Insects in animal feed: beyond the protein concept

GASCO L.

Department of Agricultural, Forest and Food Sciences

laura.gasco@unito.it

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Dubrovnik, Croatia, 27th to 31st August 2018
Insects: part of our life

- pest
- resource
- food
- feed
**Insect** = little (flying, jumping, crawling), ugly animals that can sting or bite us, or even ruin our homes or our crops
Insects: part of our life: PESTS
If all insects were to die, human beings would run out of food in just four years.

The bigger part of the insect population are not pests but good insects that help in the pollination of flowering plants, which produce most of our food.

Insects = key factor for food production
FOOD

The Future of Food
Ioanna Roumeliotis
Entomophagy

Could YOU survive on bugs? Early humans feasted on termite nests as long as 1.8 million years ago - when insects made up HALF of our diets

- Insects accounted for almost half of the diet of early man millions of years ago
- It was previously assumed early man lived on a diet of mammal meat or nuts
- Discovery came by chance after researchers carried out tests on mud
- Researchers confirmed that sediments were in fact an ancient termite nest

By PHOEBE WESTON FOR MAILONLINE
PUBLISHED: 17:30 BST, 16 April 2018 | UPDATED: 18:46 BST, 16 April 2018
Insects as FOOD

Number of recorded edible insect species per group in the world (number: 2111)

Source: Yde Jongema, 2017

Edible species: 2100
2 billion people

Recorded edible insect species, by country
In 2013, FAO recommended eating insects to help tackle food and nutrition challenges of today and tomorrow.

“Eating bugs is good for you, it’s good for the planet and it’s good for our future.”
"Considering the seasonal contribution of insects to the diet, the fact that they provide key nutrients, the low risk compared to hunting, ............... it is highly likely that insects were an important dietary component for early humans"
“Locanda delle tre lumache (tre rane)”

Ponte Vecchio (Florence)
Renewed interest

Lindner (1919)
Production protein and fat by housefly from human excreta

Impiego di larve di mosca carnaria (Calliphora vomitoria L.) nell'alimentazione della trota iridea (Salmo gairdneri RICH.)

INTRODUZIONE

L'impiego di alimenti naturali nell'alimentazione degli stadi giovanili e adulti di talune specie ittiche è una pratica nota da tempo e largamente applicata. La larva di mosca carnaria (Calliphora vomitoria L.), utilizzata quale esca nella pesca sportiva, non è mai stata variamente di alimentare. Tuttavia, se desiderato, può essere impiegata nel laboratorio per alimentare e da un sacco di rete di nylon con maglie di mm 16 di lato. Le gabbie erano collocate in un bacino di risulta dall'estrazione di ghiaia di mc 3800, rifornito con acque perfettamente compatibili con la vita del Salmonide. I soggetti sono stati equamente ripartiti in 4 gabbie di cui 2 (prova) hanno ricevuto larve di mosca carnaria e 2 (controllo) un man.
2050: **meat** (poultry / pork / bovine) and **milk products** will **double** while **fish products** (aquaculture) will be **triplicated**.

Today protein production for FEED **cannot** cover tomorrow demand.

**ALTERNATIVES**


- protein content
- EAA
- digestibility
- fat extraction

- Sustainability (low gas emission, low value rearing substrates, verticality, yield,..)
- part of natural diet

July 2017 – EU Reg. 2017/893: aquaculture market
Insects as FEED

What’s next?
Insects for HEALTH

**Consuming insects: are there health benefits?**

N. Roos¹ and A. van Huis²

*Journal of Insects as Food and Feed, 2017; 3(4): 225-229*

Bioactive compounds

- Chitin
- Fatty acids
- Anti-microbial peptides

**Can diets containing insects promote animal health?**

L. Gasco¹, M. Finke² and A. van Huis²

*Journal of Insects as Food and Feed, 2018; 4(1): 1-4*

- antimicrobial effects
- strengthen immune system
- fat reducing properties
Insects for HEALTH

