Insect-based agribusiness for sustainable grasshopper and cricket production and processing for food in Kenya and Uganda

James Peter Egonyu

On Behalf of the Insects for Food, Feed and Other Uses – INSEFF Programme

Food and Agriculture Organization of the United Nations

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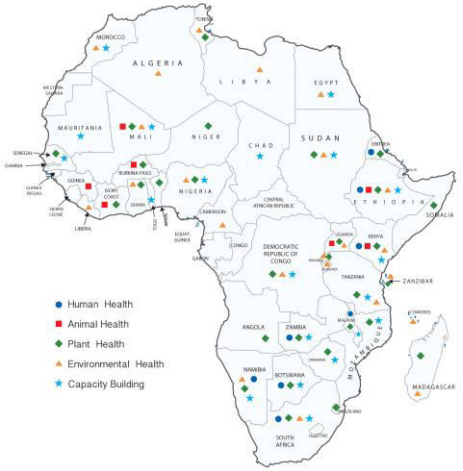
General Facts - ICIPE

- A *Center of Excellence* in Africa- for research and capacity building for insect science – Headquarter in Kenya
- An *intergovernmental organization* - Charter signed by 13 countries worldwide
- >530 staff (>40 nationalities)
- 150-180 graduate students annually
- Collaborate with > 300 partners worldwide
- Operates in >41 countries
- 4H – Themes



