



Forschungsinstitut
für Nutztierbiologie

Growth performance of black soldier fly (*Hermetia illucens*) reared on substrate mixtures from regional agricultural and food production side-streams

Thomas Freimuth¹, M. Mielenz¹, G. Daş¹, L. Hüther², S. Dänicke², C. C. Metges¹

1: Research Institute for Farm Animal Biology (FBN), 18196 Dummerstorf, Germany

2: Friedrich-Löffler Institute (FLI), 38116 Braunschweig, Germany

EAAP 2024 – Insect Nutrition

01-09-2024 Florence

Need for efficient [regional] nutrient recycling



German
feed protein supply gap

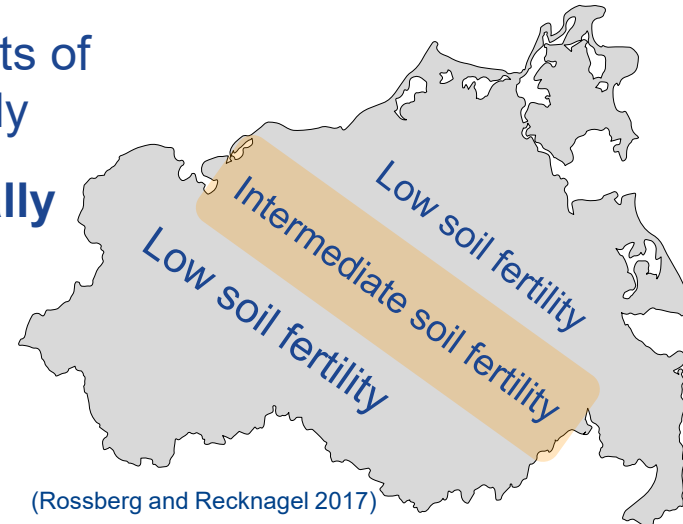
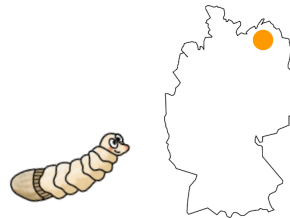
16 %

(BZL 2024)