Global **over-use of drugs treatments** in human and animal nutrition to treat diseases (or as growth promoters)

- Animals: associated with decrease in performances, high morbidity & mortality

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**Antimicrobial resistance is one of the biggest threats to global health, food security, and development today**

The Antibiotic Resistance Crisis
Part 1: Causes and Threats

C. Lee Ventola, MS

P&T, 2015. 40:277-283
Chitin

Sources of Chitin

Exoskeleton

Chitin is a major component of the exoskeleton of insects that helps in protecting their delicate soft tissues.
Insects for HEALTH: Chitin

Chitin

- structural polysaccharide that contains nitrogen
- polymer of N-acetylglucosamine
- major element in the exoskeleton of insects

Chitina

- antioxidant
- anti-inflammatory
- anticoagulant
- antitumoral & anticancer
- antibacterial
- antihypertensive
- immunostimulant
- hypocholesterolemic

Crustacean chitin

- medicinal & pharmaceutical applications
  - particles size?
    - small size = anti-inflammatory
  - chitin composition?
    - insect chitin: matrix of protein, lipids + other compounds
    - crustacean chitin: matrix of protein & minerals

Ngo & Kim, 2014

Advances in Food and Nutrition Research, Volume 73
ISSN 1043-4526
http://dx.doi.org/10.1016/B978-0-12-800268-1.00002-0
Antioxidant Effects of Chitin, Chitosan, and Their Derivatives

Dai-Hung Ngo*, Se-Kwon Kim*, †, 1

Aquaculture Nutrition 2012 18; 117–131
doi: 10.1111/j.1365-2095.2011.00919.x

REVIEW ARTICLE

Use of chitin and krill in aquaculture – the effect on gut microbiota and the immune system: a review

E. RINGØ1, Z. ZHOU2, R.E. OLSEN3 & S.K. SONG4
Insects for HEALTH: Chitin – Antibacterial effect

**Antibacterial effect**

Efficacy of mealworm and super mealworm larvae probiotics as an alternative to antibiotics challenged orally with *Salmonella* and *E. coli* infection in broiler chicks

fermented insect meal (TM & ZM) through *L. plantarum* & *S. cerevisiae*

larvae probiotics fed one-day chicks challenged with *Salmonella* & *E. coli*

- improved performances (ADG, ADFI, FCR)
- decrease of mortality
- increased IgG & IgA
- reduced bursa of Fabricius weight
- cecal *E.coli* & *Salmonella* contents reduction

**Figure 1.** Effects of dried mealworm (DMLP) and super mealworm (DSMLP) larvae probiotics on mortality rate in challenged broilers. Data are presented as the mean ± SE. Bars without a common letter differ significantly ($P < 0.05$).

TM & ZM larvae meal probiotics = alternative to antibiotics

Insects for HEALTH: Chitin – microbiota modulation

Microbiota modulation

Insect-based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens.

BSF

Ceacal microbiota modulation

development of bacteria having a chitin degradation activity

connected with SCFAs production

Probiotic effect of BSF

Borrelli et al, 2017. Scientific Reports, 487:56-63
Microbiota modulation

Characterisation of the intestinal microbial communities of rainbow trout (*Oncorhynchus mykiss*) fed with *Hermetia illucens* (black soldier fly) partially defatted larva meal as partial dietary protein source

Leonardo Bruni\(^a\), Roberta Pastorelli\(^b\), Carlo Viti\(^c\), Laura Gasco\(^d\), Giuliana Parisi\(^a,^*\)

Mucosa- (MAB) & Digesta- (DAB) Associated Bacterial community

modulation microbial community

increased incidence of *Carnobacterium* genus

- *in vitro* inhibition of pathogens
- stimulate non-specific immune response
- *in vivo* improvement of disease resistance

Eating crickets can be good for your gut, according to new clinical trial

August 3, 2018 | By Kelly April Tyrrell | For news media
Insects for HEALTH: Chitin: immunostimulation

**Immunostimulation**

**Immunomodulatory effects of dietary intake of chitin on gilthead seabream (Sparus aurata L.) innate immune system**

Fish fed 2.5 or 5% of purified **crab shell chitin**

*increased* seabream **immune activity** through the non-specific modulation of haemolytic complement activity, leucocyte respiratory burst activity and cytotoxicity.

