PROteINSECT
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

Insect Protein

Outcomes from Fish, Pig and Poultry Feeding Trials

Geert Bruggeman

nutrition sciences

PROteINSECT
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

WHAT CAN YOU EXPECT ?

- NUTRITIONAL POTENTIAL OF INSECT PROTEINS
- HOW TO IMPROVE PROTEIN CONTENT: EFFECT OF PROCESSING
- OUTCOME OF FISH, PIG AND POULTRY FEEDING TRIALS
- QC/QA PROGRAM FOR INSECT PROTEINS
- IN CONCLUSION … THE BOTTLENECKS TOWARDS LARGE SCALE PRODUCTION

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Nutritional potential of insect proteins

NO DOUBT ON PROTEIN POTENTIAL IN INSECT PROTEINS !

IN TERMS OF QUANTITY AND NUTRITIONAL QUALITY

Insect	Development stage	Protein content (% of DM)
Musca domestica	Larvae	37-68
Musca domestica	Pupa	58-80
Hermetia illucens	Larvae	37-48

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→ 41 – 61 %

→ +- 43 %

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Nutritional potential of insect proteins

FEED FORMULATION

- VEGETABLE PROTEIN:
  - SOY
  - SUBSITUTES FOR SOY
    - RAPESEED
    - LEGUMINOSES
    - ...
- ANIMAL PROTEIN
  - FISH MEAL
  - BONE MEAL
  - BLOOD PLASMA
  - FEATHER MEAL

Recipe 57 Feed for Proteininsect larvae

N°	Name	%
3*	BARLEY	34.124
21*	CORN	25.000
80*	SOYA FF Danex	10.000
199*	SOYA 49	6.003
475*	DL-METHIONIN	0.214
480*	L-LYSINE-HCl	0.529
483*	L-THREONINE	0.244
486*	L-TRYPTOPHANE	0.056
488*	L-VALINE	0.050
500*	SALT bulk	0.584
540*	LIMESTONE bulk	0.972
1215*	WHEATMEAL	15.000
100730*	M Domestica larvae	5.000
Complement		2.223
		100.000

Recipe 57 Feed for Proteininsect larvae

N°	Name	Units	Value	Final feed	Min	Max
1	NE swine	kcal/kg	2350.003	2350.003	2350.000	2400.000
2	NE swine	MJ/kg	9.833	9.833		
5	MEswine	kcal/kg	3236.552	3236.552		
6	ME swine	MJ/kg	13.542	13.542		
7	DEswine	kcal/kg	3369.006	3369.006		
8	DE swine	MJ/kg	14.106	14.106		
34	EW FU Svine		1.118	1.118		
40	Humidity	g/kg	125.921	125.921		
41	Crude protein	g/kg	170.000	170.000	170.000	175.000
53	Anim Pro	g/kg	50.000	50.000		
60	Crude fat	g/kg	57.202	57.202		
61	Starch	g/kg	417.585	417.585		
63	Sugars	g/kg	27.940	27.940		
64	Sugar+starch	g/kg	445.529	445.529		
65	Crude ash	g/kg	47.861	47.861		
66	Crude fiber	g/kg	48.368	48.368	40.000	

