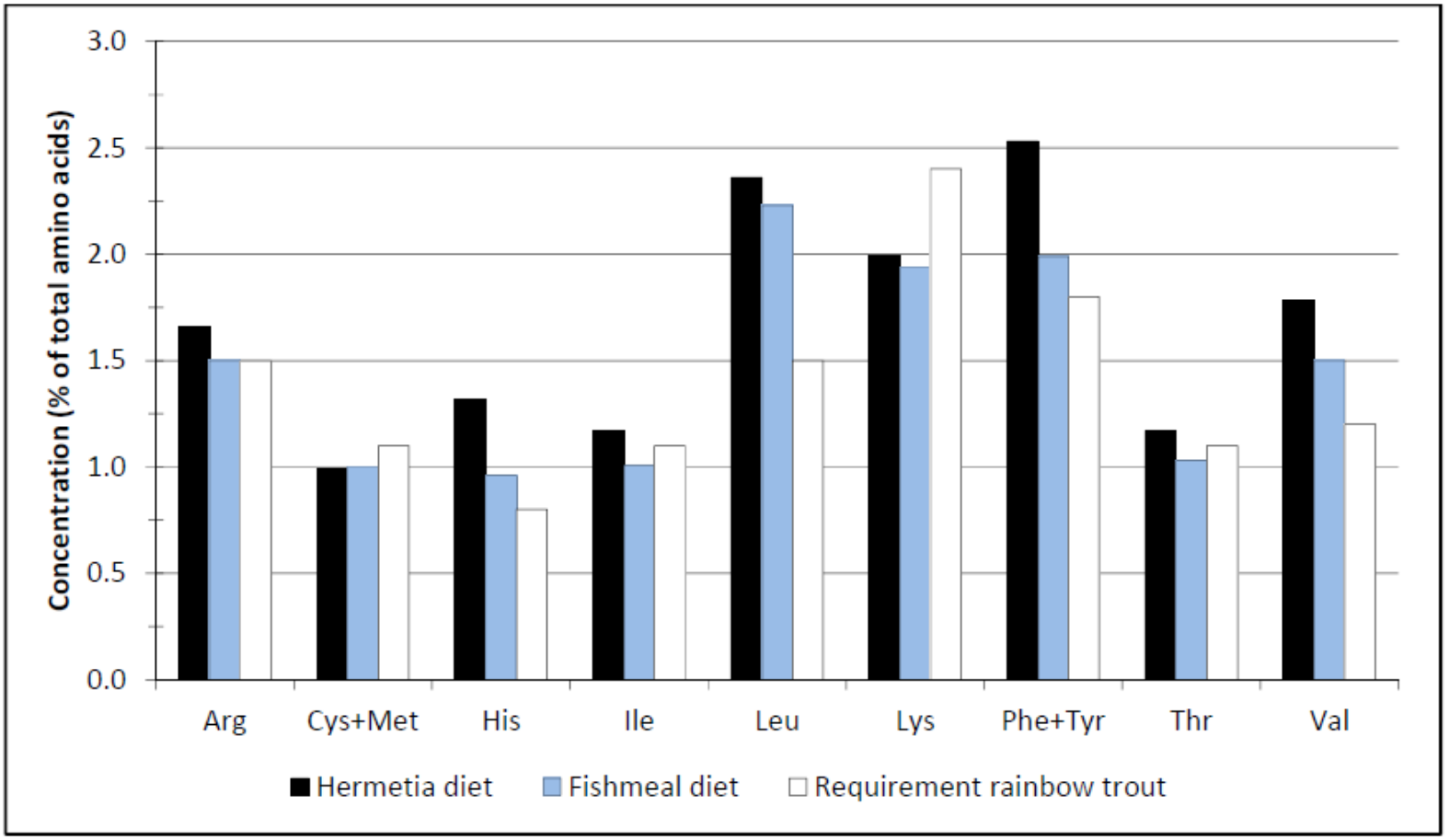
Extrusion cooked, iso-energetic diets:

- Control feed, organically certified, 61% fish meal content (trimming-based)
- Test feed: 50% of the fishmeal replaced by defatted BSF meal (28 % in total)