**crustacean chitin = insect chitin??**

Esteban et al., 2001. Fish & Shellfish Immunology, 11:303-3015
Insects for HEALTH: Chitin – immunostimulation

**Immunostimulation**

The influence of maggot meal and L-carnitine on growth, immunity, antioxidant indices and disease resistance of black carp (Mylopharyngodon piceus)

Black carp fed MD meal (2,5%)

- increased performances indexes
- improved parameters
  - Serum:
    - lysozyme
    - complement C3 and C4
    - glutathione peroxidase
    - superoxide dismutase
    - catalase
    - malondialdehyde (decrease)
  - Liver:
    - superoxide dismutase
    - catalase
    - malondialdehyde (decrease)
- increased survival rate in fish challenged with *Aeromonas hydrophila*

Low doses of dietary MD can:
- promote the growth
- improve the non-specific immunity and antioxidation capacity
- enhance fish resistance to disease

Immunostimulation

Dietary effects of housefly (*Musca domestica*) (Diptera: Muscidae) pupae on the growth performance and the resistance against bacterial pathogen in red sea bream (*Pagrus major*) (Perciformes: Sparidae)

*Pagrus* fed MD pupae meal (6 month trial)

- increased peritoneal leucocyte phagocytic activity
- increased protection against *Edwardsiella tarda*

MD chitin or AMP or other bioactive compounds?
Insects for HEALTH: Chitin – immunostimulation

**Immunostimulation**

**TM: 0%, 9%, 18%, 27%**

in fish fed 18% TM

- decrease in plasma MDA content + increase in plasma SOD activity
- increase in plasma
  - lysozyme activity
  - IgM levels
- up-regulation of immune related genes (MHC II, IL-1, CypA, Img, HE)
- increase of survival rate after **challenged** with *Edwardsiella ictaluri*

**TM could improve immune response & bacterial resistance**

Su et al., 2017. Fish & Shellfish Immunology, 69:59-66
Insects for HEALTH: Chitin – immunostimulation

**Immunostimulation**

Yellow catfish fed 10.8% or 22.3%, BSF larvae meal

- Increased weight (+29.1%)
- Lowest FCR: 0.9
- Lysozyme activity (+31.9%)

- Increased weight (+21.7%)
- Lysozyme activity (+6.8%)

BSF had **positive effects** on growth performance & **immune indexes**

Xiao et al., 2018. Aquaculture Research, 49:1569-1577
Immunostimulation

Does dietary insect meal affect the fish immune system? The case of mealworm, *Tenebrio molitor* on European sea bass, *Dicentrarchus labrax*

M.A. Henry a,*, L. Gasco b, S. Chatzifotis c, G. Piccolo d

fish fed 25 & 50% of full fat TM larva meal

- improved lysozyme activity (tendance)
- increased anti-protease activity

related to anti-parasitic activity of fish immune system

similarities between the composition of insects and parasites exoskeleton

Immunostimulant effect

Henry et al., 2018. Dev & Comp Immunol, 81:204-209
Insects for HEALTH: Chitin – immunostimulation

Immunostimulation

Yellow mealworm larvae (Tenebrio molitor, L.) as a possible alternative to soybean meal in broiler diets

Table 6. Blood chemistry at end of the trial (62 d of age)