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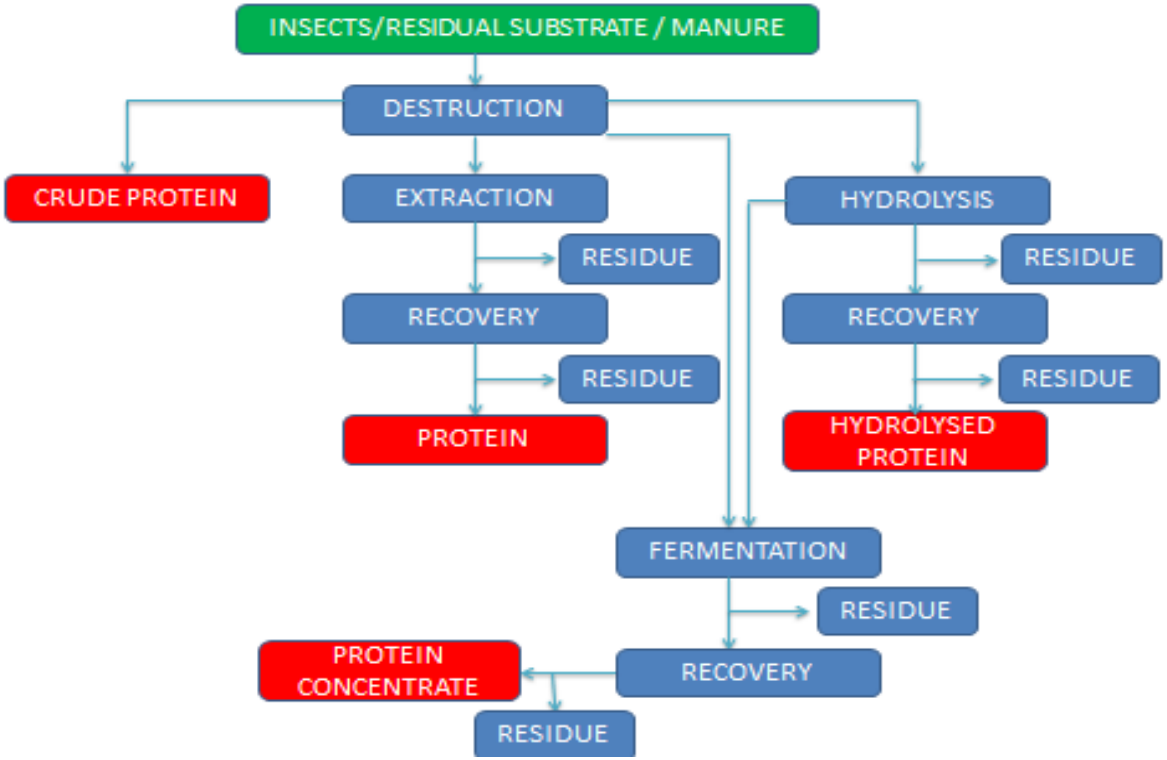
How to improve protein content ?

PROCESSING: *THE WAY TO GO ?*



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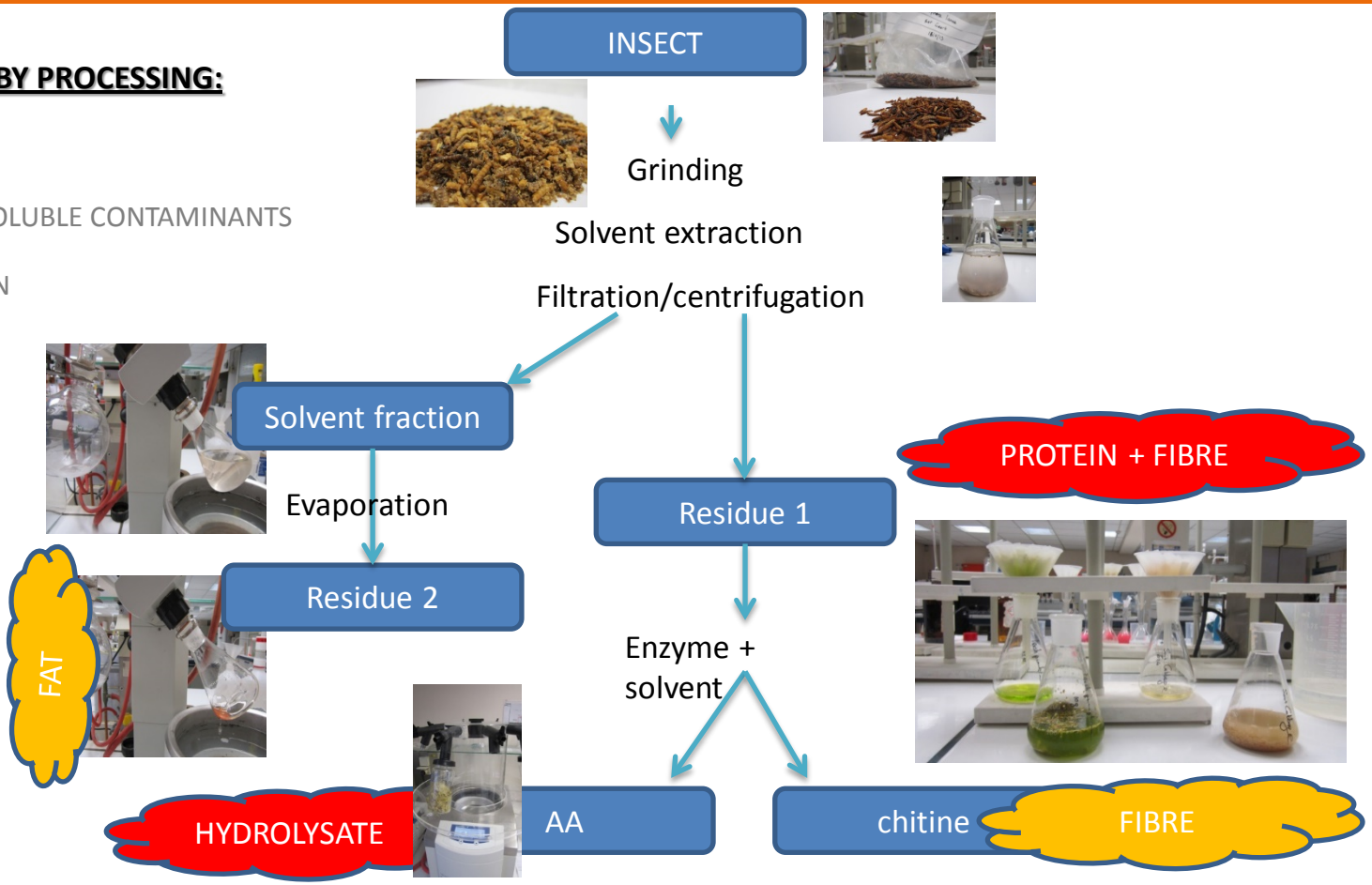
How to improve protein content ?