	Control diet	BSF diet
Dry matter (g/kg FM)	931	942
Protein (g/kg DM)	457	491
Fat (g/kg DM)	151	126
Ash (g/kg DM)	134	126
Fiber (g/kg DM)	13	44
Digestible energy (MJ/kg)	18.5	18.4

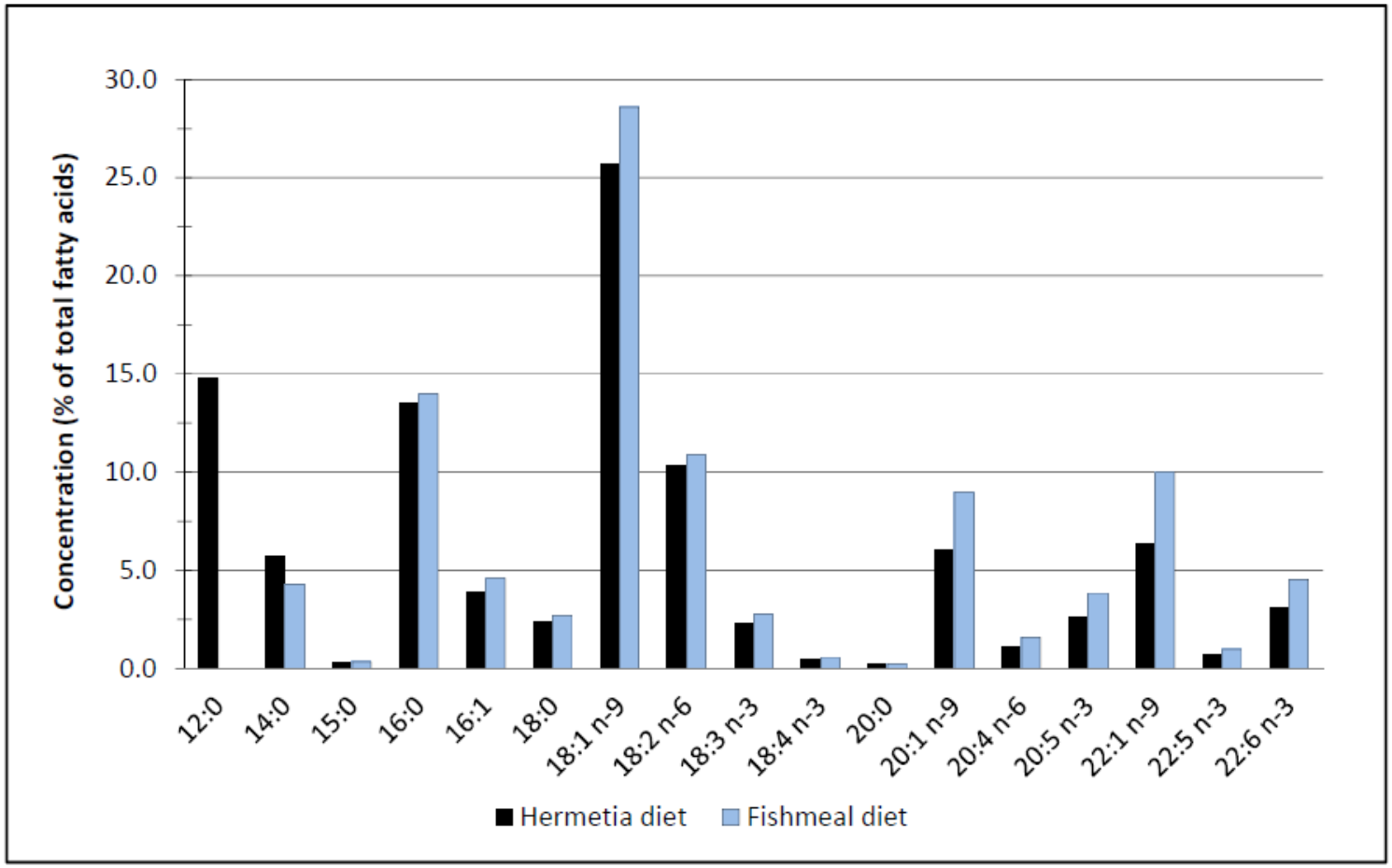
Rainbow trout feeding trial: experimental diets