A *unique* history: 50+ years

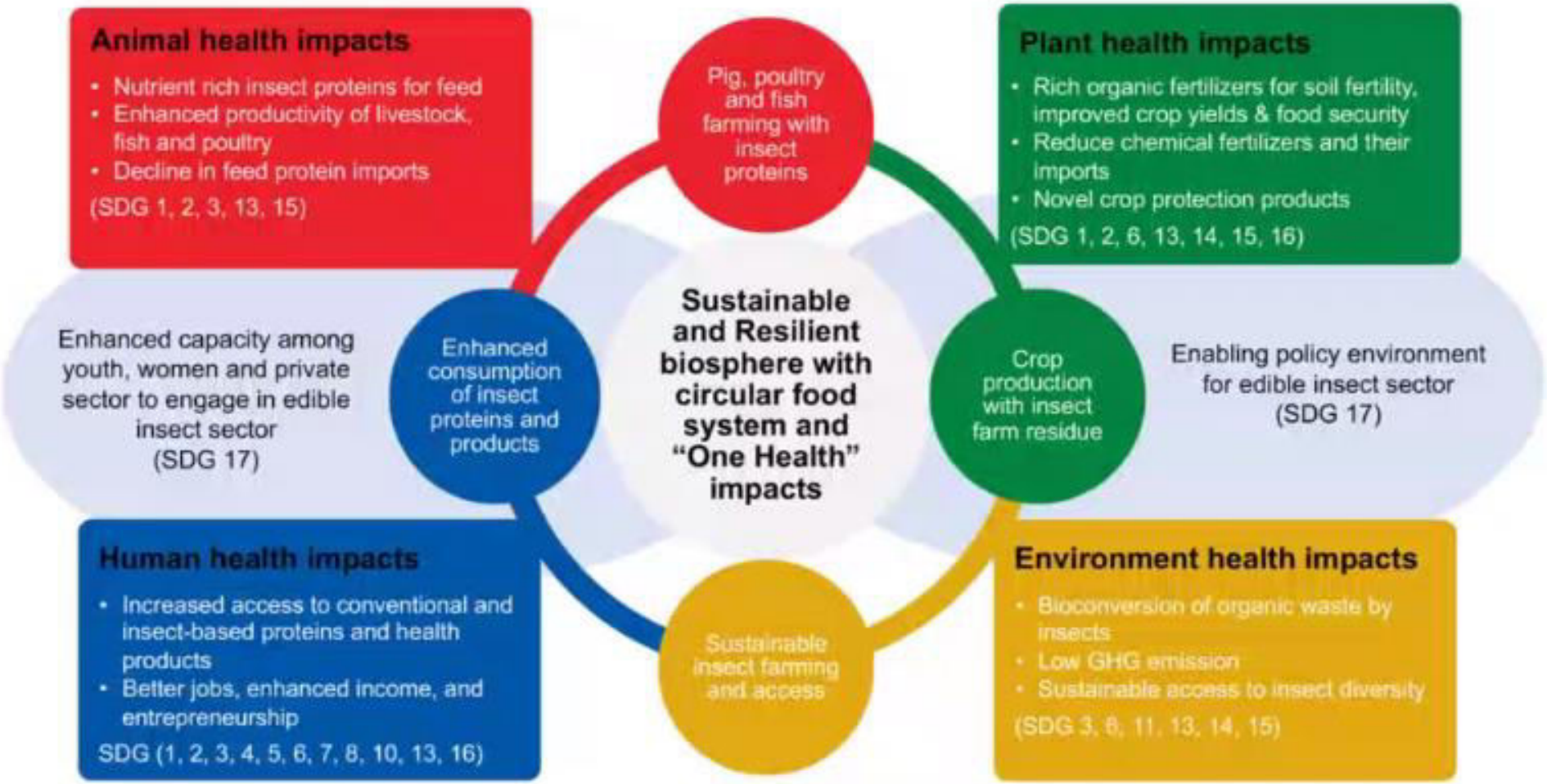
T.R. Odhiambo

H.R. Herren

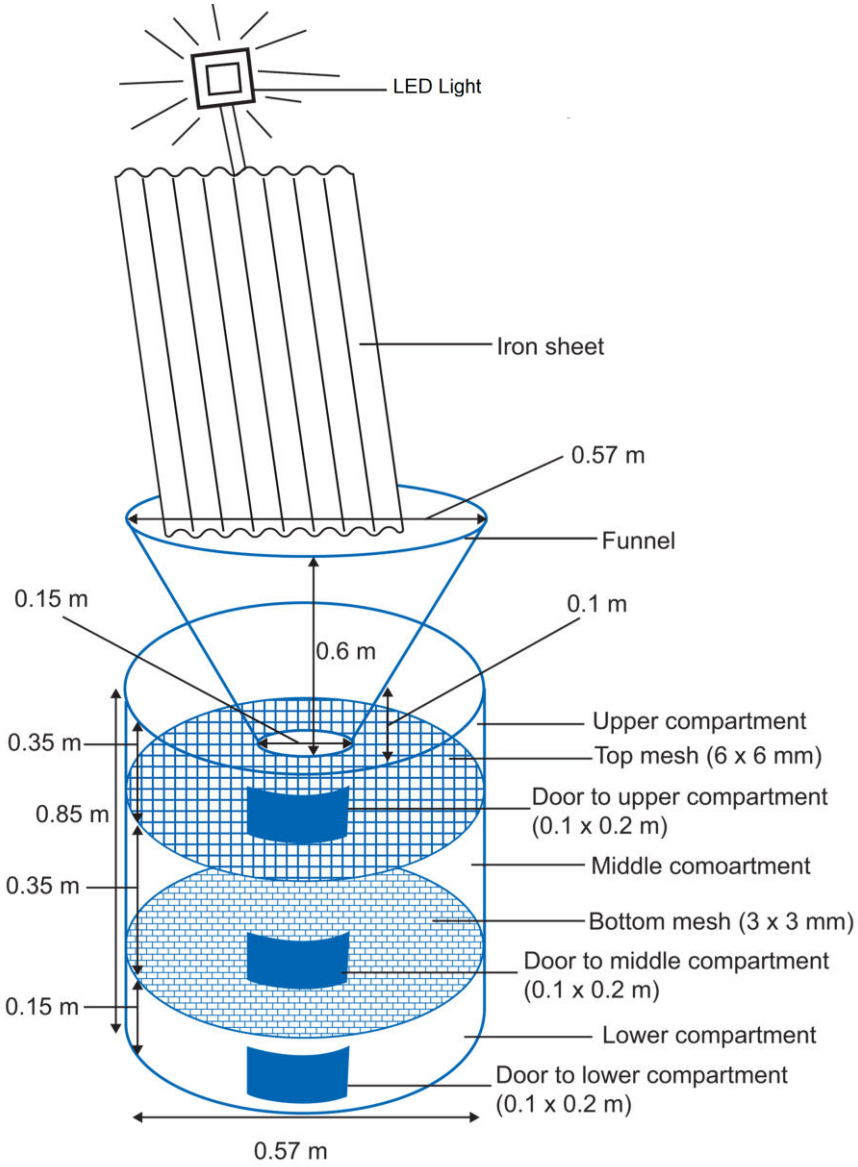
C. Borgemeister

S. Kelemu

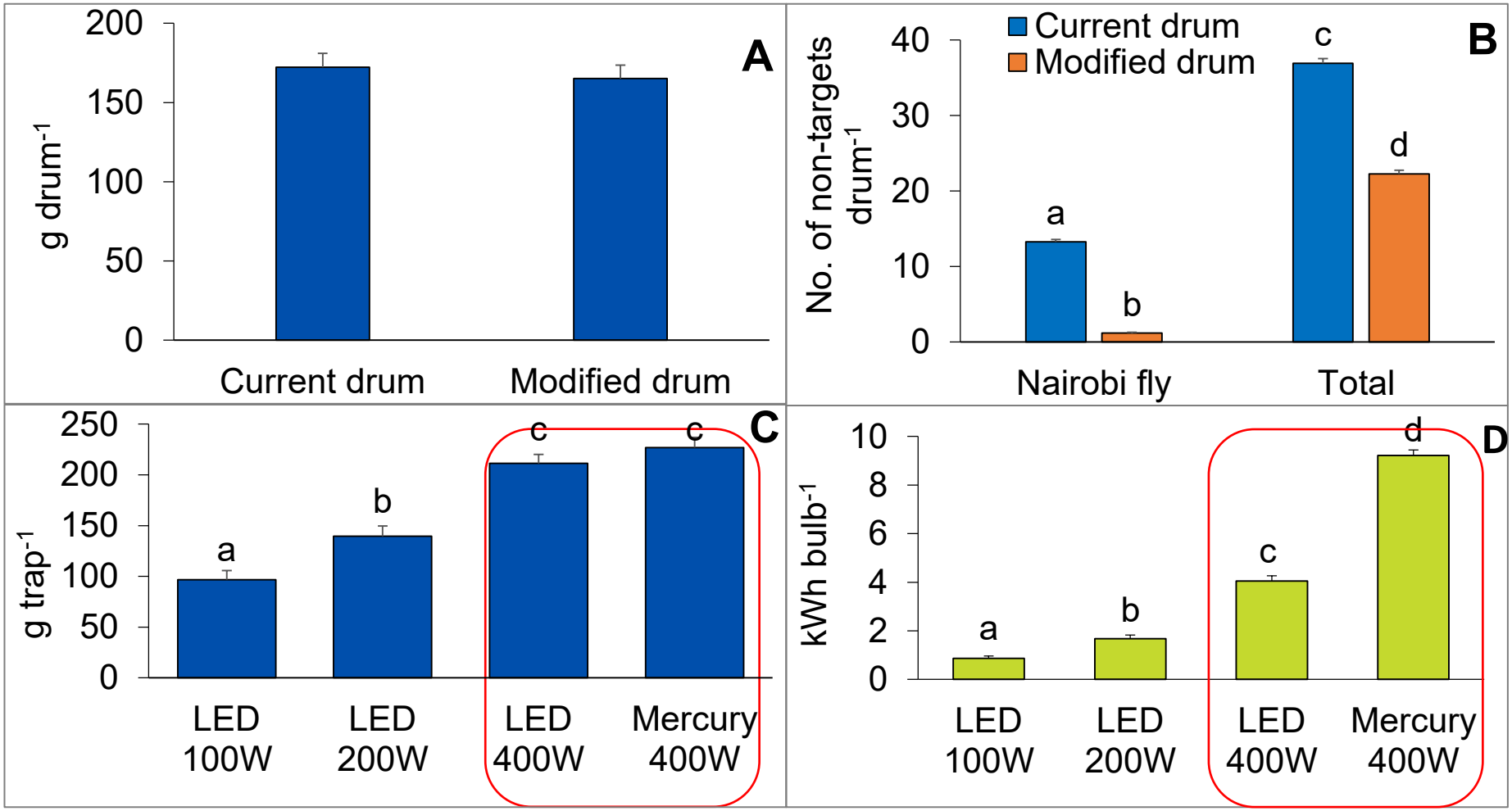
ONE HEALTH CONCEPT OF THE PROJECT



Sustainable harvest of edible grasshopper *(nsenene)*



Efficiency & profitability of the improved technique



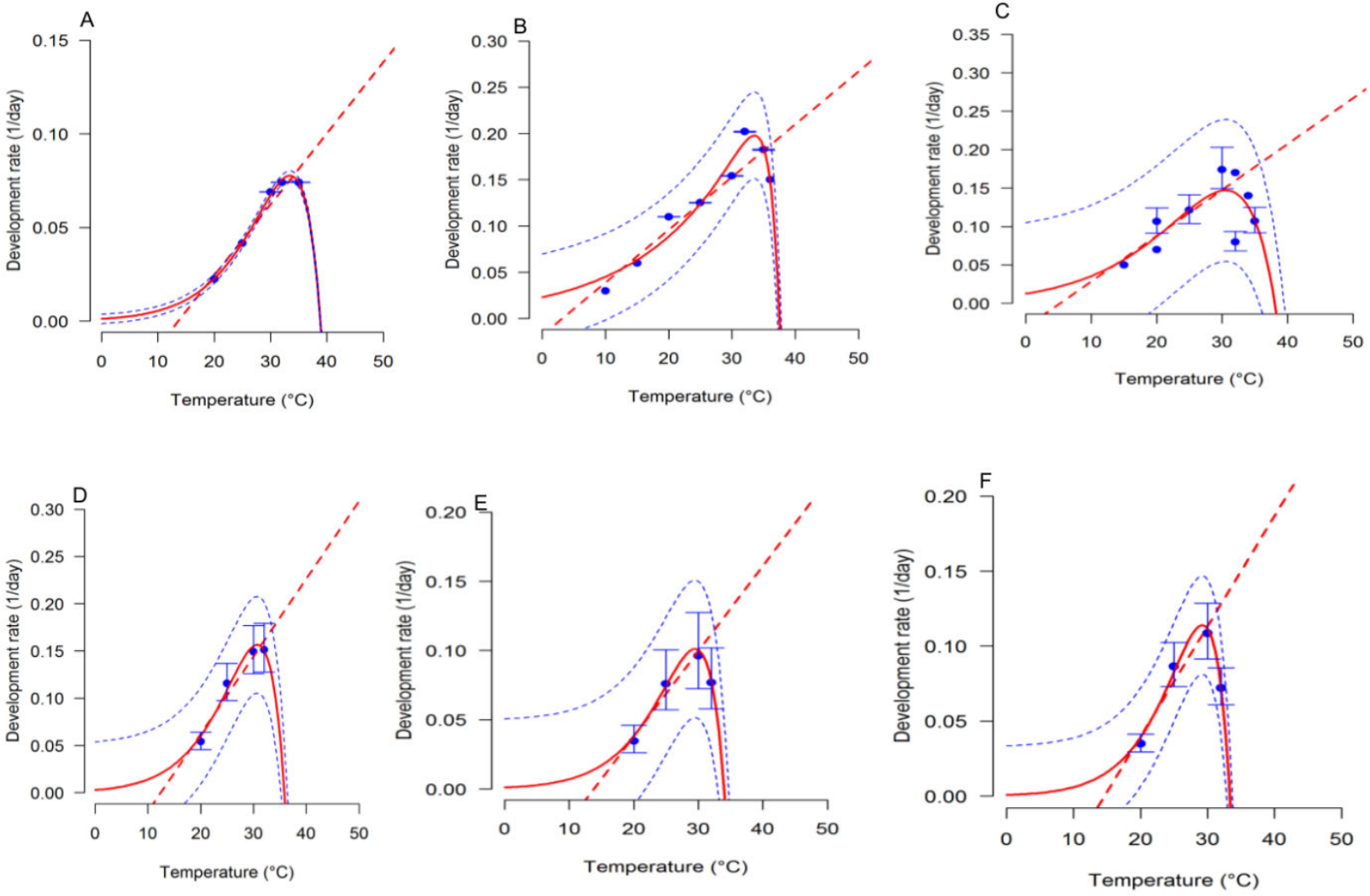
Parameter	Current	Improved
Net present value (NPV; US$)	3080	4487
Benefit cost ratio (BCR)	2	3.2
Payback period	0.2	0.6

Sengendo et al 2021-IJTIS

Mass rearing of *nsenene*

Temperature (°C)	Egg hatchability (%)	Egg to adults (days)	5th Instar mortality (%) -	Fecundity (Eggs)
15	-	-	-	-
20	48.0±7.1c	153.0±2.3d	56.7±0.1a	124.0±0.9b
25	76.0±6.0b	78.0±0.9c	17.1±0.1b	187.7±0.4c
30	81.4±2.5a	58.0±0.9b	12.3±0.1c	159.7±0.3bc
32	75.7±6.1b	52.5±0.7a	17.2±0.2b	51.4±0.4a
35	47.1±7.1c	-	-	-