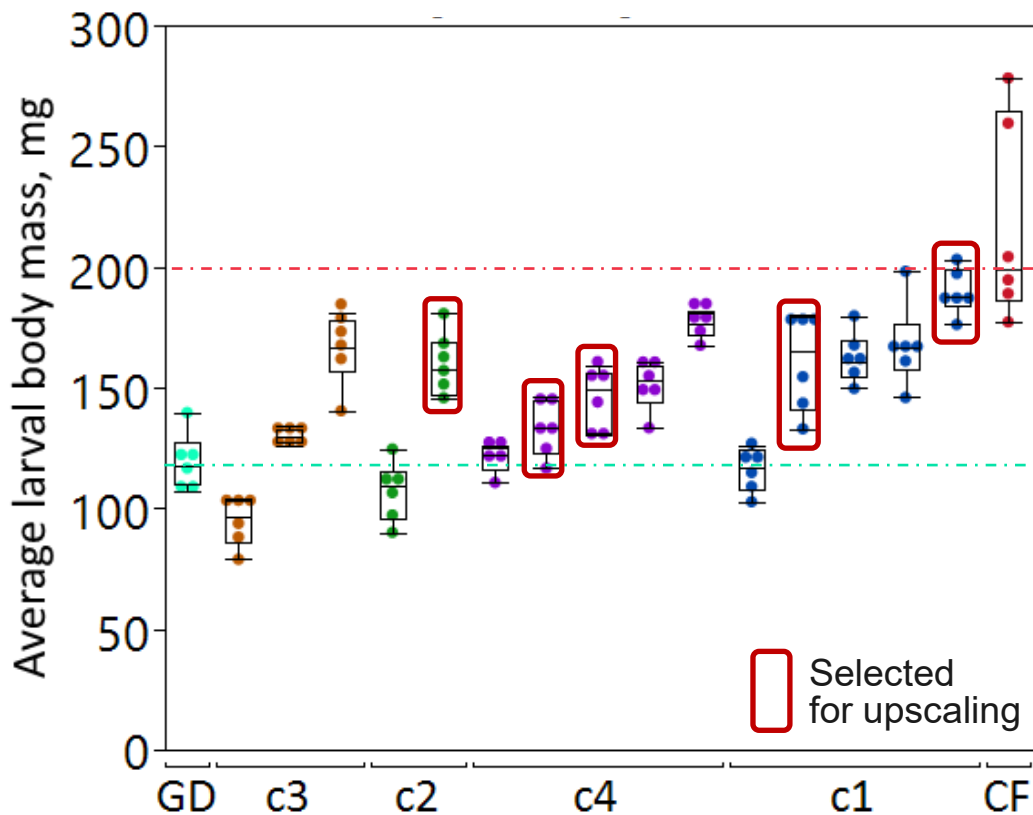


Black soldier fly larvae (BSFL) (*Hermetia illucens*)

- High quality and quantity of protein in larvae
- Conversion of low grade by-products to protein and fat
- Sustainability improvements of regional feed protein supply
- **But: Reliance on regionally available sidestreams!**



Previous results - screening for high performance mixtures





Hypothesis

Regionally available by-products fed as complex substrate mixtures can outperform Gainesville diet (Hogsette 1993) (GD) and achieve a similar growth performance as with chicken feed (CF).

Aim

- Feeding refined regional plant & animal based residual substrate mixtures to BSFL
- Determine growth performance & nutrient conversion efficiency on a larger scale