<table>
<thead>
<tr>
<th></th>
<th>SBM</th>
<th>TML</th>
<th>RMSE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total protein, g/l</td>
<td>30.2</td>
<td>31.0</td>
<td>6.45</td>
<td>0.7536</td>
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<td>Albumin, g/l</td>
<td>8.9</td>
<td>7.1</td>
<td>3.79</td>
<td>0.2325</td>
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<td>Globulin, g/l</td>
<td>21.4</td>
<td>23.9</td>
<td>4.85</td>
<td>0.1745</td>
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<tr>
<td>Albumin/globulin</td>
<td>0.44a</td>
<td>0.30b</td>
<td>0.082</td>
<td>0.0487</td>
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<td>Cholesterol, mmol/l</td>
<td>2.27</td>
<td>2.44</td>
<td>0.471</td>
<td>0.0932</td>
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<tr>
<td>Triglycerides, mmol/l</td>
<td>0.35</td>
<td>0.34</td>
<td>0.132</td>
<td>0.9478</td>
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<tr>
<td>AST, U/l</td>
<td>178.6B</td>
<td>195.5A</td>
<td>15.93</td>
<td>0.0082</td>
</tr>
<tr>
<td>ALT, U/l</td>
<td>46.7B</td>
<td>82.1A</td>
<td>14.67</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>GGT, U/l</td>
<td>16.0</td>
<td>19.4</td>
<td>6.23</td>
<td>0.1538</td>
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<tr>
<td>ALP, U/l</td>
<td>661.6</td>
<td>636.0</td>
<td>82.28</td>
<td>0.4091</td>
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<tr>
<td>Ca., mmol/l</td>
<td>2.23</td>
<td>2.23</td>
<td>0.128</td>
<td>0.9210</td>
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<tr>
<td>BUN, mmol/l</td>
<td>0.35</td>
<td>0.27</td>
<td>0.179</td>
<td>0.2820</td>
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<tr>
<td>Creatinine, pmol/l</td>
<td>26.5</td>
<td>24.7</td>
<td>5.48</td>
<td>0.4309</td>
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<tr>
<td>Uric acid, mmol/l</td>
<td>0.92a</td>
<td>0.25b</td>
<td>0.018</td>
<td>0.0227</td>
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<tr>
<td>CK, U/l</td>
<td>4204</td>
<td>3884</td>
<td>1266</td>
<td>0.0929</td>
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<tr>
<td>LDH, U/l</td>
<td>961.6</td>
<td>856.7</td>
<td>166.7</td>
<td>0.1025</td>
</tr>
</tbody>
</table>

SBM, soybean meal group; TML, Tenebrio molitor larvae meal group; RMSE, root mean square error; AST, aspartate aminotransferase; ALT, alanine aminotransferase; GGT, gamma glutamyl-transferase; ALP, alkaline phosphatase; CK, creatine kinase; LDH, lactic dehydrogenase; BUN, blood urea nitrogen. \(^{a,b}P < 0.05\); \(^{A,B}P < 0.01\).

Bovera et al., 2015. British Poultry Science, 56:569-575

lower albumin / globulin ratio

suggests a higher immune response
Immunostimulation

Productive performance and blood profiles of laying hens fed *Hermetia illucens* larvae meal as total replacement of soybean meal from 24 to 45 weeks of age

S. Marono,* R. Loponte,* P. Lombardi,* G. Vassalotti,* M. E. Pero,* F. Russo,‡ L. Gasco,‡ G. Parisi,‡ G. Piccolo,* S. Nizza,* C. Di Meo,* Y. A. Attia,§ and F. Bovera*.$1$

Table 6. Haematological traits, serum proteins, glucose, and lipids of laying hens fed insect and soybean meal from 24 to 45 wk of age.