Temperature-based phenology models for immatures

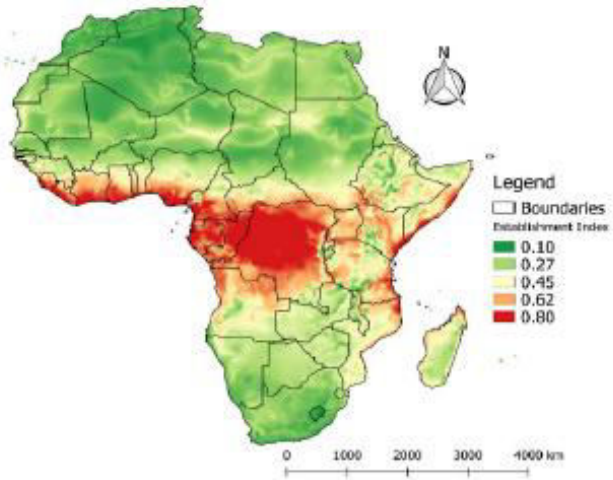


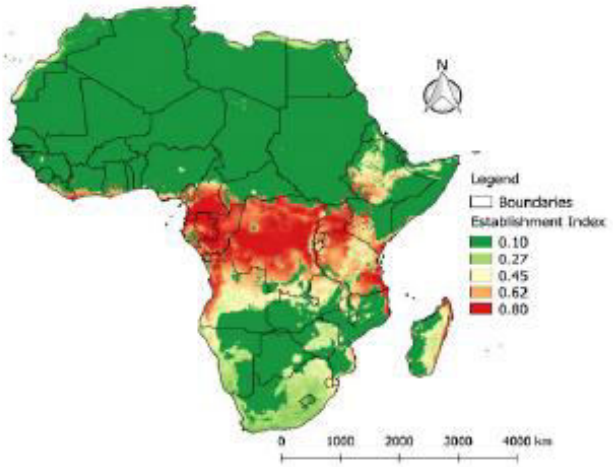
Predictions of suitable sites and number of generations

