INSBIZ-INSect-based agriBIZiness for sustainable grasshopper and cricket production and processing for food in Kenya and Uganda

Prof. Dorothy Nakimbugwe & Dr. Geoffrey Ssepuuya

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TECHNICAL PROGRESS

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Project objectives

- Assessing the market size and testing the market performance of insect based food products
- Adaptation, piloting of mass rearing protocols for crickets and grasshoppers
- Development and characterisation of ready-to-eat whole insects, insect flours for use as ingredients in food preparation and processing insect-enriched porridge flours and cookies
- Favourable enabling environment for insect based food through policy, advocacy and awareness creation established

Objective 1: Assessing the market size and testing the market performance of insect based food products

1.1 Supply of grasshoppers

Estimations were based on:

- A season lasting 28 – 105 days
- 31 – 74 Kg/season/harvester (4 – 10 tons/season)
- 1800 – 200 ugx profit margin/Kg (0.5 – 0.6 USD/Kg)

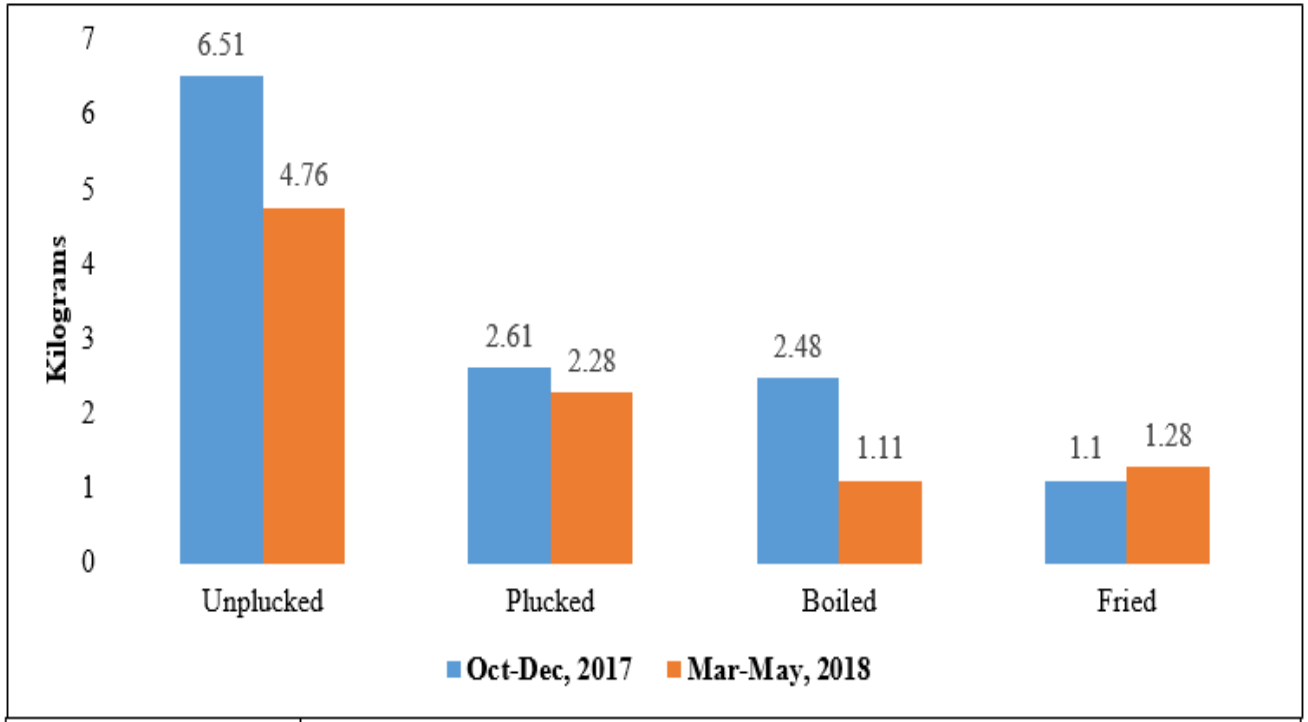
Average Estimates (Raw Un-plucked Grasshoppers)	Period		
	March – May, 2017	October – December, 2017	March – May, 2018
Total input (Ugx)	6,444,406	5,173,344	3,024,412
Total income (Ugx)	15,200,000	23,100,000	15,000,000
GH harvested (Kg)	4,482	10,632	5,463
GH sold (Kg)	4,626	10,508	5,632
Portion of the harvest sold (%)	103	99	103
Average expenditure per kilo	1,438	487	554
Price per kilo	3,286	2,198	2,663
Margin per kilo	1,848	1,712	2,110
Average harvest per season (Kg)	31	74	38
Registered harvesters (Number)*	1,784	1,784	1,848
Total amount harvested and sold (Kg)	55,304	132,016	70,224
Annual harvest May - Dec, 2017	187,320		
Annual harvest Dec 2017-May 2018		202,240	