Main substrate components



HIFI LOFI



SIPE



SLRE



CAFI



Rye silage



Bakery



Dairy



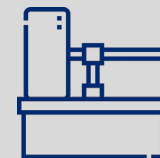
Fruit/vegetable



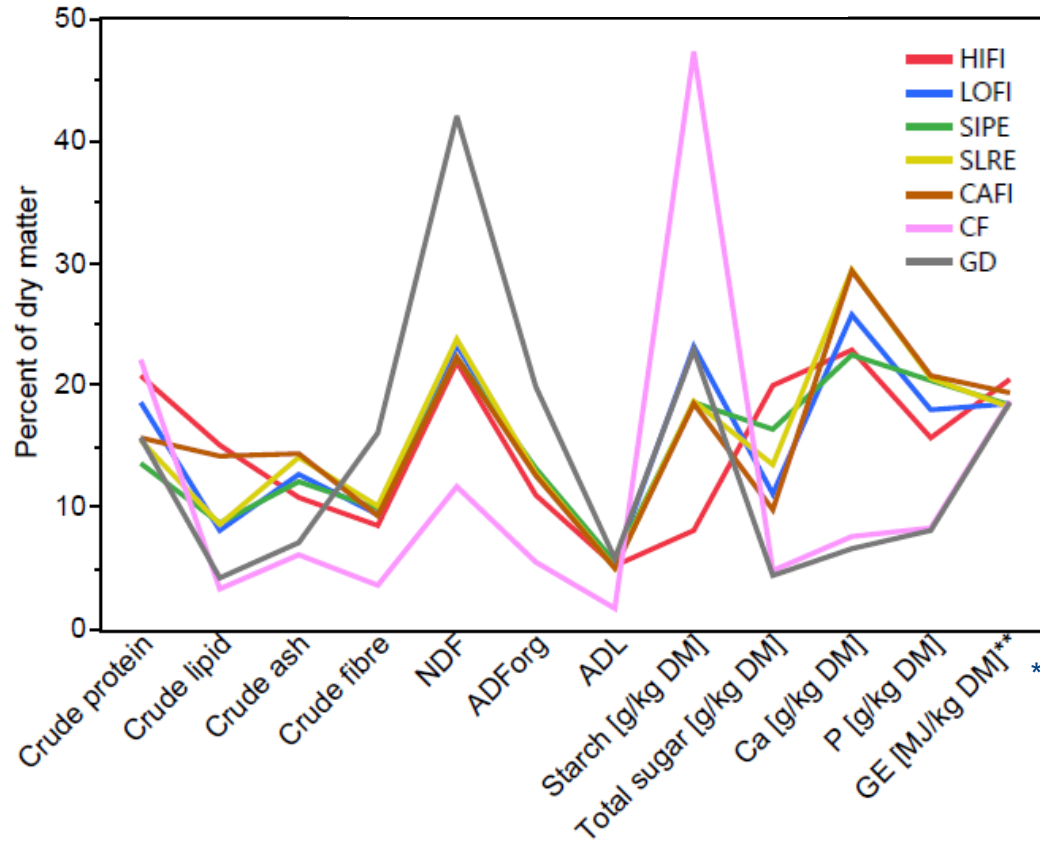
Workflow & ingredients of the mixtures



	HIFI	LOFI	SIPE	SLRE	CAFI	CF	GD
Protein source	17.4	15.1	9.9	10.7	18	-	-
Dairy residues	25	1	14.8	8	-	-	-
Fruit/vegetable residues	20	49.5	32.2	37	30	-	-
Brewers grains	15	6	14.9	3	10.4	-	-
Rye silage	11	12	-	17.2	12	-	-
Bakery residues	3	9	9	8	8	-	-
Wheat bran	3	4.5	2.1	4.5	2.5	-	17.3
Rapeseed cake	-	-	3	-	2	-	-
Oil mix	0.4	-	-	-	0.5	-	-
Mineral mix	2.3	2.9	2.7	3.5	3.5	-	-
Demineralised water	2.9	-	11.6	8.2	13.1	66.2	66
Alfalfa meal	-	-	-	-	-	-	9.8
Maize meal	-	-	-	-	-	-	6.9
Chicken feed	-	-	-	-	-	33.8	-



Nutrient profiles of substrate mixtures



Dry matter [%]*						
HIFI	LOFI	SIPE	SLRE	CAFI	CF	GD
29.4	29.8	28.6	28.9	28.3	29.9	28.8

*analysed post formulation

**GE = 23.9*CP+39.8*CL+20.1*CF+17.5*NFE (GfE 1995)



Experimental setup



Day 1-5	Day 5	Growth phase	Harvest	Post Experiment
Neonates raised on CF	~4000 BSFL / 5 kg WM 30*40*17 cm crates n = 6, N = 42	Moisture replenishment	Daily check for 1st prepupae starting from day 13	Dry matter Weende analysis Van Soest



Specific growth rate [%]: $(\log(\text{harvest mass}) - \log(\text{initial mass})) / \text{time}$ (Lugert 2016)

Feed conversion rate: Substrate (g FM)/ larval mass (g FM)

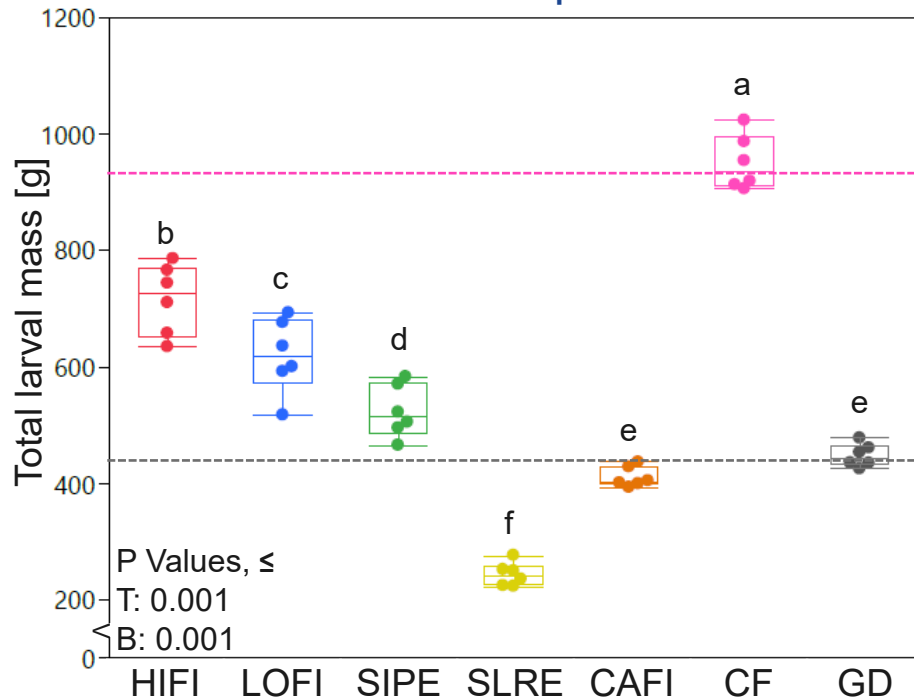
Statistics: Proc Mixed (Version 9.4., SAS Institute Inc., Cary, NC, USA)