2000

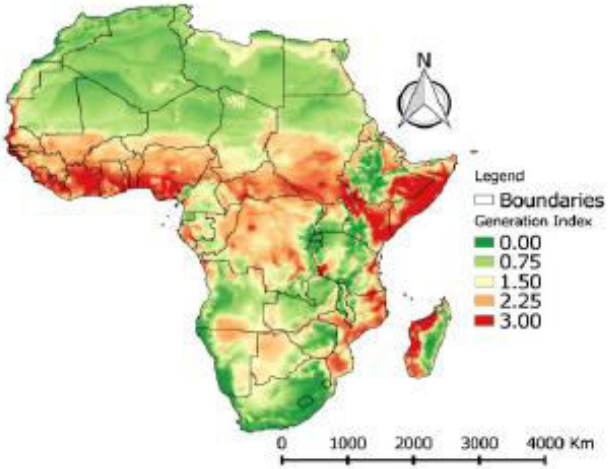
2050

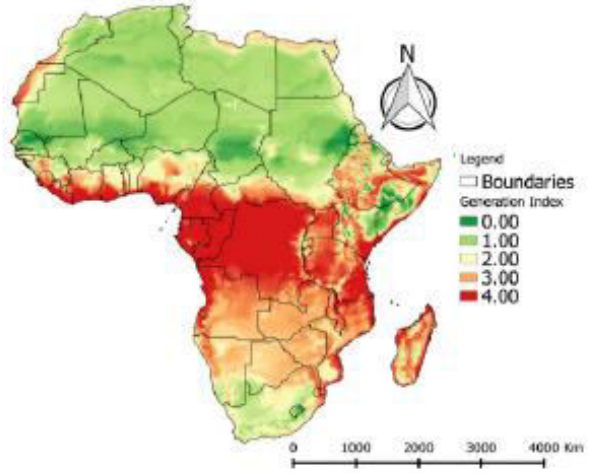
Establishment





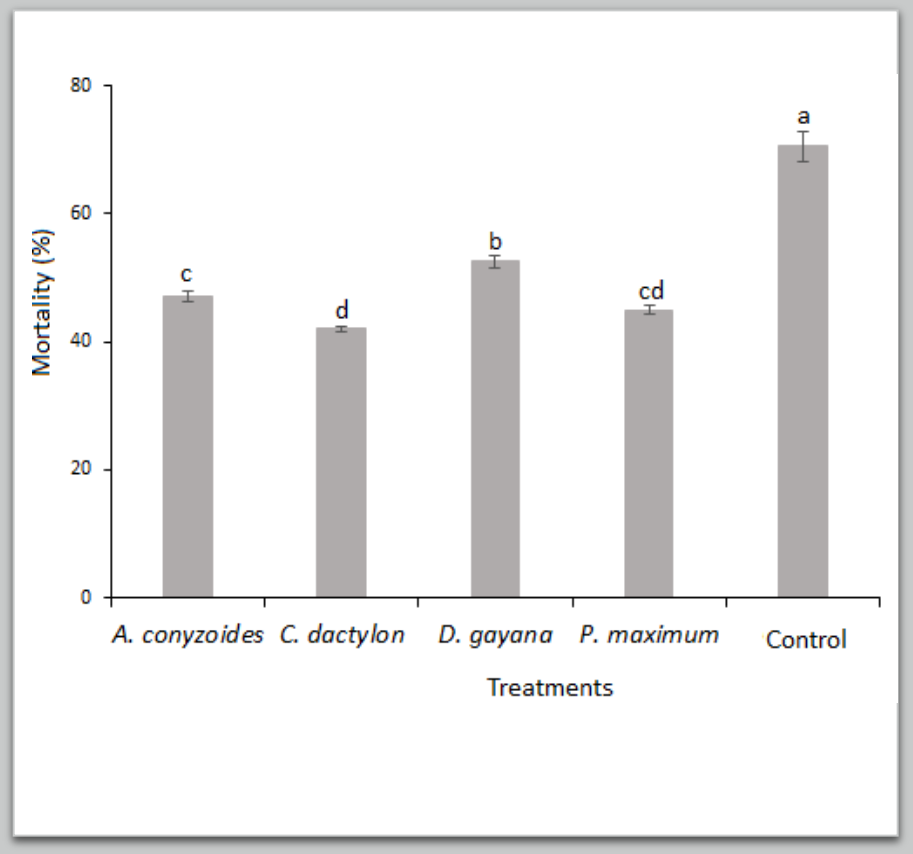
Generations/year

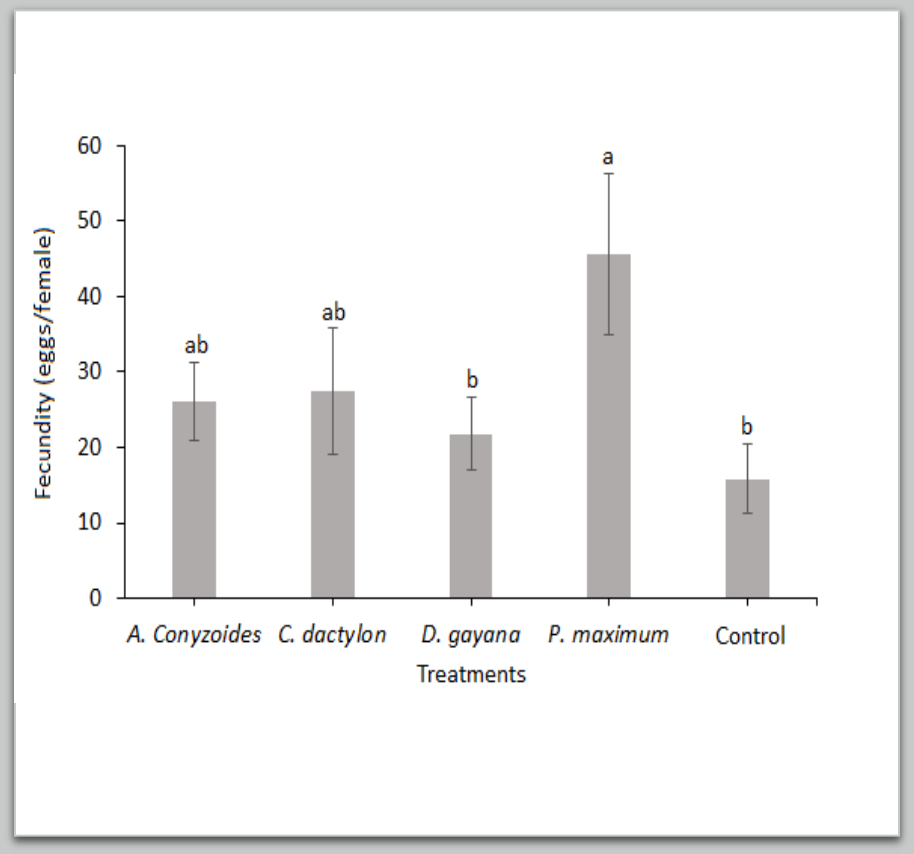




Developing rearing diet: host plant identification

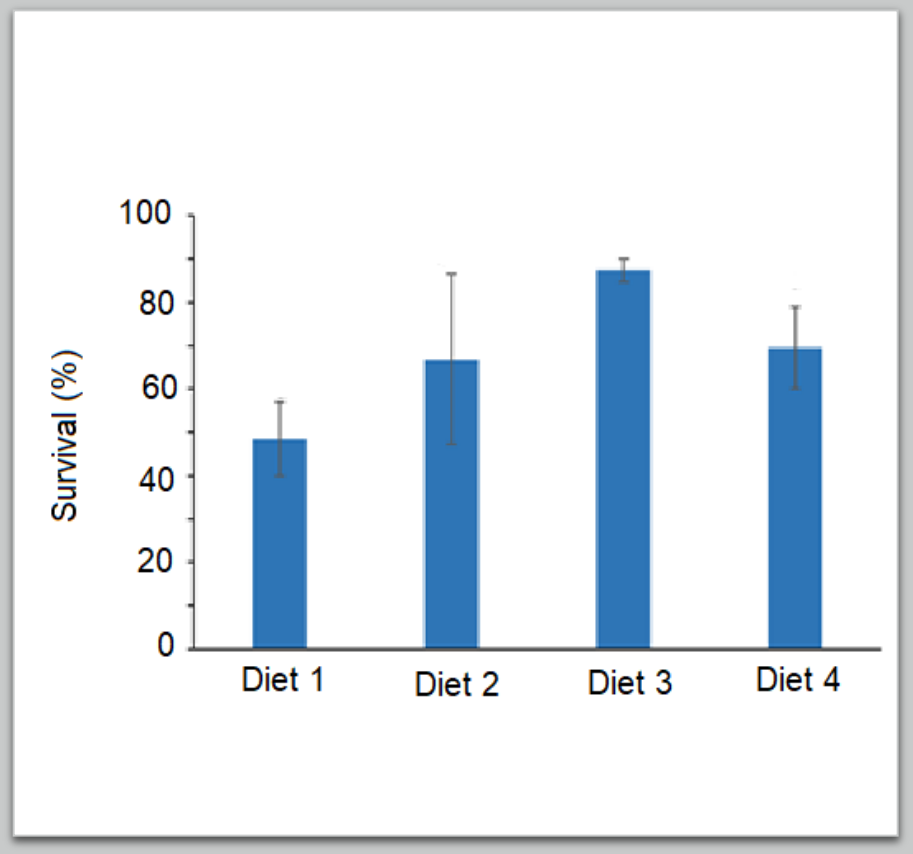
- *Digitaria gayana*
- *Ageratum conyzoides*
- *Citrus depressa*
- *Cynodon dactylon*
- *Eragrostis mexicana*
- *Eucalyptus saligna*
- *Indigofera arrecta*
- *Persicaria nepalensis*
- *Sorghum halepense*

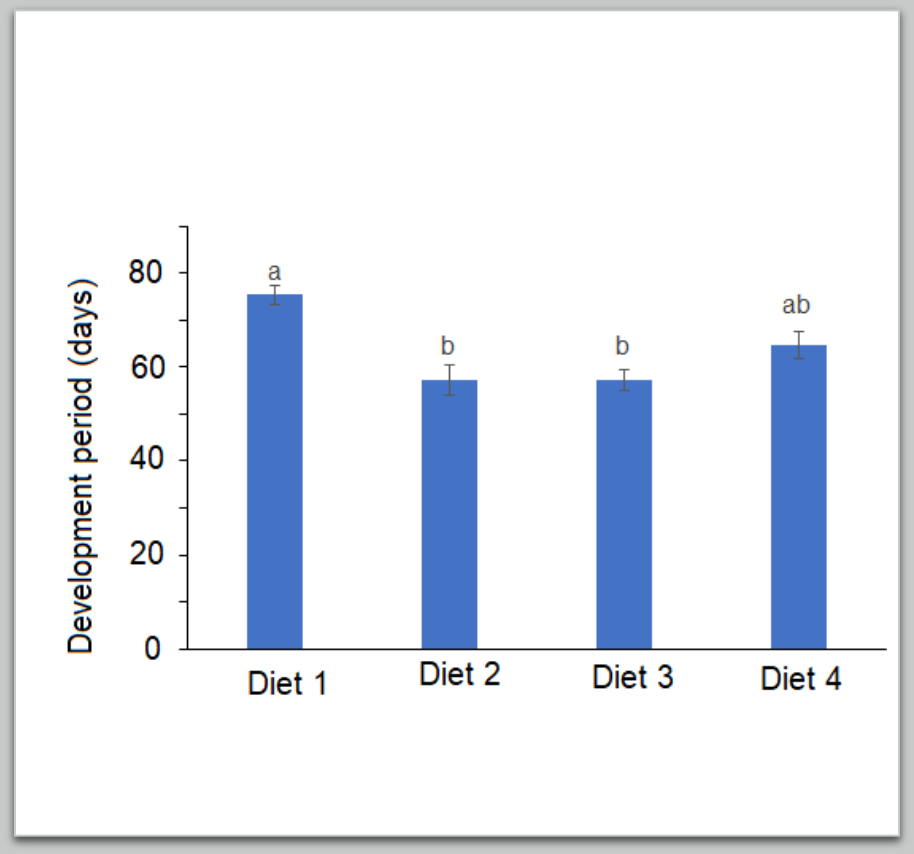




Mortality and fecundity under host-plant based diets

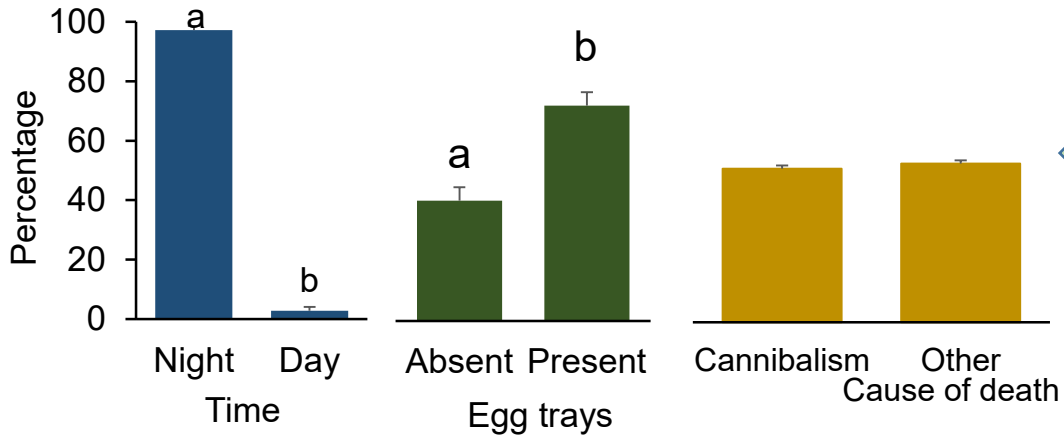
Leonard et al 2022-JIS



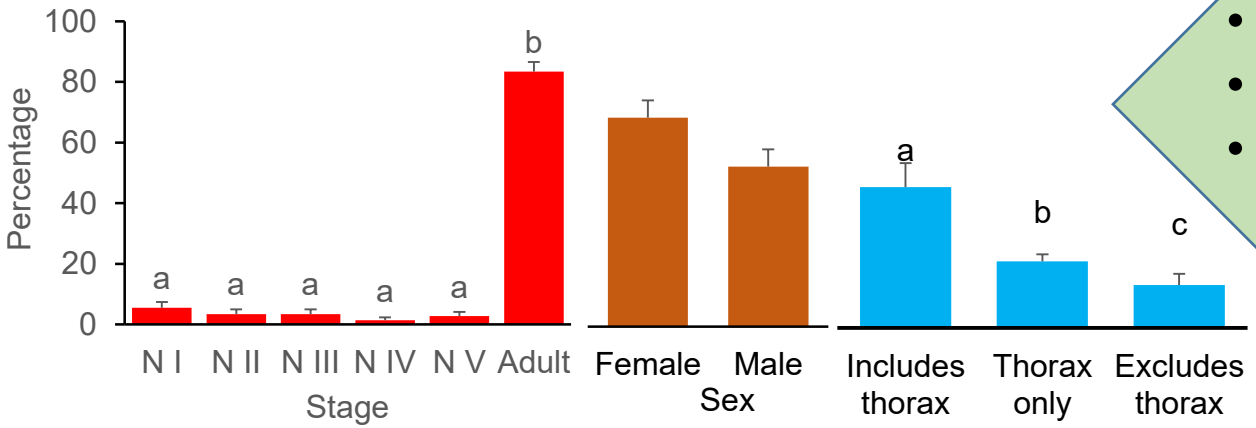


Exploring readily available substrates to optimise *nsenene* diet: maize bran, wheat bran, soybean, moringa and shrimps