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<tr>
<td>Haematocrit, %</td>
<td>33.3</td>
<td>33.8</td>
<td>0.67</td>
<td>3.642</td>
</tr>
<tr>
<td>Haemoglobin, g/dl</td>
<td>11.1</td>
<td>10.1</td>
<td>0.071</td>
<td>1.451</td>
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<td>RBC, x10^6/mm$^3$</td>
<td>3.65</td>
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<td>WBC, x10^3/mm$^3$</td>
<td>21.1</td>
<td>20.9</td>
<td>0.86</td>
<td>2.982</td>
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<tr>
<td>Heterophils, %</td>
<td>37.1</td>
<td>37.3</td>
<td>0.35</td>
<td>0.841</td>
</tr>
<tr>
<td>Lymphocytes, %</td>
<td>47.3</td>
<td>48.9</td>
<td>0.34</td>
<td>0.173</td>
</tr>
<tr>
<td>Monocytes, %</td>
<td>2.94</td>
<td>2.69</td>
<td>0.97</td>
<td>0.471</td>
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<tr>
<td>Eosinophils, %</td>
<td>11.4</td>
<td>10.1</td>
<td>0.22</td>
<td>0.090</td>
</tr>
<tr>
<td>Basophils, %</td>
<td>1.31</td>
<td>1.00</td>
<td>0.12</td>
<td>0.472</td>
</tr>
<tr>
<td>H/L</td>
<td>0.79</td>
<td>0.77</td>
<td>0.11</td>
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HILM: *Hermetia illucens* larvae meal; SBM: soybean meal; RBC: Red blood cells; WBC: White blood cells; H/L: Heterophils to lymphocytes ratio.

$^A,bP < 0.01; ^a,bP < 0.05; RMSE: $Root mean square error; $n = 36$ (18/group).

lower albumin / globulin ratio suggests a higher immune response
Insects for HEALTH: Chitin – immunostimulation

**Immunostimulation**

Black soldier fly (*Hermetia illucens*) larvae enhances immune activities and increases survivability of broiler chicks against experimental infection of *Salmonella Gallinarum*.

Birds fed low levels of BSF larvae meal (1%, 2%, 3%)

- increase of:
  - performances
  - frequency of CD4+ T lymphocyte
  - serum lysozyme activity
  - spleen lymphocyte proliferation
  - survival rate of broiler challenged with *Salmonella Gallinarum*

BSF: positive effect on growth + **stimulate non specific immune response**

Insects for HEALTH: Chitin: hypolipidaemic & hypocholesterolaemic effects

Hypolipidaemic & hypocholesterolaemic effects

Article

Influence of Chitosan Treatment on Surrogate Serum Markers of Cholesterol Metabolism in Obese Subjects

Dieter Lütjohann, Milka Marinova, Karsten Wolter, Winfried Willinek, Norman Bitterlich, Martin Coenen, Christoph Coch and Frans Stellaard

Nutrients 2018, 10, 72; doi:10.3390/nu10010072
Insects for HEALTH: Chitin: hypolipidaemic & hypocholesterolaemic effects

Hypolipidaemic & hypocholesterolaemic

Dietary ingestion of crustacean chitin (0.25%, 0.5%, 0.75%)

- Reduction of:
  - Triglyceride concentrations in liver and breast meat
  - Serum cholesterol and triglycerol concentrations
Insects for HEALTH: Chitin – cholesterol

**Hypolipidaemic & hypocholesterolaemic**

rats fed MD meal
- reduction of visceral fat
- reduction of serum LDL cholesterol

**MD**

promote the efflux of excess cholesterol in the body and inhibit cholesterol re-absorption from the intestine

![Graph showing visceral fat accumulation](image)

*Fig. 6* Visceral fat accumulation in rats fed with the diet containing HfPM for 28 days. Weight of visceral fat deposits is expressed as a percentage (visceral fat weight/body weight × 100). Results are given as the mean ± SEM. *p < 0.05 against the control is considered to indicate statistical significance (Bonferroni post hoc test)

![Graph showing serum cholesterol and triglyceride concentrations](image)

*Fig. 7* Serum cholesterol and triglyceride concentrations in rats receiving a diet containing HfPM for 28 days. Results are given as mean ± SEM. **p < 0.01 against control is considered to indicate statistical significance (Bonferroni post hoc test)

Ido et al., 2015. Appl Entomol Zool, 50:213–221
Insects for HEALTH: Chitin – cholesterol