SAFETY BY PROCESSING:

- FAT SOLUBLE CONTAMINANTS
- CHITIN



How to improve protein content ?

CHEMICAL PROCESSING:

Insect sample	% protein (initial)	% protein (after extraction)
A. Musca domestica - UK	41,8	68,1
B. Calliphora vomitoria – UK	44,5	72,6
C. Musca domestica – China	60,7	71,8
D. Calliphora vomitoria – UK	42,9	73,0
E. Musca domestica – Ghana	57,8	67,8
F. Chrysomya spp. – Ghana	56,7	65,0
G. Hermetia illucens – Ghana	43,9	57,9
H. Musca domestica – Mali	56,2	68,7
I. Musca domestica – China	55,0	68,6

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Outcomes of fish trials: Salmon

Growth performance of Atlantic salmon fed experimental diets (housefly larvae meal) for 8 weeks.

	FM100	MM25	MM50	MM75	MM100	DMM50
Initial weight (g)	5.34±0.03	5.17±0.14	5.16±0.15	5.09±0.23	5.26±0.13	5.14±0.07
Final weight (g)	22.85±1.12^{a}	23.74±1.77^{a}	21.25±1.12^{abc}	18.95±0.53^{bc}	18.15±1.39^{c}	21.83±0.66^{ab}
Weight gain (g)	17.50±1.11^{a}	18.58±1.64^{ab}	16.08±0.96^{ab}	13.86±0.53^{ab}	12.89±1.28^{b}	16.69±0.70^{ab}
SGR (%bw/day)	2.55±0.08^{a}	2.67±0.09^{a}	2.48±0.04^{ab}	2.30±0.09^{bc}	2.16±0.10^{c}	2.53±0.07^{a}
FCR	0.90±0.06^{a}	0.91±0.08^{a}	0.96±0.06^{ab}	1.00±0.04^{ab}	1.11±0.12^{b}	0.93±0.04^{ab}
PER	0.02±0.00	0.02±0.00	0.02±0.00	0.02±0.00	0.02±0.00	0.02±0.00
Survival rate (%)	100±0.0	99.8±0.3	100±0.0	99.8±0.3	100±0.0	100±0.0

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Outcomes of fish trials: Salmon

Apparent digestibility coefficients (ADC) of nutrients, energy and fatty acids of the six experimental diets. Means ± SD (n=3) bearing identical superscripts are not significantly different (P>0.05).

	Experimental diets					
	FM100	**MM25**	**MM50**	**MM75**	**MM100**	**DMM50**
ADC						
Dry matter	0.67 ± 0.02^{a}	0.66 ± 0.01^{a}	0.66 ± 0.02^{a}	0.62 ± 0.01^{b}	0.65 ± 0.01^{ab}	0.64 ± 0.01^{ab}
Crude protein	0.86 ± 0.01^{a}	0.89 ± 0.00^{c}	0.88 ± 0.01^{bc}	0.87 ± 0.01^{ab}	0.89 ± 0.01^{bc}	0.87 ± 0.01^{ab}
Crude lipid	0.95 ± 0.02^{a}	0.91 ± 0.04^{ab}	0.90 ± 0.01^{ab}	088 ± 0.03^{b}	0.87 ± 0.02^{b}	0.92 ± 0.02^{ab}
Gross Energy	0.78 ± 0.02^{a}	0.77 ± 0.01^{a}	0.77 ± 0.01^{a}	0.73 ± 0.02^{b}	0.75 ± 0.01^{ab}	0.76 ± 0.01^{ab}