Cannibalism: A major hindrance to mass rearing



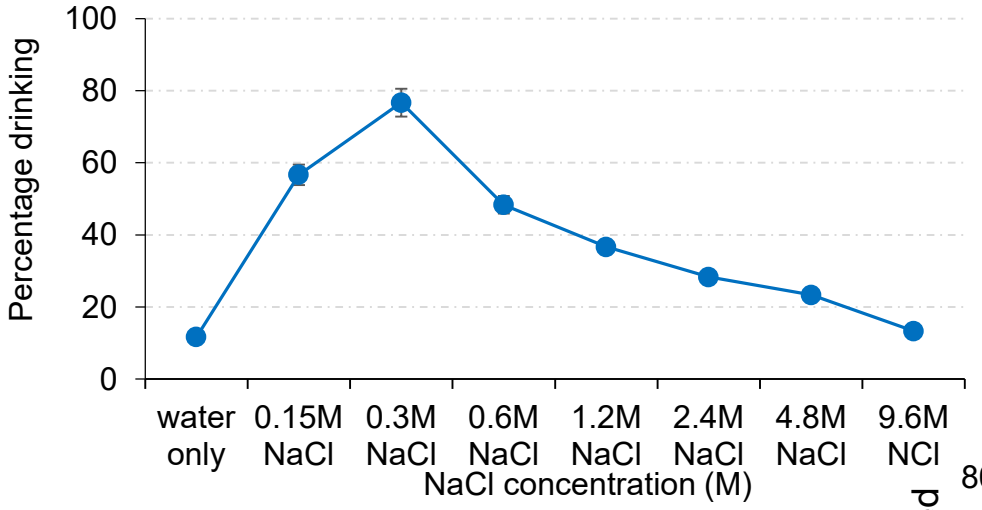
- 49% of *R. differens* deaths
- Egg trays almost doubled cannibalism
- 97% in the night



- thoraxes of 77% eaten
- No sex bias
- 83% victims were adults

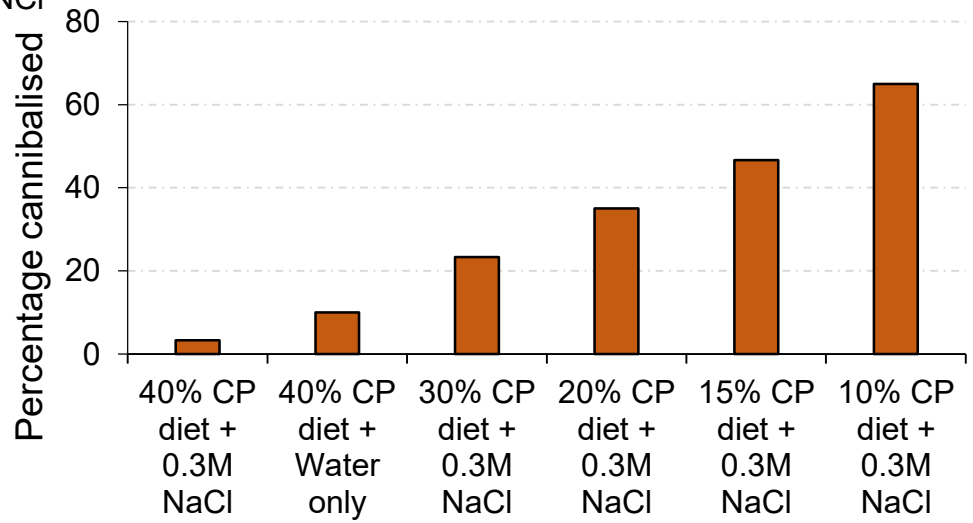
Egonyu et al 2021-JIFF

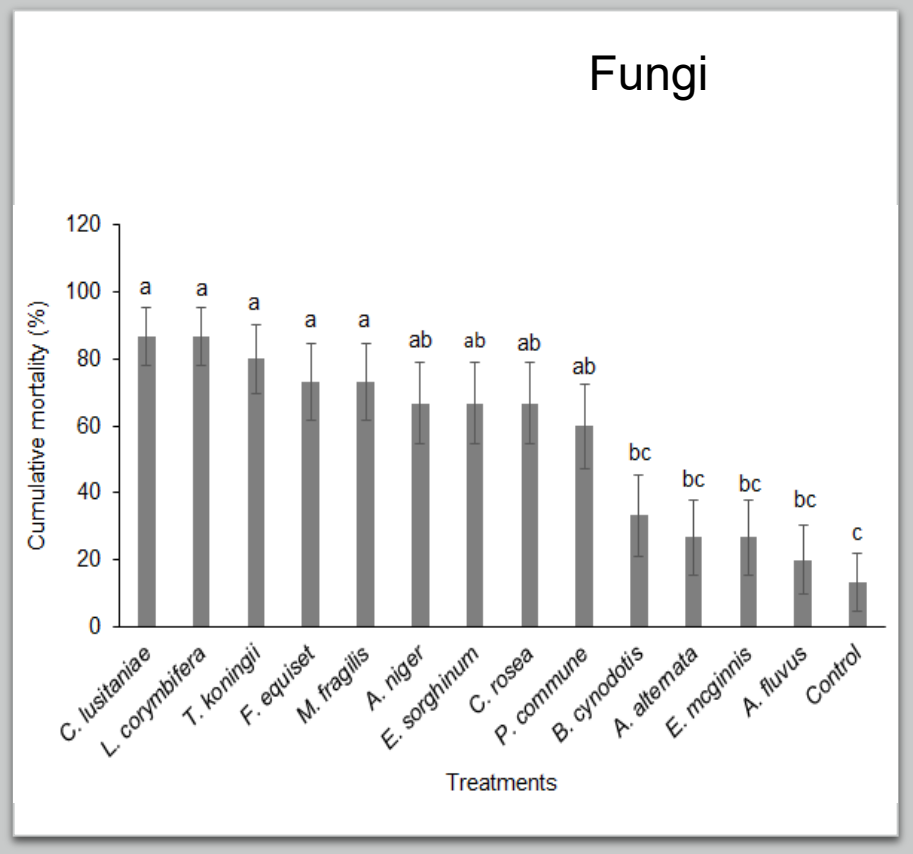
Salt and protein manipulation to curb cannibalism