Tukey-Kramer, $\alpha < 0.05$, tendency: $0.05 < P \leq 0.1$

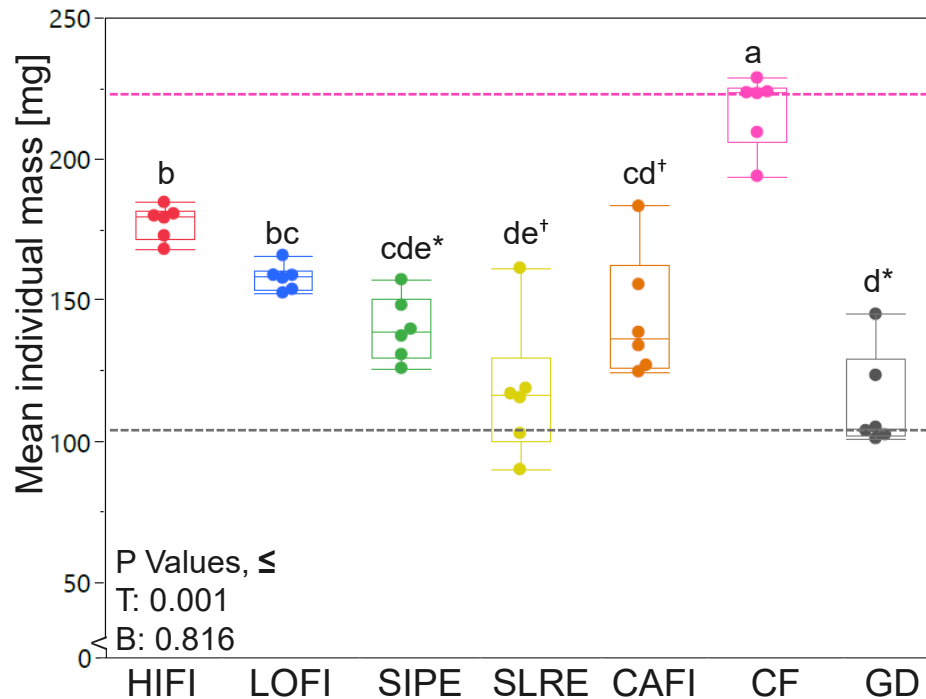
Growth performance



Larval mass per box



Mean individual larval mass



Growth indicators



	Feeding Substrate							P Values ¹ , ≤		
	HIFI	LOFI	SIPE	SLRE	CAFI	CF	GD	SE	T	B
Fattening period [d]	16 ^b	16 ^{b*}	18 ^a	18 ^a	18 ^a	15 ^{b*}	14 ^c	0.2	0.001	0.004
Calculated nr. larvae/ box*	4034 ^{ab}	3927 ^b	3753 ^b	2126 ^d	2908 ^c	4393 ^a	4023 ^{ab}	144	0.001	0.001
Specific growth rate [%]	60.3 ^b	57.2 ^b	47.4 ^c	41.4 ^d	46.3 ^c	66.2 ^a	67.3 ^a	1.0	0.001	0.001
FCR F _{FM} F _{FM}	7.0 ^{d*}	6.0 ^{d*}	6.0 ^c	6.0 ^c	6.0 ^c	5.0 ^c	4.1 ^c	0.07	0.001	0.001

Specific growth rate [%]: $(\log(\text{harvest mass}) - \log(\text{initial mass})) / \text{time}$ (Lugert 2016)