Dietary amino acid requirements mostly exceeded (except Lys & Cys+Met)



Rainbow trout feeding trial: experimental diets

Fatty acid profile of the control and BSF diets differed



Rainbow trout feeding trial: results

Growth, feed conversion, protein & lipid utilization, & proximate composition of rainbow trout after 7 weeks

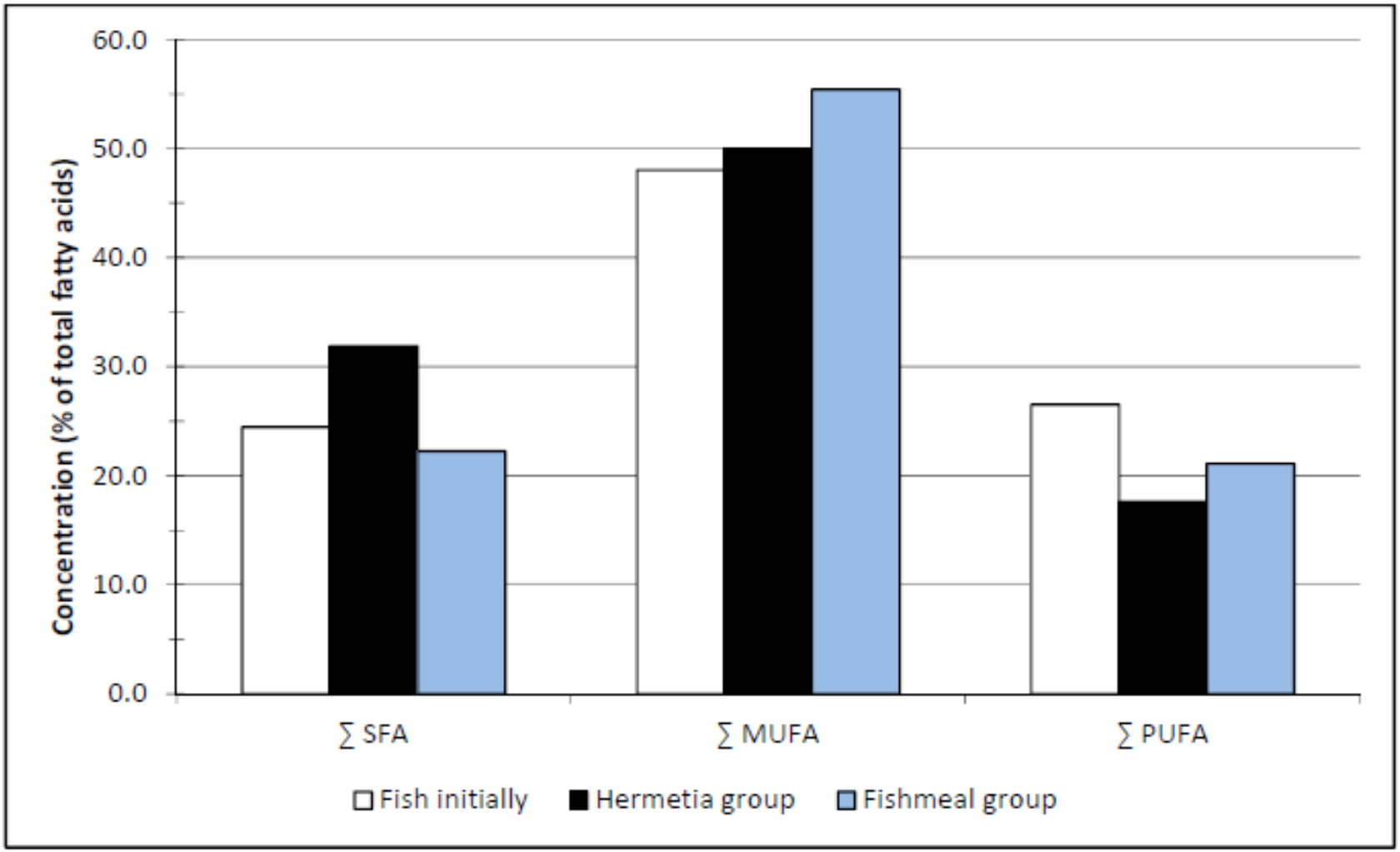
	Control	BSF
Initial body mass (g)	67.0	66.2
Final body mass (g)	125.8	125.5
Body mass gain (%)	87.8	89.6
Specific growth rate (% day^{-1})	1.43	1.45
Feed conversion ratio (as is)	0.80	0.81