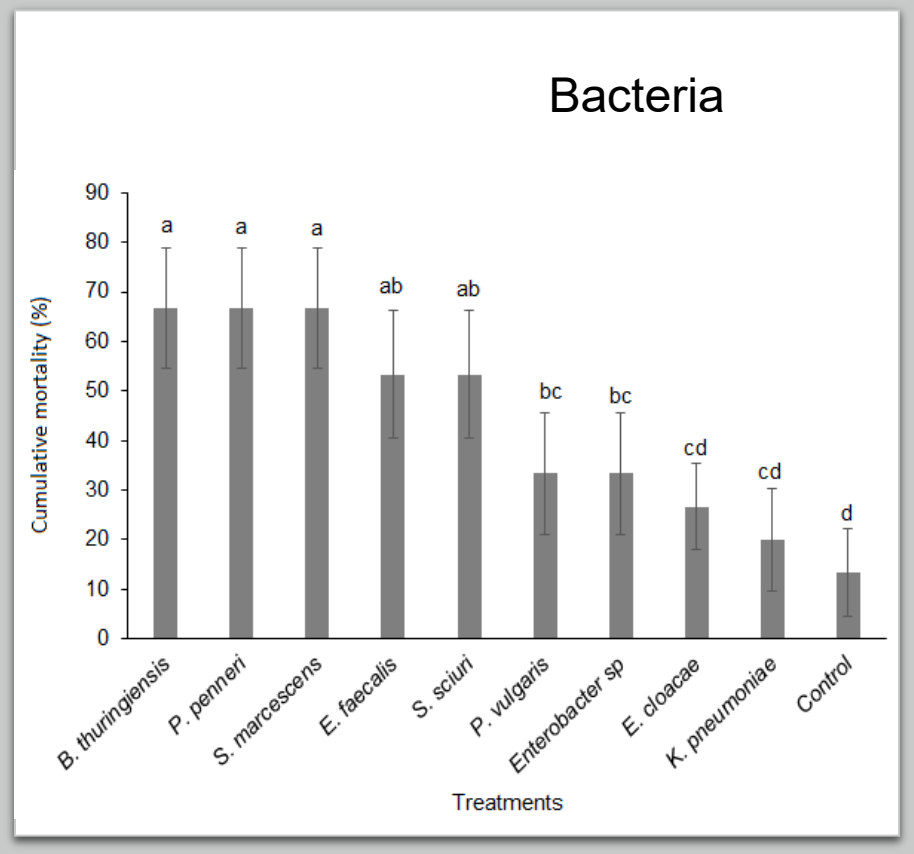


0.30 M NaCl most preferred

40% CP + 0.3M NaCl reduced cannibalism to 3.3% from 65% in 10% CP diet



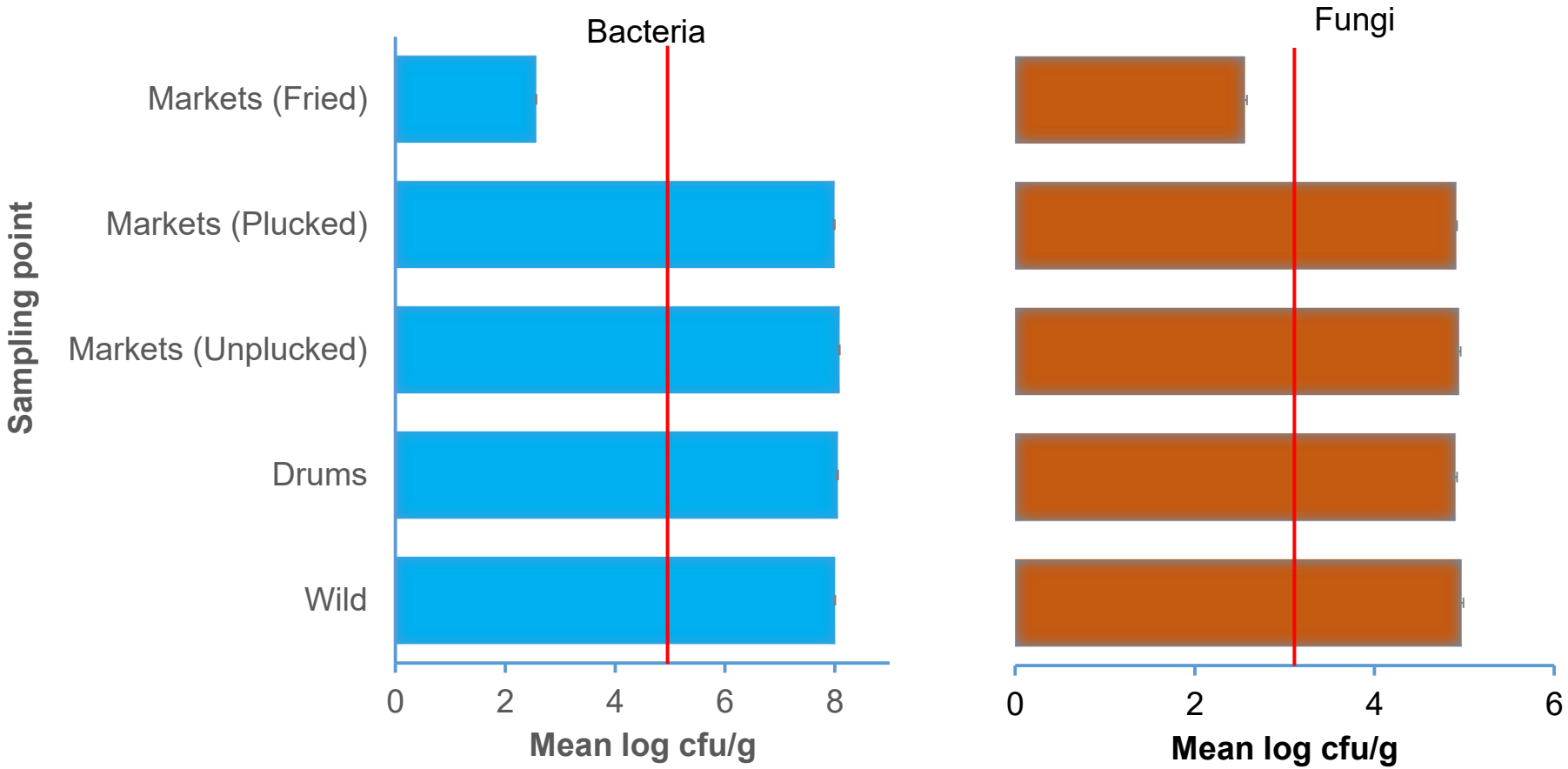




Diseases: A setback to mass rearing

Leonard et al-Afr Ent

Nsenene safety from microbial loads



Leonard et al 2021-JIFF

Spectrum of microbial contaminants of *R. difference*

Contaminant microbe	Whole insect			Processed insect (market)	
	Wild vegetation	*Harvesting drums*	*Market*	*Plucked*	*Deep-fried*
Gram positive bacteria					
Bacillus cereus	■	■	■	■	■
Bacillus thuringiensis		■			
Staphylococcus sp. Strain		■			
Staphylococcus sciuri		■			
Gram negative bacteria					
Serratia marcescens		■	■		
Acinetobacter baumannii			■		
Roseomonas sp				■	
Basidiomycota					
Rhodotorula muscilaginosa	■	■	■		
Rhodotorula dairenensis		■		■	
Trichosporon asahii			■	■	
Papiiliotrema laurentii	■				
Ascomycota					
Trichoderma asperellum	■	■	■	■	■
Clavispora lusitaniae	■	■	■	■	
Pichia kudriavzevii			■	■	

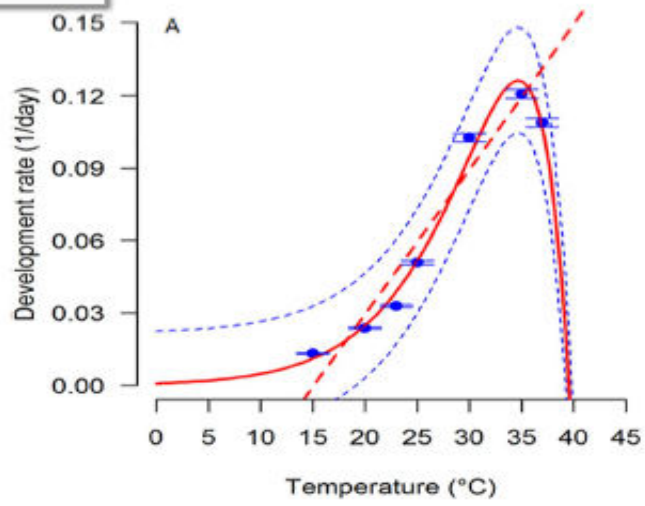
Labu et al 2021-JIFF: Red highlights are food-born pathogens

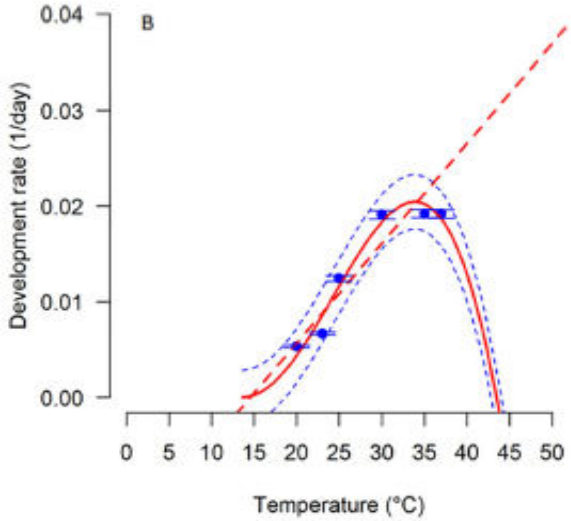
Effect of processing on *nsenene* nutritional value

Proximate composition						
Processing method	Moisture	Dry Matter	Protein	Fat	Ash	Fibre
Blanching	1.8 ± 0.05^{b}	98.2 ± 0.05^{b}	40.1 ± 1.33^{b}	43.8 ± 0.41^{b}	2.2 ± 0.00^{b}	11.2 ± 0.01^{b}
Boiling	14.5 ± 0.10^{c}	85.6 ± 0.10^{a}	43.1 ± 1.60^{bc}	36.3 ± 1.06^{a}	2.3 ± 0.09^{b}	10.9 ± 0.19^{b}
Toasting	1.6 ± 0.06^{b}	98.4 ± 0.06^{b}	44.7 ± 1.03^{c}	46.0 ± 0.82^{b}	2.4 ± 0.17^{b}	9.0 ± 0.74^{a}
Deep-frying	0.8 ± 0.03^{a}	99.2 ± 0.03^{c}	7.8 ± 0.59^{a}	83.0 ± 1.54^{c}	1.2 ± 0.16^{a}	8.7 ± 0.39^{a}
F_{df}	$F_{(3,8)}$	$F_{(3,8)}$	$F_{(3,8)}$	$F_{(3,8)}$	$F_{(3,8)}$	$F_{(3,8)}$
P-value	0.001	0.001	0.001	0.001	0.001	0.001