Hypolipidaemic & hypocholesterolaemic

Defatted black soldier fly (Hermetia illucens) larvae meal in diets for juvenile Jian carp (Cyprinus carpio var. Jian): Growth performance, antioxidant enzyme activities, digestive enzyme activities, intestine and hepatopancreas histological structure

Jian carp fed BSF meal (0%, 2.6%, 5.3%, 7.9% & 10.6%)

- no differences in growth performances
- reduction of hepatopancreas fat
- reduction of serum cholesterol
- Increase in CAT activity

Hypocholesterolaemic effect + bost antioxidant status

Li et al., 2017. Aquaculture, 477:62-70
Insects for HEALTH: Chitin – cholesterol

Hypolipidaemic & hypocholesterolaemic

Productive performance and blood profiles of laying hens fed *Hermetia illucens* larvae meal as total replacement of soybean meal from 24 to 45 weeks of age

S. Marono,* R. Loponte,* P. Lombardi,* G. Vassalotti,* M. E. Pero,* F. Russo,† L. Gasco,† G. Parisi,§ G. Piccolo,* S. Nizza,* C. Di Meo,* Y. A. Attia,# and F. Bovera*1

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<td>5.18</td>
<td>5.31</td>
<td>0.58</td>
<td>0.629</td>
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<tr>
<td>Albumin, g/dl</td>
<td>2.72</td>
<td>2.58</td>
<td>0.44</td>
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<td>Globulin, g/dl</td>
<td>2.74a</td>
<td>2.12b</td>
<td>0.030</td>
<td>0.763</td>
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<td>Albumin/Globulin</td>
<td>1.01b</td>
<td>1.62a</td>
<td>0.033</td>
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<td>Glucose, mg/dl</td>
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<td>295</td>
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<tr>
<td>Cholesterol, mg/dl</td>
<td>108b</td>
<td>134a</td>
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<td>Triglycerides, mg/dl</td>
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<td>1942A</td>
<td>0.007</td>
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</table>

BSF

lower cholesterol & triglycerids in birds fed BSF

ability of chitin to bind bile acids & free fatty acids

Marono et al., 2017. Poultry Science, 96:1783-1790
Fatty acids

Saturated fatty acid (no double bonds)

Unsaturated – trans (H atoms opposite)

Unsaturated – cis (H atoms same side) → bent configuration

\[ \text{O = C, O = O, H} \]
Antimicrobial Property of Lauric Acid Against *Propionibacterium Acnes*: Its Therapeutic Potential for Inflammatory Acne Vulgaris

strong antibacterial properties of C12:0

Nakatsuji et al., 2009. Journal of Investigative Dermatology, 129:2480-2488
Antibacterial Activity of Lauric Acid on Some Selected Clinical Isolates

Abbas Abel Anzaku¹, Josiah Ishaku Akyala², Adeola Juliet³ and Ewenighi Chinwe Obianuju⁴

Conclusion and Recommendation

This study establishes the fact that lauric acid has antibacterial effect on Gram positive bacteria more compare to the Gram-negative bacteria. This however recommends that lauric acid beneficially be used in treating some of the microbial infection caused by some Gram-positive bacteria. More studies should be done to ascertain the mechanisms of actions of this acid on the bacterial cell including the non-cellular (viruses) strains.

C12:0: more active against Gram+

could be used in combatting some microbial strains resistant to antibiotics
Insects for HEALTH: Fatty acids

Insect fatty acid composition

- Fatty acid composition is specie – specific
- Could be manipulated through rearing substrate
- BSF: lauric acid (C12:0)
- TM: Oleic acid (C18:1) – linoleic acid (C18:2)

Barroso et al., 2014
Fatty acids: Lauric acid (BSF)

Gut antimicrobial effects and nutritional value of black soldier fly (Hermetia illucens L.) prepupae for weaned piglets

- *In vitro* trial (0.58g/100 ml):
  - suppressed growth of lactobacilli & D-streptococci
**Pasteurella multocida**