	Start	Control	BSF
Moisture (%)	71.3	73.0	72.9
Crude protein (% FM)	10.8	14.5	15.2
Crude lipids (% FM)	6.73	6.30	6.46

[A] corrected for estimated chitin content in BSF meal

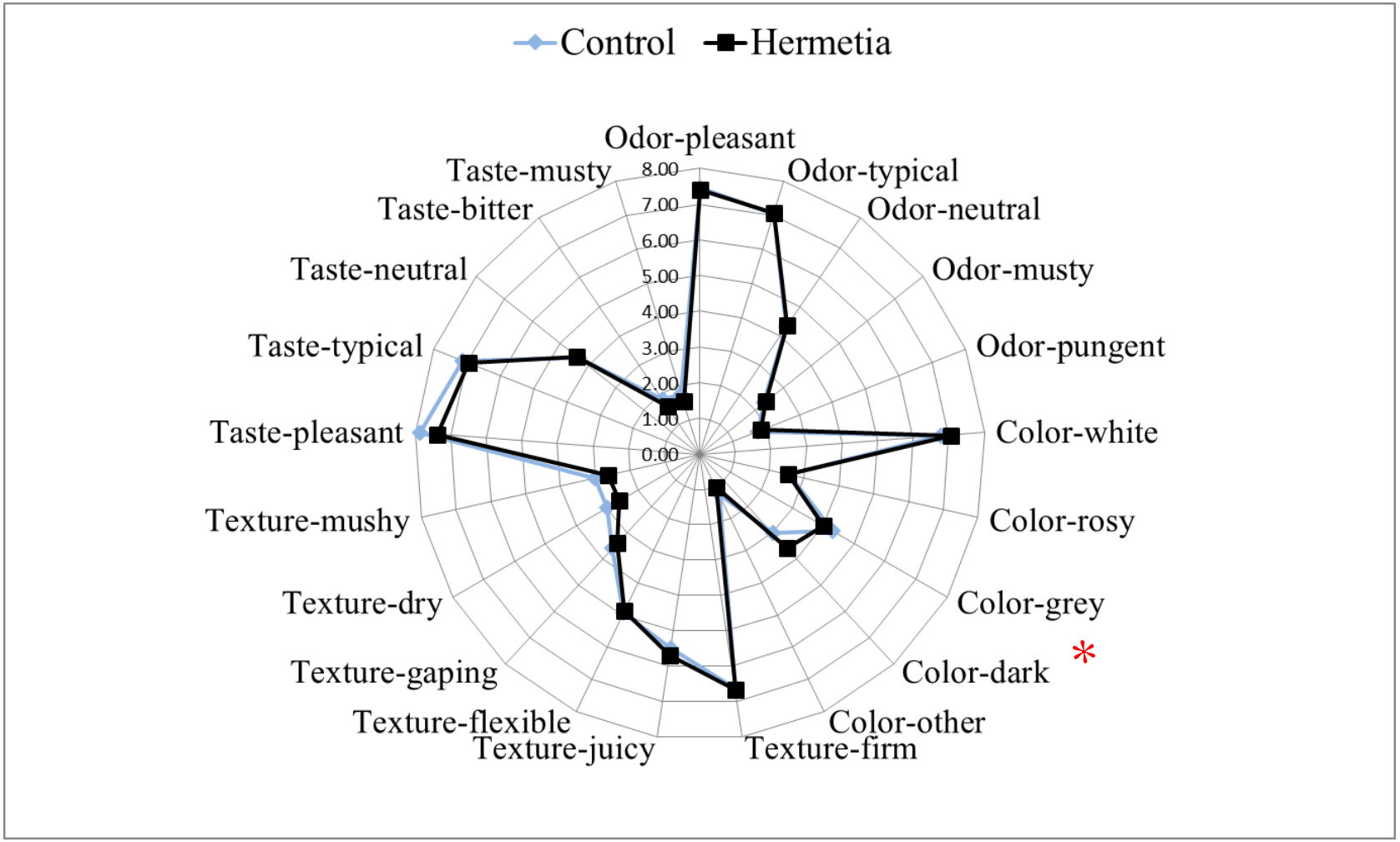
Rainbow trout feeding trial: results

Fatty acid profiles of initial fish and control & BSF diet fish at study termination



Rainbow trout feeding trial: results

Organoleptic evaluation of differently fed trout by 15 untrained panelists



Rainbow trout feeding trial: conclusions

Substitution of 50% fish meal by BSF meal possible without negative impact on performance:

- Growth
- Feed conversion ratio
- Specific growth rate
- Overall chemical composition

Effects of BSF meal inclusions on fatty acid profiles - proportion of (poly-) unsaturated fatty acids (reduced)

No influence on taste, structure or odour of trout filets, yet, filets of trout fed BSF meal appeared slightly darker in colour

High suitability of BSF meal to substitute fish meal

Replacement of soybean cake by BSF meal in diets for layers

Experimental setup:

- Laying hens (Lohman Selected Leghorn)
- 3 diet groups (1 control, 2 BSF meal levels)
- 30 individuals per group (69 weeks old)
- Perches with nests & covered outdoor area
- One week adaptation, 3 weeks experiment
- 4 subsequent replicates (with new hens)

Evaluated parameters:

- **Feed intake (group level)**
- **Egg production traits (daily, group level)**
- **Animal health - feather & wound scores**

Maurer *et al.*, 2016
Journal of Insects as Food & Feed