Ochieng et al 2022- Food Chem

Improving cricket rearing





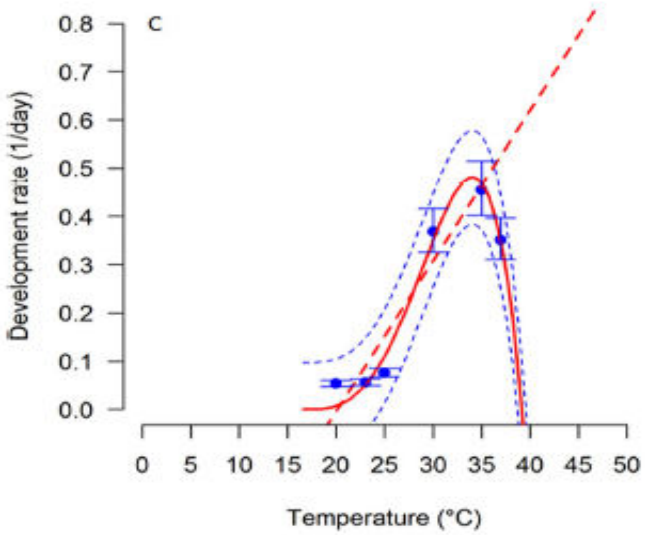
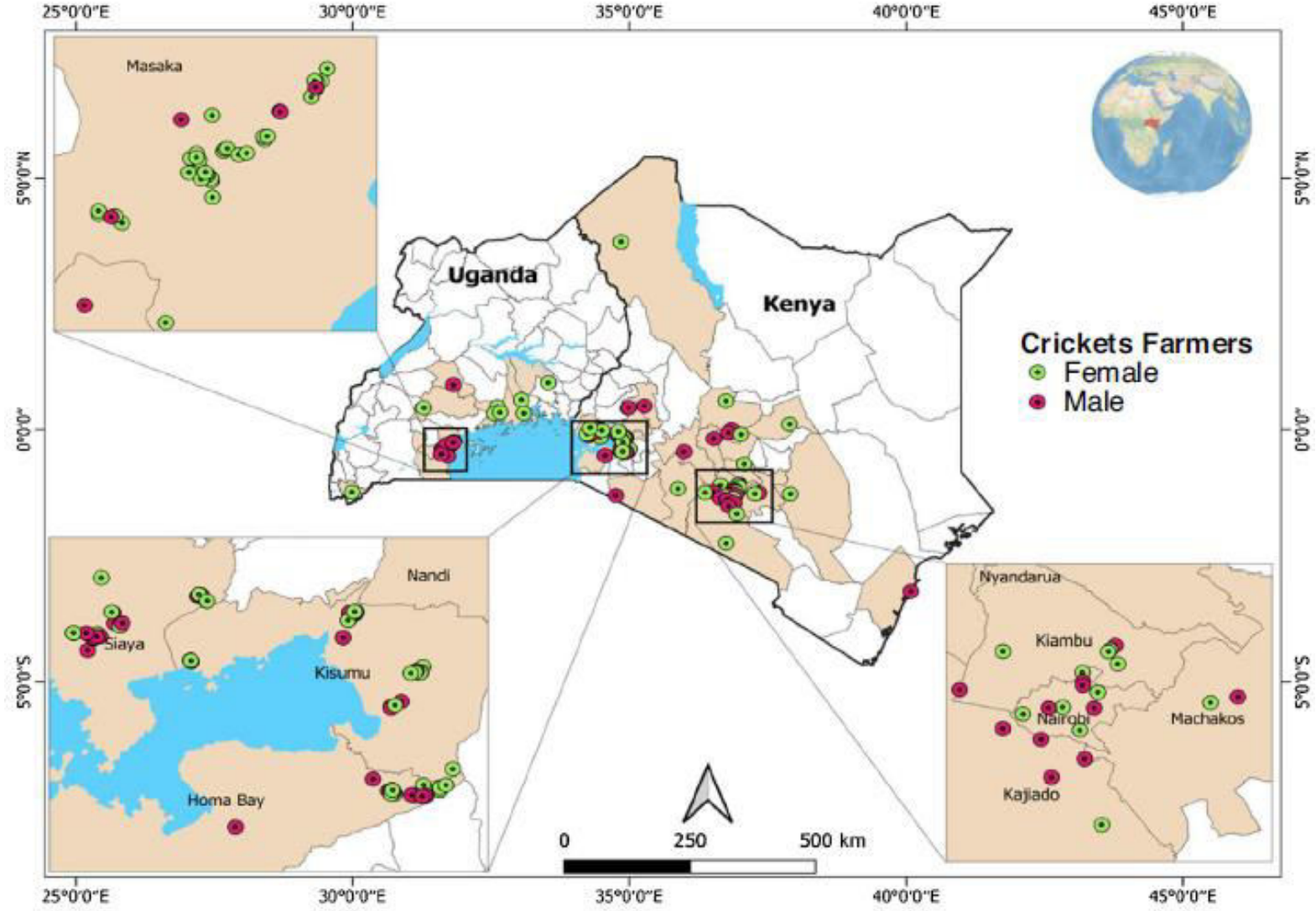


Fig 2. Temperature-dependent developmental rate of *Scapsipedus icipe*. (A) Egg; (B) Nymphs; (C) Pre-adult. Observed values are the solid points, with bars

Magara et al 2019-PlosOne

Scaling cricket rearing



Tanga et al 2022-COIS

Protein & fat content: crickets vs other protein sources

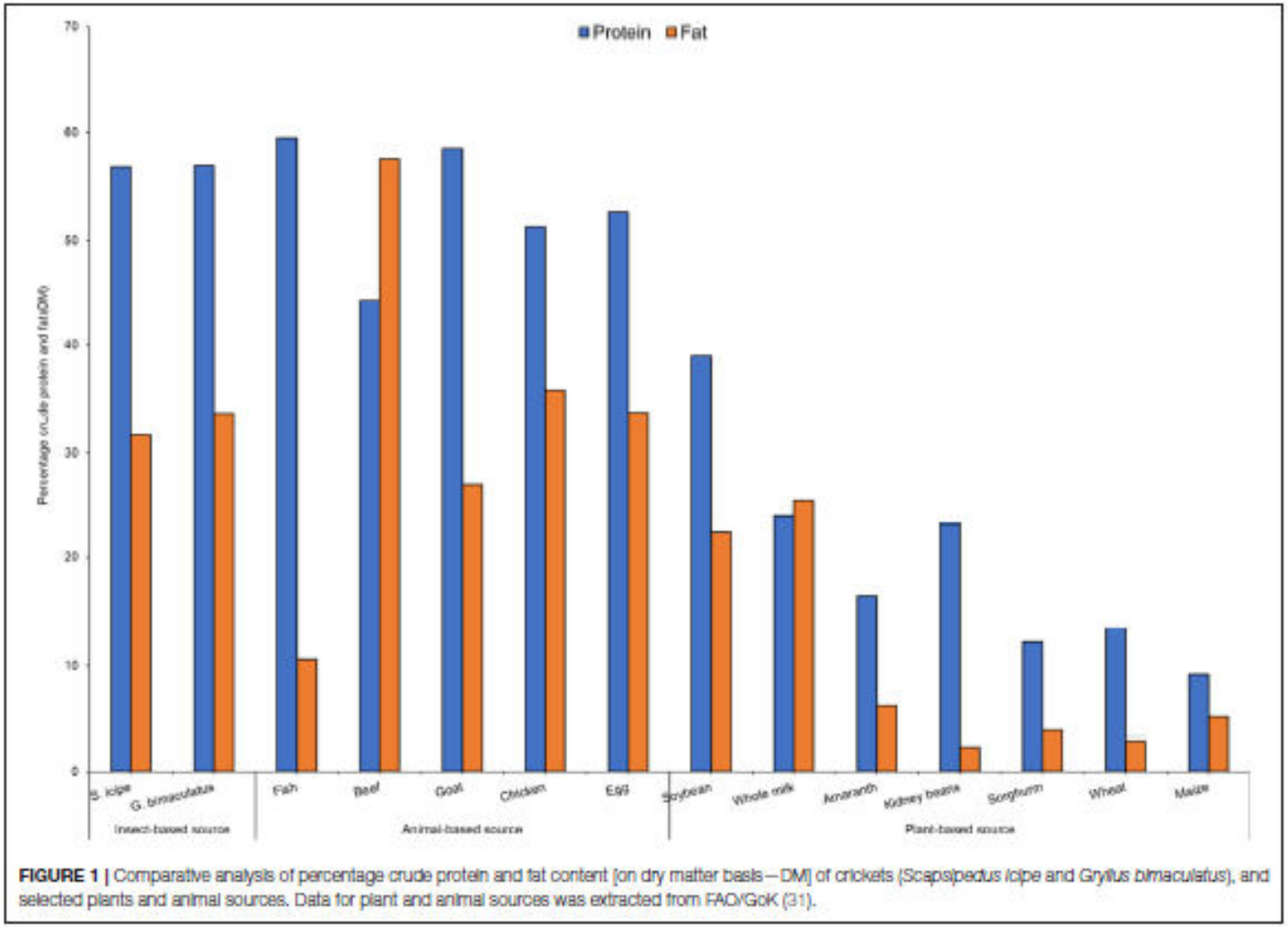


FIGURE 1 | Comparative analysis of percentage crude protein and fat content [on dry matter basis—DM] of crickets (*Scapsipedus icipe* and *Gryllus bimaculatus*), and selected plants and animal sources. Data for plant and animal sources was extracted from FAO/GoK (31).