**The number was obtained from chairpersons of the different harvester association through a key informant. Only the harvesters that registered for electric supply was available.*

1.2 Demand of grasshoppers

Estimations were based on:

- Persons aged between 15 – 64 years in central Uganda and Urban areas



	Grasshopper consumption (Kg)			
	Un-plucked	Plucked	Boiled	Fried
Individual estimate	5.64	2.45	1.8	1.19
[1]Central Uganda* estimate	15,708,621	6,823,780	5,013,390	3,314,408
[1]Urban Uganda estimate	20,605,881	8,951,136	6,576,345	4,347,695

1.3 Annual Supply of crickets

Estimated at 1.6 – 2.8 tons per year

Parameter	Farm Capacity					
	60 Rearing Containers			30 Rearing containers		
Major inputs	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*
Feed	75,625	29,000	200,000	26,341	9,200	45,100
Hide-outs (eggs trays)	54,000	54,000	54,000	27,159	2,700	54,000
Transport	7,375	4,000	12,000	6,382	2,500	10,000
Cost of troughs	120,000	120,000	120,000	60,000	60,000	60,000
Plat form	6,660	6,660	6,660	3,330	3,330	3,330
Egg incubation containers	2,400	2,400	2,400	1,200	1,200	1,200
Costs						
Total Input Cost	266,060	217,060	388,060	124,412	104,730	154,530
crickets produced (Kg)/Season	7	2	14	4	1	8
Production cost/kg cricket	***38,433***	***18,147***	***63,765***	***36,909***	***16,871***	***58,700***
Benefits (profit)						
Total Income @ 50,000 Ugx per Kilo	408,333	200,000	700,000	201,333	95,000	375,000
Margin @ 50,000 Ugx per Kilo	***133,607***	***- 55,060***	***445,940***	***76,257***	***- 16,530***	***248,470***