Outcomes of fish trials: Salmon

- Lipid digestibility was reduced when up to 75% or more FM was replaced by MM or DMM

=> lipid composition of housefly larvae may reduce lipid digestibility, potentially caused by high contents of saturated FA and chitin.

- Overall, results for diet containing DMM50 were comparable with the control (FM100).
- Higher potential (inclusion rates) of DMM as a substitute to FM?
- Overall performance of fish during the 8-week experiment were promising.

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Conclusions fish trials: ICPC countries

Tilapia trial Ghana

Tilapia trial China

Clarias trial Mali

Tilapia trial Thailand

Conclusions fish trials: ICPC countries

Tilapia: zootechnical performance and nutrient utilization (at least) similar to control up to 75% replacement of FM by MM. Complete replacement suboptimal (in terms of survival rate and zootechnical performance)
=> Validated in China, Thailand and Ghana

Catfish: identical observations as for Tilapia (Mali trial).

=> Fishmeal can be partially replaced by maggot meal, without harming fish performance

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Outcomes of pig trial

Zootechnical parameters of the piglets

PARAMETER	CONTROL DIET	INSECT MEAL DIET	INSECT EXTRACT DIET
Body weight (kg)			
Day 0	5.25 ± 0.88 [a]	5.34 ± 0.83 [a]	5.25 ± 0.88 [a]
Day 28	13.91 ± 2.49 [a]	14.07 ± 2.21 [a]	13.65 ± 2.28 [a]
Average daily gain (g)			
Day 0-28	309.5 ± 61.5 [a]	311.8 ± 57.8 [a]	300.2 ± 64.2 [a]
Feed intake (g)			
Day 0-28	467.2 ± 65.5 [a]	489.6 ± 62.6 [a]	478.8 ± 40.7 [a]
Feed conversion ratio			
Day 0-28	1.51 ± 0.05 [a]	1.58 ± 0.05 [a]	1.60 ± 0.08 [a]

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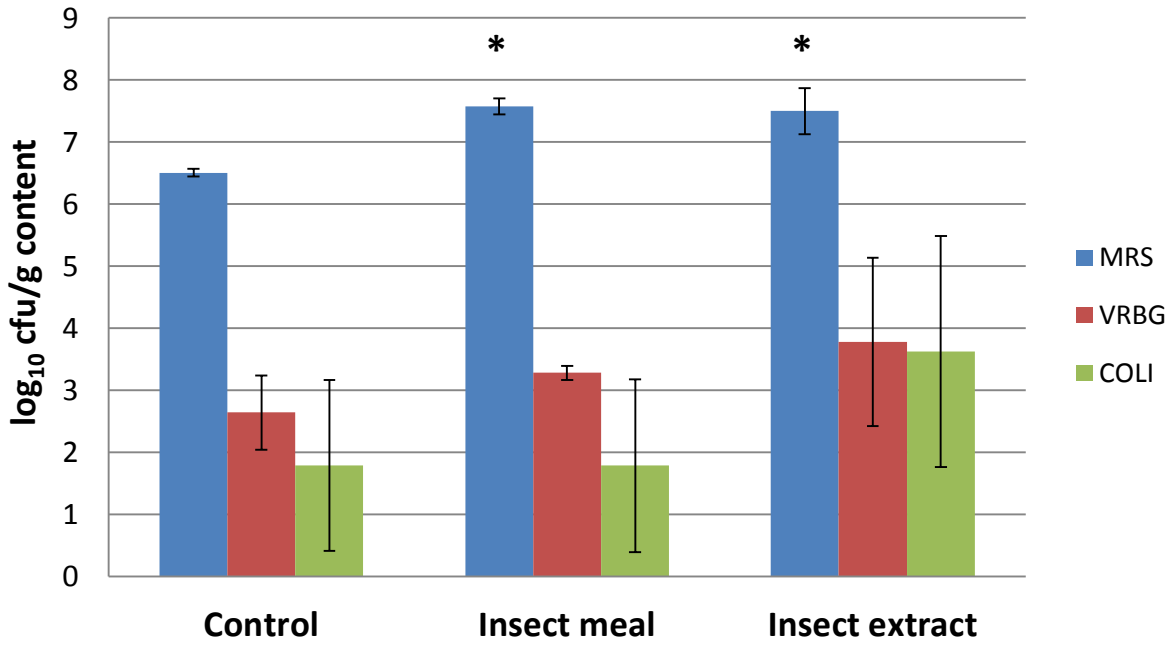
Outcomes of pig trial