*Initially: approx. 4000 larvae

SE: Standard error of LSMEANS



Larval nutrient contents



% of DM	Feeding Substrate							P Values ¹ , ≤		
	HIFI	LOFI	SIPE	SLRE	CAFI	CF	GD	SE	T	B
Dry matter, g/kg	33.2 ^a	30.8 ^{b*}	32.1 ^{ab*}	33.1 ^a	33.0 ^{ab}	33.7 ^a	26.9 ^c	0.5	0.001	0.784
Crude protein	40.7 ^c	42.0 ^c	42.2 ^{bc*}	41.9 ^c	41.9 ^c	44.9 ^{b*}	48.2 ^a	6.4	0.001	0.001
Crude lipid	34.2 ^{a*}	29.8 ^{bc}	30.4 ^{bc}	31.7 ^{ab*}	28.8 ^{ct}	31.3 ^{bc†}	19.3 ^d	5.7	0.001	0.000
Crude fibre	5.78 ^b	5.34 ^b	5.45 ^b	4.57 ^c	5.74 ^b	5.34 ^b	6.57 ^a	2.22	0.001	0.079
NDForg	10.5 ^{ab}	9.1 ^{bc}	10.2 ^{ab}	8.4 ^{c*}	10.0 ^{abc*†§}	9.9 ^{abc}	11.5 ^{a†§}	3.70	0.001	0.124
ADForg	6.91 ^{ab*}	6.05 ^{bc}	6.63 ^b	5.37 ^{ct§}	6.26 ^{bct†}	6.29 ^{bc§}	7.81 ^{a*}	2.21	0.001	0.014
ADL	0.67 ^b	0.47 ^b	0.72 ^b	0.46 ^b	0.70 ^b	0.47 ^b	1.30 ^a	0.98	0.001	0.005
Chitin*	6.51 ^{a†}	6.24 ^a	5.90 ^{ab§}	5.82 ^{ab&}	5.58 ^{ab*}	5.56 ^{ab†}	4.90 ^{b§&}	2.27	0.001	0.222
Crude ash	11.7 ^d	14.3 ^b	13.0 ^c	13.7 ^{bc}	14.5 ^b	8.2 ^e	15.7 ^a	3.7	0.001	0.970

*Chitin = ADForg – ADL (Hahn et al. 2018)

SE: Standard error of LSMEANS

Discussion

Promising growth performance

- Favourable nutrient profiles (crude protein & gross energy)
- Oddon (2022): crude lipid contents >1% - 4.5 % DM support growth performance
 - Crude lipid contents of 8 to 15 % DM seem to be possible!

Promising nutrient conversion efficiency

- Stocking density of 4 larvae/cm² ensured comparability to previous results
 - Guillaume (2022): FCR (Dry/Dry) optimised at 11.4 larvae/cm²
- Presumably adverse physical properties increased mortality

Conclusion and Outlook



The tested substrate mixtures have the potential to enable the use of high volume by-product streams that can supply BSFL growth performance in operations with minor adjustments.



Further analysis of particle characteristics, fatty acid and amino acid patterns are needed to better understand the effects of the substrate mixtures.

Thank you for your attention!



Acknowledgement

Katharina Grot, Birgit Mielenz, Elke Wünsche, Kirsten Kàrpàti, Kerstin Pilz, Tanja Lenke, Sophie Ohde, Dirk Oswald, Thomas Geick



Forschungsinstitut für Nutztierbiologie
Wilhelm-Stahl-Allee 2
18196 Dummerstorf

www.fbn-dummerstorf.de

Thomas Freimuth

freimuth@fbn-dummerstorf.de
+49 382 0868 – 665



8th EAAP International Symposium on Energy and Protein Metabolism and Nutrition (ISEP 2025)

15 – 18 September 2025
Rostock-Warnemünde, Germany

<https://isep2025-fbn.de/>

Abstract submission:
9 December 2024 – 1 March 2025



Research Institute for
Farm Animal Biology

Freie Universität



Berlin

Universität
Rostock



Traditio et Innovatio

C | A | U

Christian-Albrechts-Universität zu Kiel

Statistical model



Model:	Proc Mixed (Version 9.4., SAS Institute Inc., Cary, NC, USA)
Fixed effects:	Substrate (T), Block (B), interaction omitted as not significant
Post Hoc Test:	Tukey-Kramer, $\alpha < 0.05$, tendency: $0.05 < P \leq 0.1$