Layer feeding trial: Composition & nutrient concentration of experimental feeds (iso-energetic)

	Control	H12	H24
Feed components [g/100g fresh matter]			
BSF meal, partly defatted	0.0	12.0	24.0
Soybean cake	36.0	15.6	0.0
Corn, cereals, legumes	52.1	61.1	64.3
Minerals, Limestone, Vitamins	11.8	11.3	11.7
Nutrient concentrations [g/100g DM]			
Crude protein	20.0	20.3	21.4
Crude fat	4.50	5.72	6.44
Metabolizable energy [MJ/kg]	11.3	11.3	11.3
Crude ash	14.0	13.4	13.7

Layer feeding trial:
Performance, feed intake, egg production & egg composition

	Control	H12	H24	
Δ live weight (g/21 days)	22.5	30	-5.0	n.s.
Laying performance (%)	79.0	84.4	83.4	n.s.
Feed intake (g/d)	116	131	107	n.s.
Feed intake (g/egg)	148	159	134	n.s.
Feed intake (g/g egg weight)	2.15	2.38	2.03	n.s.
Weight of egg yolk (g)	19.2	18.6	18.6	n.s.
Weight of albumen (g)	39.6	39.2	36.6	n.s. trend
Weight of egg shell (g)	9.4	9.3	9.3	n.s.
Total egg weight (g)	68.5	67.3	64.8	n.s.

Layer feeding trial : Animal health

	Control	H12	H24
Plumage (6-24)	16.5	17.0	16.6
Comb wound	3.25	3.17	3.15
Belly wound	4.00	3.98	3.90
Foot pad lesion	3.20	3.20	3.31
Keel bone fracture	2.88	3.33	2.95
Missing toes	0.08	0.10	0.08

Layer feeding trial: conclusions

BSF meal can serve as a valuable replacer for soybean products in diets for layers.

Feed efficiency maintained on a level equivalent to soy-based feeds.

No indications for affected metabolic & health status of the hens.

Yet, further research on long-term feeding effects including hens before & during peak of lay, & on resulting egg quality is needed (ETH/FiBL project this summer).