Microbiological analyses of gastro-intestinal samples (ileum)



Outcomes of pig trial

- Significantly more positive bacteria (lactic acid bacteria) could be detected in the ileum of piglets receiving insect-supplemented diets.

- Overall, no significant differences could be observed in piglet performance, indicating that exchanging crude insect meal or extracted insect proteins for a similar amount of soybean meal and oil, does not lead to reduced animal performance.

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Outcomes of poultry trials

Zootechnical parameters of broilers through the 39-day trial

Feeding phase	Parameter	CONTROL	INSECT MEAL	INSECT EXTRACT
Total period	Body weight (g)	2269 ± 82[a]	2324 ± 86[a]	2287 ± 56[a]
	Average daily gain (g/d)	57.1 ± 2.1[a]	58.5 ± 2.2[a]	57.6 ± 1.4[a]
	Feed intake (g/d)	90.5 ± 3.0[a]	93.8 ± 3.5[a]	93.6 ± 3.8[a]
	FCR	1.59 ± 0.03[a]	1.60 ± 0.06[a]	1.63 ± 0.05[a]

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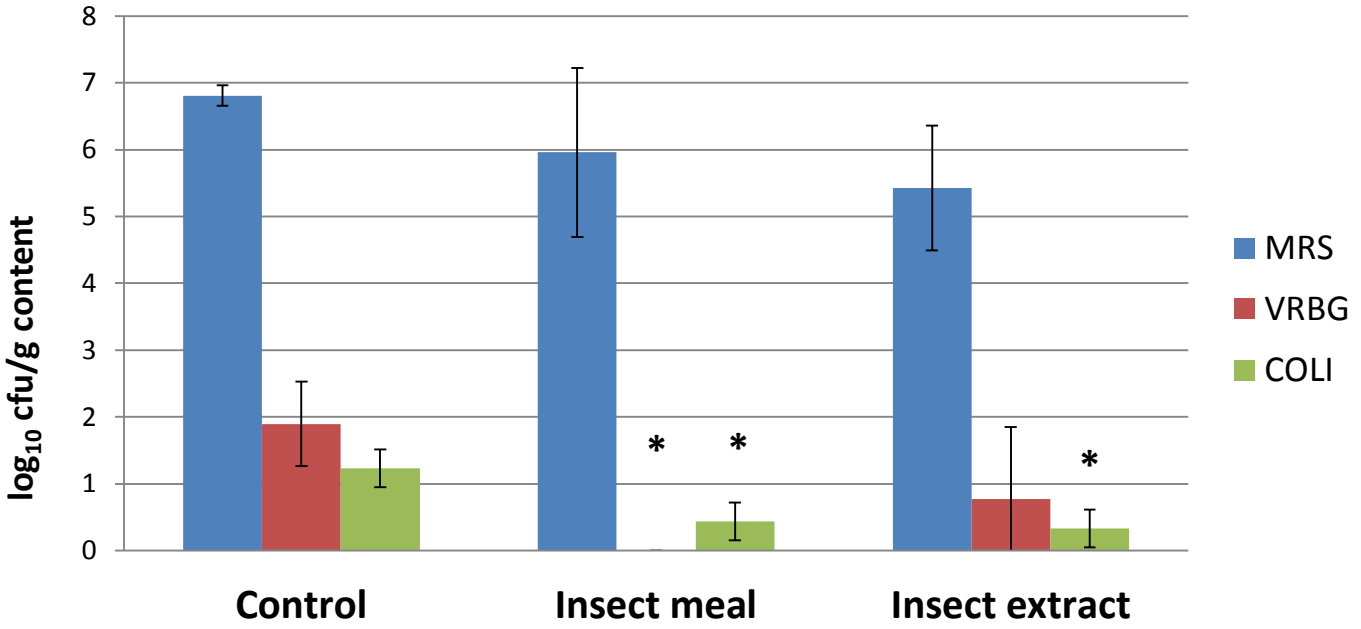
INSECTS AS A SUSTAINABLE SOURCE OF PROTEIN

Outcomes of poultry trials

Microbiological analyses of gastro-intestinal samples (gizzard)



Outcomes of poultry trials

- Significantly less pathogenic bacteria (coliforms and *Enterobacteriaceae*) could be detected in the gizzard (stomach) of chickens receiving insect-supplemented diets.