Minerals: crickets vs other protein sources

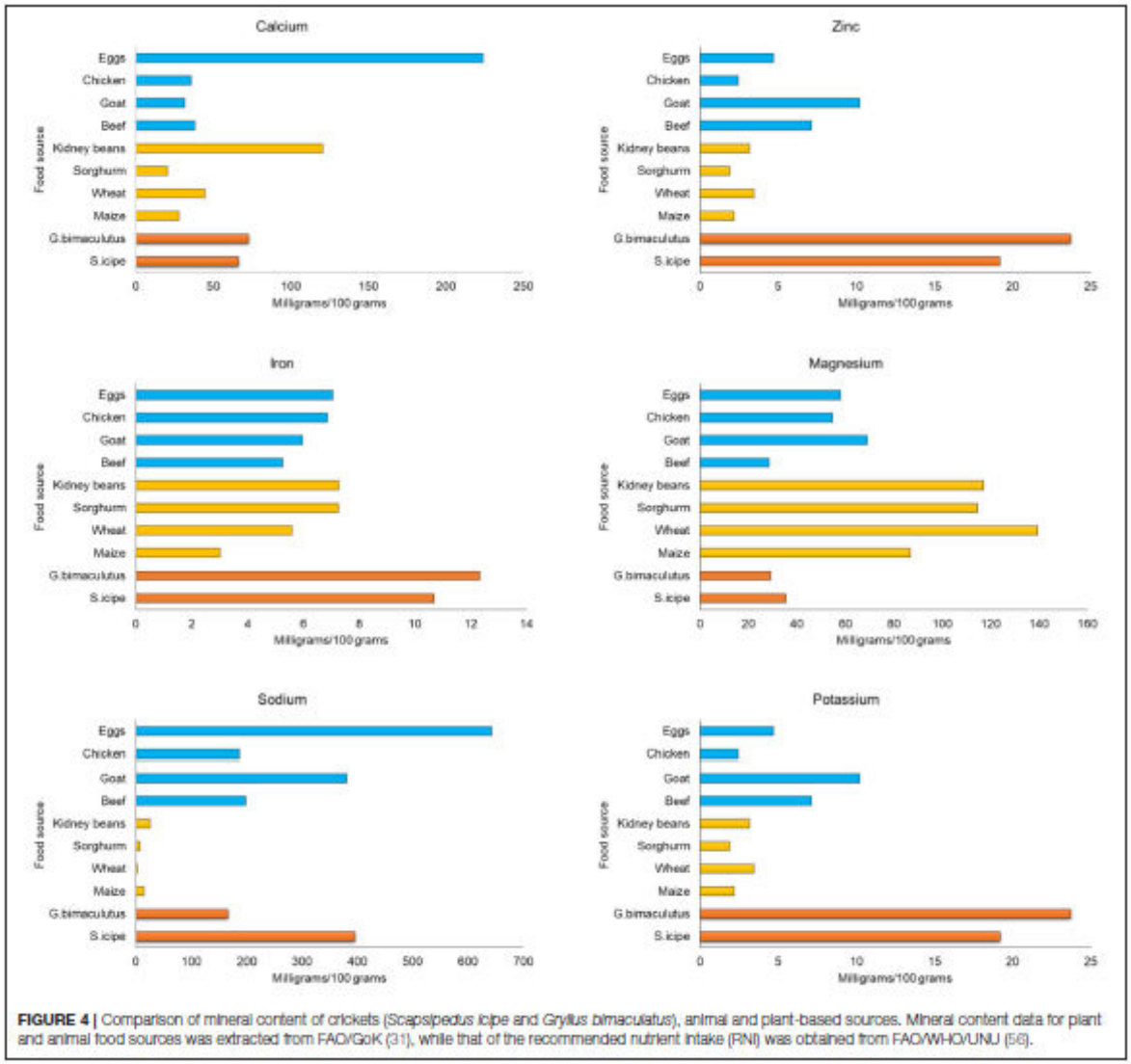
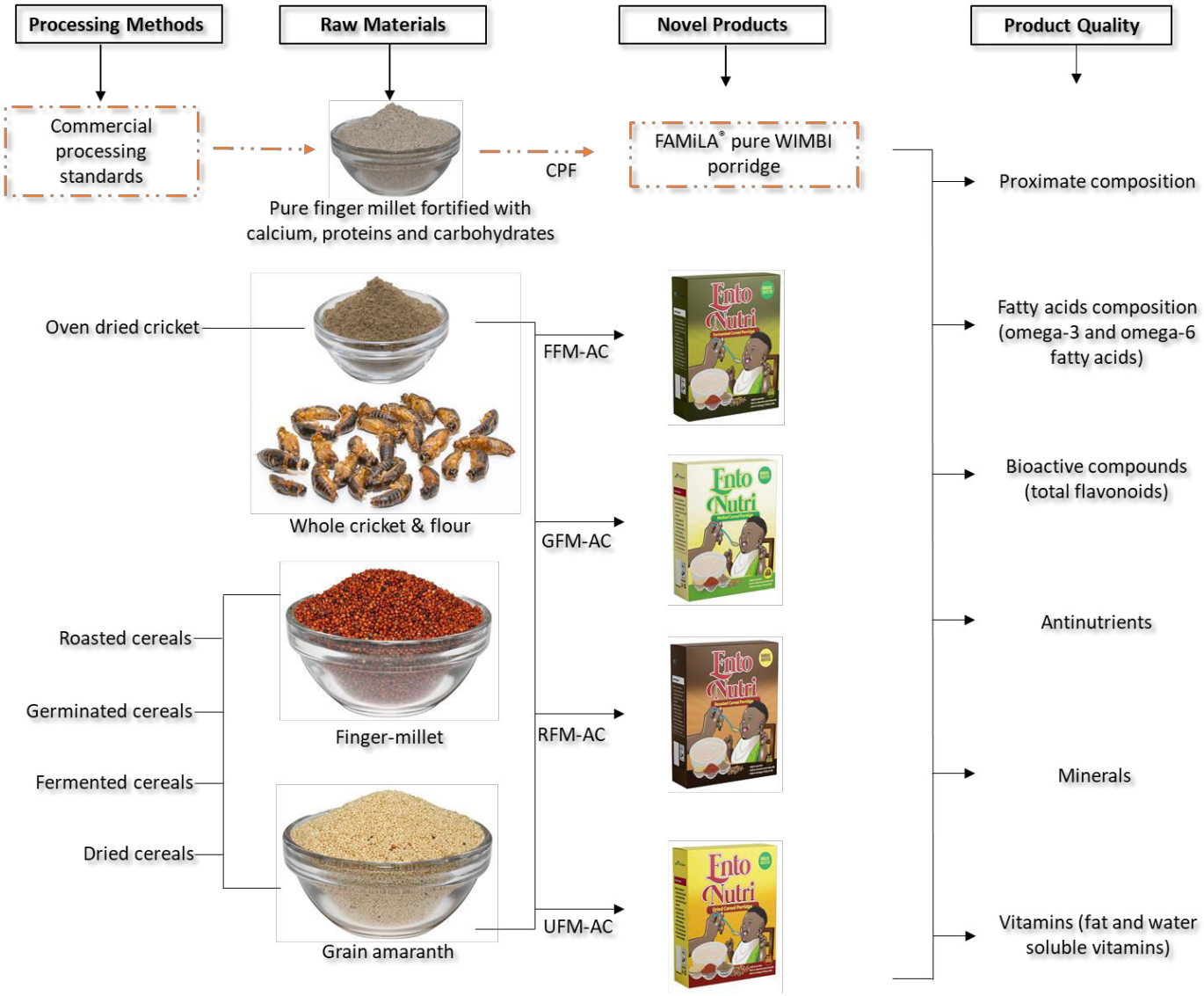


FIGURE 4 | Comparison of mineral content of crickets (*Scapsipedus icipe* and *Gryllus bimaculatus*), animal and plant-based sources. Mineral content data for plant and animal food sources was extracted from FAO/GoK (31), while that of the recommended nutrient intake (RNI) was obtained from FAO/WHO/UNU (56).

Food fortification with cricket



Crickets boost protein & fat content of porridge

Products	Proximate Composition						
	Moisture (%)	Ash (g/100 g)	Fiber (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	CHO (g/100 g)	Energy (kcal/100 g)
CPF	11.8 ^{e}	2.6 ^{ab}	4.8 ^{c}	8.6 ^{a}	2.1 ^{a}	81.9 ^{d}	381.2 ^{a}
FFM–AC	4.8 ^{b}	2.2 ^{a}	3.3 ^{a}	15.3 ^{b}	7.2 ^{b}	71.9 ^{c}	413.9 ^{c}
GFM–AC	5.9 ^{c}	2.9 ^{b}	5.3 ^{d}	16.1 ^{d}	8.2 ^{c}	67.5 ^{a}	408.1 ^{b}
RFM–AC	3.0 ^{a}	2.8 ^{ab}	3.9 ^{b}	15.5 ^{bc}	8.1 ^{c}	69.7 ^{b}	413.8 ^{c}
UFM–AC	7.4 ^{d}	2.8 ^{ab}	4.6 ^{c}	15.9 ^{cd}	8.3^{c}	68.3 ^{a}	411.7 ^{bc}

Going forward

Scaling production and value addition technologies

More product development

New insect onboard: palm weevils, fruit beetles, locusts

Acknowledgement

Donors directly providing financial support to *icipe*

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Thank you

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