- **Log (UFC/ml)**
  - **T0**: 3.43
  - **2H**: 3.7
  - **4H**: 3.75
  - **6H**: 3.15
  - **8H**: 3.48
  - **10H**: 3.79
  - **12H**: 4.4
  - **24H**: 6

**Yersinia enterocolitica**

- **Log (UFC/ml)**
  - **T0**: 3.1
  - **2H**: 3.3
  - **4H**: 3.8
  - **6H**: 4.3
  - **8H**: 4.5
  - **10H**: 5.3
  - **12H**: 5.1
  - **24H**: 5.8

**Detection Limit**: 0.7

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**TM oil against some common rabbit bacteria**

Gasco et al., in progress
Insects for HEALTH
Insect proteins as a potential source of antimicrobial peptides in livestock production. A review

AMPs

• small cationic proteins that exhibit activity against bacteria, fungi, parasites & virus
• AMPs boost host specific innate immune response and exert selective immunomodulatory effects
• Insects are a primary source of AMPs

great potential to be use in animal nutrition
Insect defensins: inducible antibacterial peptides*

Jules A. Hoffmann and Charles Hetru

In response to bacterial challenge or trauma, insects produce a battery of bactericidal or bacteriostatic molecules with a broad spectrum of activity against Gram-positive and/or Gram-negative bacteria; most are small-sized cationic peptides. This review focuses on insect defensins, a large group of inducible antibacterial peptides that are present both in ancient and recent insect orders. This immune response of insects shares many of the characteristics of the mammalian acute phase response.
Diversity, evolution and medical applications of insect antimicrobial peptides

Eleftherios Mylonakis¹, Lars Podsiadlowski², Maged Muhammed¹ and Andreas Vilcinskas³,⁴

Antimicrobial peptides (AMPs) are short proteins with antimicrobial activity. A large portion of known AMPs originate from insects, and the number and diversity of these molecules in different species varies considerably. Insect AMPs represent a potential source of alternative antibiotics to address the limitation of current antibiotics, which has been caused by the emergence and spread of multidrug-resistant pathogens. To get more insight into AMPs,
Insects for HEALTH: Antimicrobial peptides

1 Isolation and Purification of Active Antimicrobial Peptides from *Hermetia illucens* L., and Its Effects on CNE2 Cells

---- anticancer effect of antimicrobial peptides

5 Zhong Tian*, Qun Feng*, Hongxia Sun, Ye Liao, Lianfeng Du, Rui Yang, Xiaofei Li,

6 Yufeng Yang, Qiang Xia*

- Isolation and purification of an active antimicrobial peptide HI-3 (5th instar)
- antibacterial activity
  - *Staphylococcus aureus*
  - *Bacillus subtilis*
  - *Escherichia coli*
  - *Enterobacter aerogenes*
- inhibitory activity on the proliferation of CNE2 cells (nasopharyngeal carcinoma cells)

Potential antitumoral drug

Tian et al., 2018. bioRxiv doi.org/10.1101/353367
Insects: Alternative Protein Source for Animal Feed

Guest Editor:

Message from the Guest Editor

Dear Colleagues,

World population is expected to grow by over a third, reaching over 9 billion people in 2050. This will have as main consequence that the world will have to produce 70% more food. Livestock production (in particular that of poultry and swine) will have to grow rapidly if per capita intake is to be maintained. Therefore, a major concern is to guarantee the global capacity to provide enough animal feed (in particular protein ingredients), trying to avoid as much as possible competition with human food demand. For this purpose, insects have been proposed as a high quality, efficient and sustainable alternative protein source for poultry, fish or swine. Results are promising but as industry interest is growing further information is needed to fully assess the potential of these innovative raw materials.

Dr. Laura Gasco
Department of Agricultural, Forest and Food Sciences (DISAFA), University of Turin, Largo Paolo Braccini 2, 10095 Grugliasco, Turin, Italy
laura.gasco@unito.it

Deadline for manuscript submissions:
28 February 2019
There is a world in which people do not let things happen. They make them happen.

Sergio Marchionne