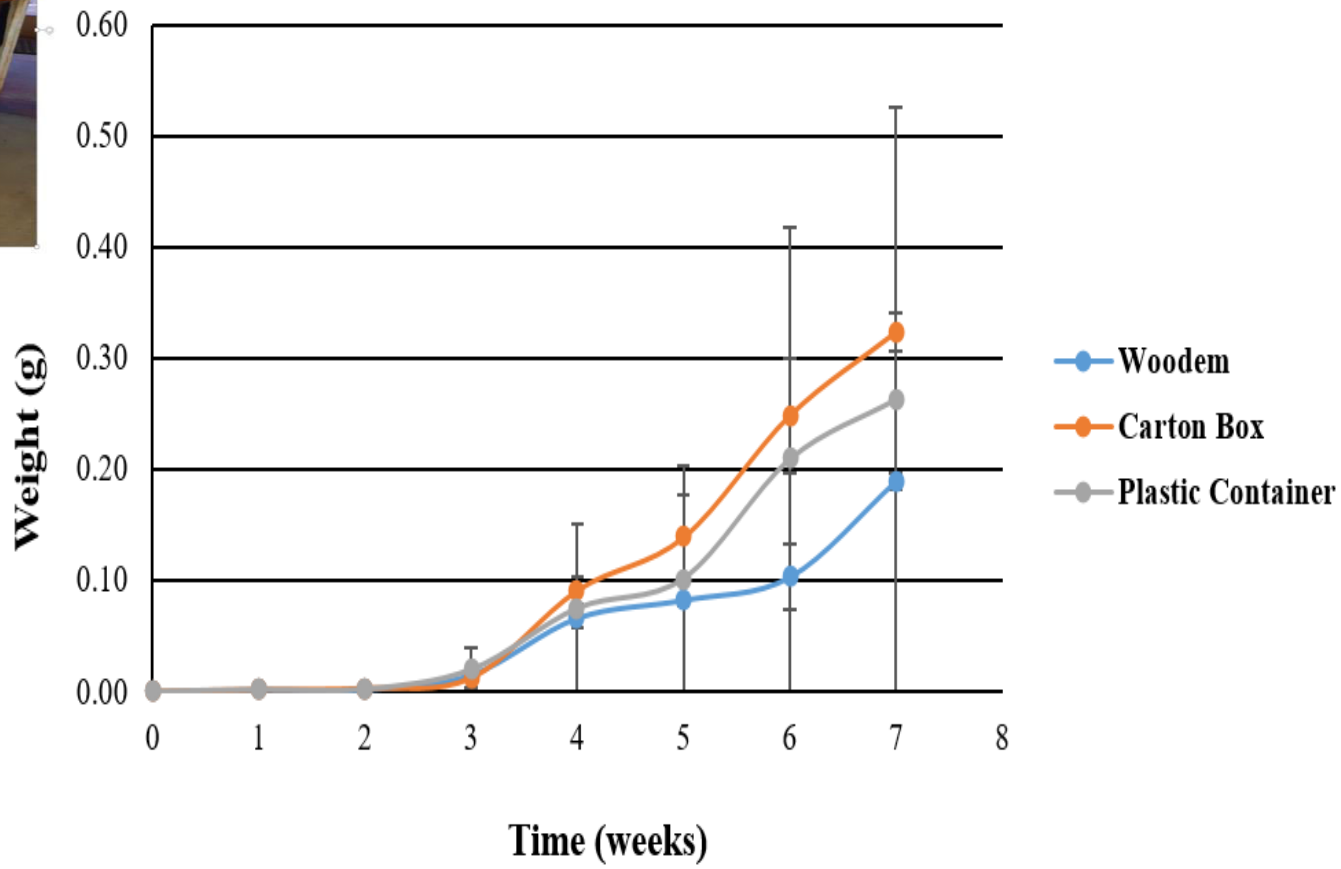
1.4 Willingness to pay

Estimated at 1.6 – 2.8 tons per year

ATRRIBUTE	LEVELS	PROPORTION OF MAIN EFFECTS (%)	RELATIVE IMPORTANCE
PRICE	5,500 UGX	26.2	51.5
	7,000 UGX	4.4	
	8,600 UGX	1	
	*None**	*68.4*	
CRICKET FLOUR PRESENCE	Yes	17.5	40.3
	No	3.6	
	*None**	*78.9*	
COOKIE COLOR	Dark Brown	8.5	8.2
	Light Brown	12.5	
	*None**	*79*	

Objective 2: Adaptation, piloting of mass rearing protocols for crickets and grasshoppers

2.1 Alternative rearing containers



2.2 Developed alternative feeds

Diet	W1	W2	W3	W4	W5	W6	W7	W8
FBD	0.02±0.38^{a}	0.06±0.65^{b}	0.08±0.61^{b}	0.19±3.95^{b}	0.33±3.32^{a}	0.37±4.55^{b}	0.42±3.85^{b}	0.42±3.50^{b}
CBD	0.03±0.27^{a}	0.08±0.85^{a}	0.13±1.04^{a}	0.26±4.19^{a}	0.34±3.88^{a}	0.46±4.52^{a}	0.51±3.73^{a}	0.51±2.80^{a}
BSFBD	0.03±0.38^{a}	0.08±1.49^{a}	0.14±1.15^{c}	0.25±3.62^{a}	0.38±3.89^{b}	0.52±3.89^{c}	0.58±2.76^{c}	0.59±2.82^{c}
PBD	0.03±0.38^{a}	0.04±0.88^{c}	0.05±0.45^{d}	0.13±4.19^{c}	0.24±3.14^{c}	0.26±5.02^{d}	0.28±2.02^{d}	0.35±3.27^{d}