Insect & legume-based protein sources to replace soybean cake in an organic broiler diet: Effects on growth performance & physical meat quality

Experimental setup:

- Broiler fattening, day 7-82
- 5 dietary groups (1 control, 4 experimental)
- 15 individuals per group (Hubbard S757, 7-8 males/females each, individually marked)
- In separate pens (3 x 2.5m)
- Permanent access to feed and water

Evaluated parameters:

During feeding

- **Groupwise feed intake (weekly)**
- **Individual weighing (biweekly)**

Post-slaughtering:

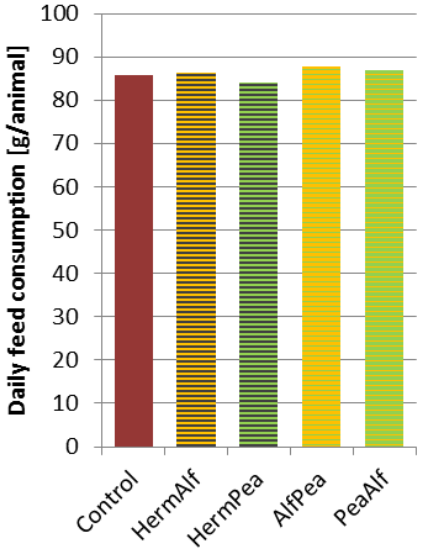
- **Total carcass weights**
- **Physical meat quality of breasts (colour, cooking loss, tenderness)**

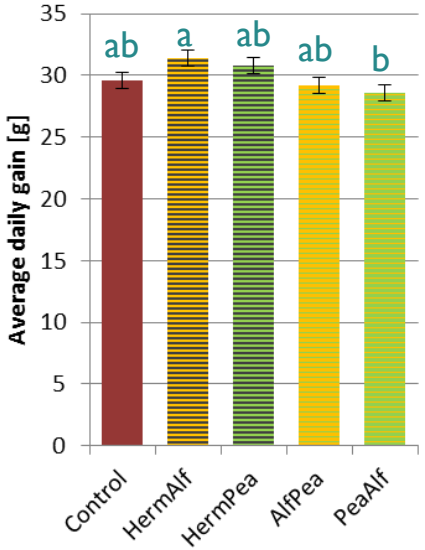
Leiber *et al.*, 2017
Renewable Agriculture & Food Systems

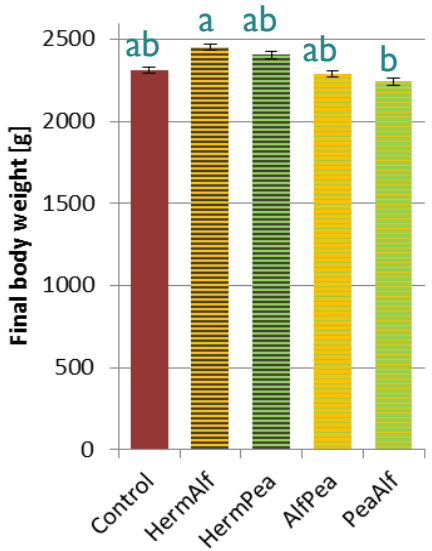
Broiler feeding trial: composition of experimental diets

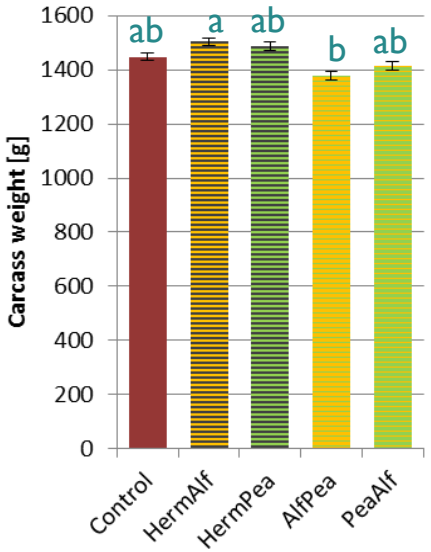
	Control	BSF-Alf	BSF-Pea	Alf-Pea	Pea-Alf
Main protein sources [g/100g DM]					
Soybean meal	**25.5**	**12.5**	**12.5**	12.5	12.5
BSF meal	**0**	**7.8**	**7.8**	0	0
Alfalfa meal	**0**	**5.2**	**0**	7.8	5.2
Pea meal	**0**	**0**	**5.2**	5.2	7.8
Nutrients [g/100g DM]					
Dry matter	**88.0**	**88.2**	**87.5**	87.4	88.8
Crude protein	**22.4**	**22.3**	**22.3**	19.7	18.9
Crude fat	**5.07**	**5.23**	**5.15**	3.70	4.46
Crude fibre	5.65	5.60	5.80	6.75	6.75
Crude ash	7.22	6.46	5.62	6.64	6.20