- Overall, no significant differences could be observed in broiler performance, indicating that exchanging crude insect meal or extracted insect proteins for a similar amount of soybean meal and oil, does not lead to reduced animal performance.

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Conclusions poultry trials: ICPC countries

Broiler trial China

Broiler breeder trial China

Broiler trial Mali

Layer trial Mali

Conclusions poultry trials: ICPC countries

Broilers: feeding maggots to broilers does not reduce zootechnical performance compared to animals receiving 100% fish meal => Validated in Mail and China.

Broilers and Layers : feeding insects improved production performance in both broilers (Mali) and layers (laying rate and feed-to-egg ratio) (China). In addition, egg characteristics (fertility and hatchability) in layers was better.

=> Maggot-based diets can replace traditional poultry diets based on other protein sources, with similar performance.

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QC/QA program for insect proteins

SAFETY PARAMETERS:

- VETERINARY MEDICINES
- PESTICIDES
- MYCOTOXINS
- HEAVY METALS
- DIOXINS / PCB
- ALLERGENS & CHITIN
- MICROBIOLOGY

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Exploring the chemical safety of fly larvae as a source of protein for animal feed

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Risk profile related to production and consumption of insects as food and feed

EFSA Scientific Committee

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QC/QA program for insect proteins

CHALLENGES BEFORE PROCESSING (AT DRIED INSECT STATUS):

- POTENTIAL PUBLIC OPINION ISSUE: ANIMAL WELFARE. SUITABLE KILLING PROTOCOL FOR INSECTS BEFORE EXTRACTION.

- THE PRESENCE OF PARASITES ON FLY LARVAE, INFLUENCING SAFETY OF EXTRACTED INSECT PROTEIN.

- RESIDUAL SUBSTRATES IN THE GASTROINTESTINAL TRACT AND ON THE SURFACE OF FLY LARVAE, IN CASE OF CONTAMINATED SUBSTRATES FOR INSECT GROWING. THIS IS IMPORTANT TO COPE WITH FUTURE LEGISLATION.

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QC/QA program for insect proteins

CHALLENGES AFTER PROCESSING:

- TOXICITY ISSUES ON CO-EXTRACTED CHITIN. SO FAR, NO CLEAR CONSENSUS EXISTS ON THE ANTINUTRITIONAL EFFECT OF CHITIN. THIS WAY, THE FINAL CHITIN STRUCTURE AND PRESENCE IN PROCESSED PROTEINS NEEDS FURTHER ATTENTION. SMALL OLIGOSTRUCTURES OF CHITIN CAN HAVE INTERESTING FEATURES IN ANIMAL NUTRITION (NON-PUBLISHED RESEARCH AT PARTNER NS), WHILE LONG MOLECULAR WEIGHT CHITIN CAN SHOW ANTI-NUTRITIONAL EFFECTS. BUT INCLUSION LEVELS ARE LOW !!

- RESIDUAL SOLVENTS (IN CASE OF SOLVENT EXTRACTION)

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In conclusion, insect protein has potential …

MAIN QUESTIONS TO BE ANSWERED TOWARDS POSSITIVE LEGISLATION FOR FEED APPLICATIONS:

SUBSTRATES FOR INSECT REARING ? GMP+ GRADE OR SIMILAR …

SCALE OF INSECT PRODUCTION ?

IDENTIFICATION OF MAIN RISKS – MONITORING PLAN (INCL. PROCESSING)

- BIOACCUMULATION OF CHEMICAL SUBSTANCES (HEAVY METALS, VETERINARY MEDICINE, PESTICIDES, ANTIBIOTICS, MYCOTOXINS) AND PATHOGENS → MEAT/MILK/EGG QUALITY ??

- ANTINUTRITIONAL ASPECTS ON CO-EXTRACTED CHITIN

- ALLERGENS (TYPE TROPOMYOSINS) ?

IF ISSUES ABOVE ARE SOLVED EN THEY SEEM EASY TO SOLVE !! :

… LEGISLATION

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QUESTIONS ?