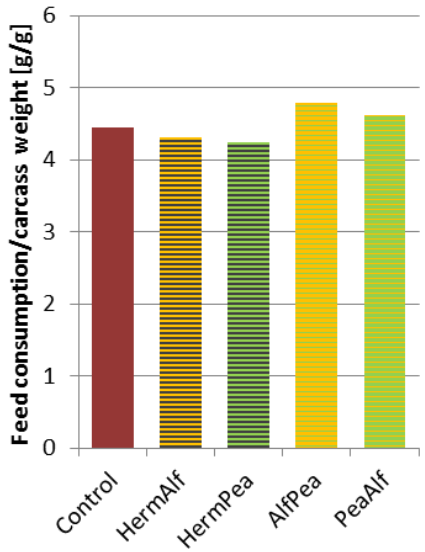
Broiler feeding trial: effect of diet on feed intake, growth performance & feed efficiency

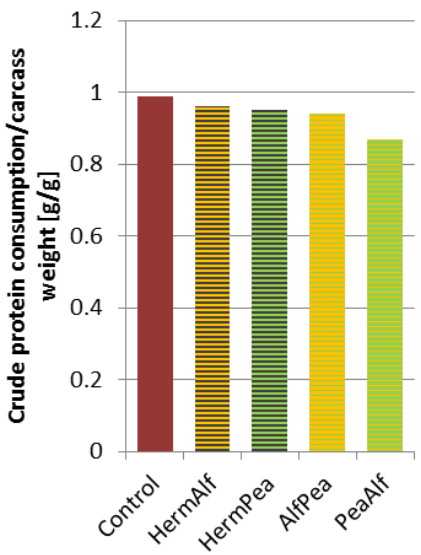












Broiler feeding trial: effect of diet on meat cut weights & meat quality

	Control	BSF-Alf	BSF-Pea	Alf-Pea	Pea-Alf	
Weights of meat cuts (g)						
Breast muscle	**468^{bc}**	**479^{c}**	**470^{bc}**	407^{a}	428^{ab}	*
Legs	436	457	436	465	425	n.s.
Wings	189	193	193	192	185	n.s.
Physical quality (breast)						
Cooking loss (%)	**12.7^{a}**	**13.2^{a}**	**16.2^{b}**	14.3^{ab}	13.1^{a}	*
Shear force (N)	19.8	18.7	19.8	18.8	20.4	n.s.
Meat color						
L* (lightness)	47.9	46.7	48.2	48.4	48.5	n.s.
a* (redness)	**4.90^{a}**	**5.67^{ab}**	**5.06^{a}**	6.21^{b}	4.93^{a}	*
b* (yellowness)	9.08	9.53	10.89	9.58	9.70	n.s.

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Broiler feeding trial: conclusions

Diets including soybean replacers (plant or insect-based) show

- similar or improved protein conversion efficiencies in organic poultry systems (slow-growing genotypes)
- no effect on growth performance relative to standard commercial organic feed
- no major effect on meat quality traits

Mixtures of regionally available legumes (e.g. from crop rotations) & defatted BSF meal (reared on side-products, depending on regulations) may have good potential as protein rich feed components in broiler diets.

BSF meal (de-fatted) for aquaculture & poultry feeding: overall conclusions & future directions

BSF meal can be equivalent to conventional protein sources – but is equivalence good enough?

Thank you for your attention!