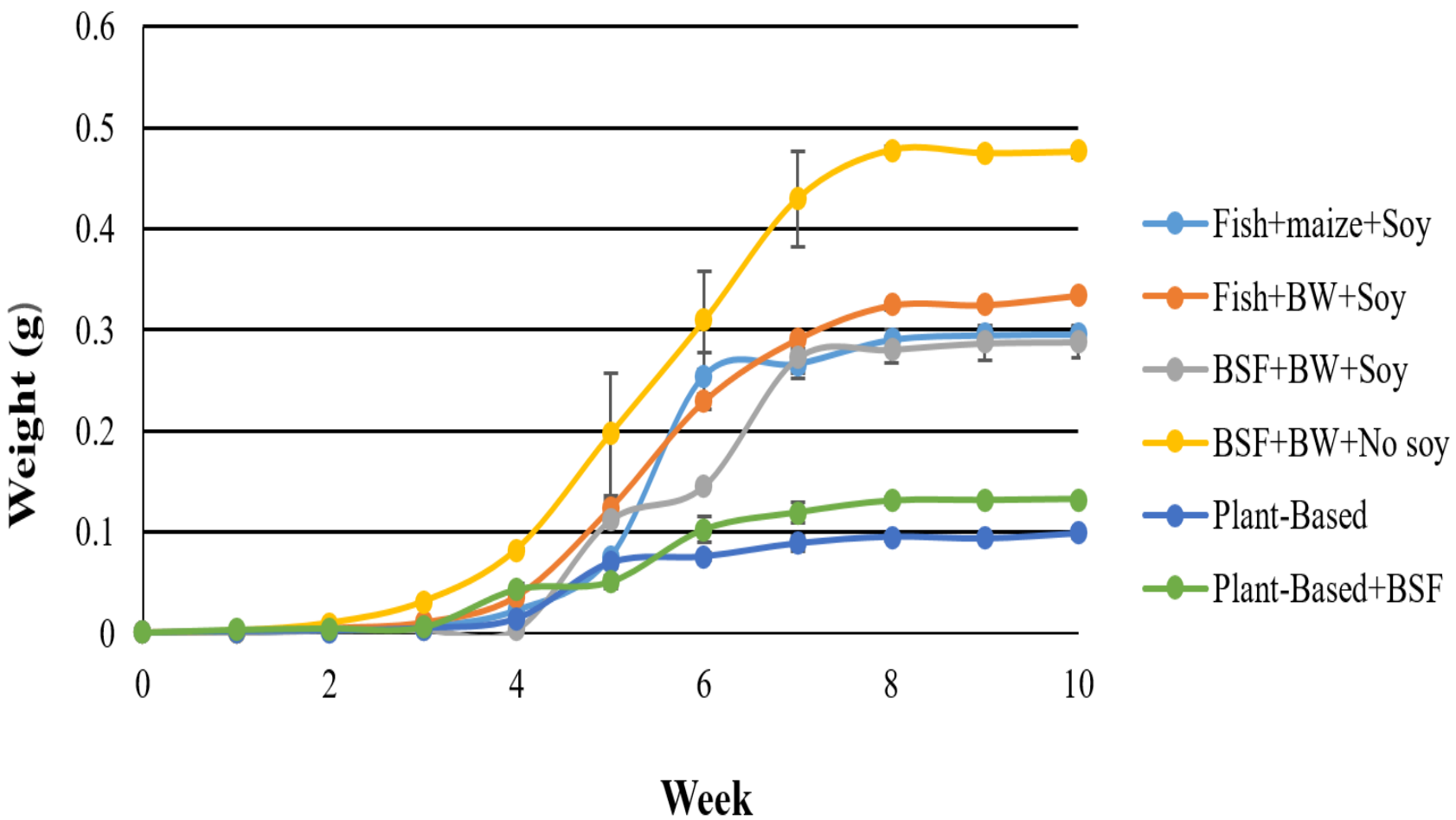
Values carrying the same letter as superscripts in the same column are not significantly different at p>0.05. CBD = Calliphora based diet, FBD = Fish based diet, BSFBD = Black soldier fly based diet and PBD Plant based diet (with no animal protein component)

Feed Type	Fat	Protein	Chitin	Ash	NFE
FBD	2.94 ± 029^{a}	61.11 ± 0.08^{a}	7.92 ± 0.38^{a}	10.19 ± 0.41^{a}	17.85 ± 0.87^{a}
CBD	4.51 ± 0.15^{a}	66.04 ± 0.18^{a}	10.56 ± 2.60^{a}	7.33 ± 0.33^{a}	11.56 ± 2.28^{b}
BSFBD	23.38 ± 3.23^{b}	55.76 ± 4.96^{a}	5.07 ± 1.63^{a}	7.03 ± 0.38^{a}	8.76 ± 0.78^{b}
PBD	10.56 ± 2.49^{b}	62.64 ± 2.40^{a}	6.45 ± 0.84^{a}	8.45 ± 0.35^{a}	11.90 ± 1.51^{b}

2.2 Developed alternative feeds

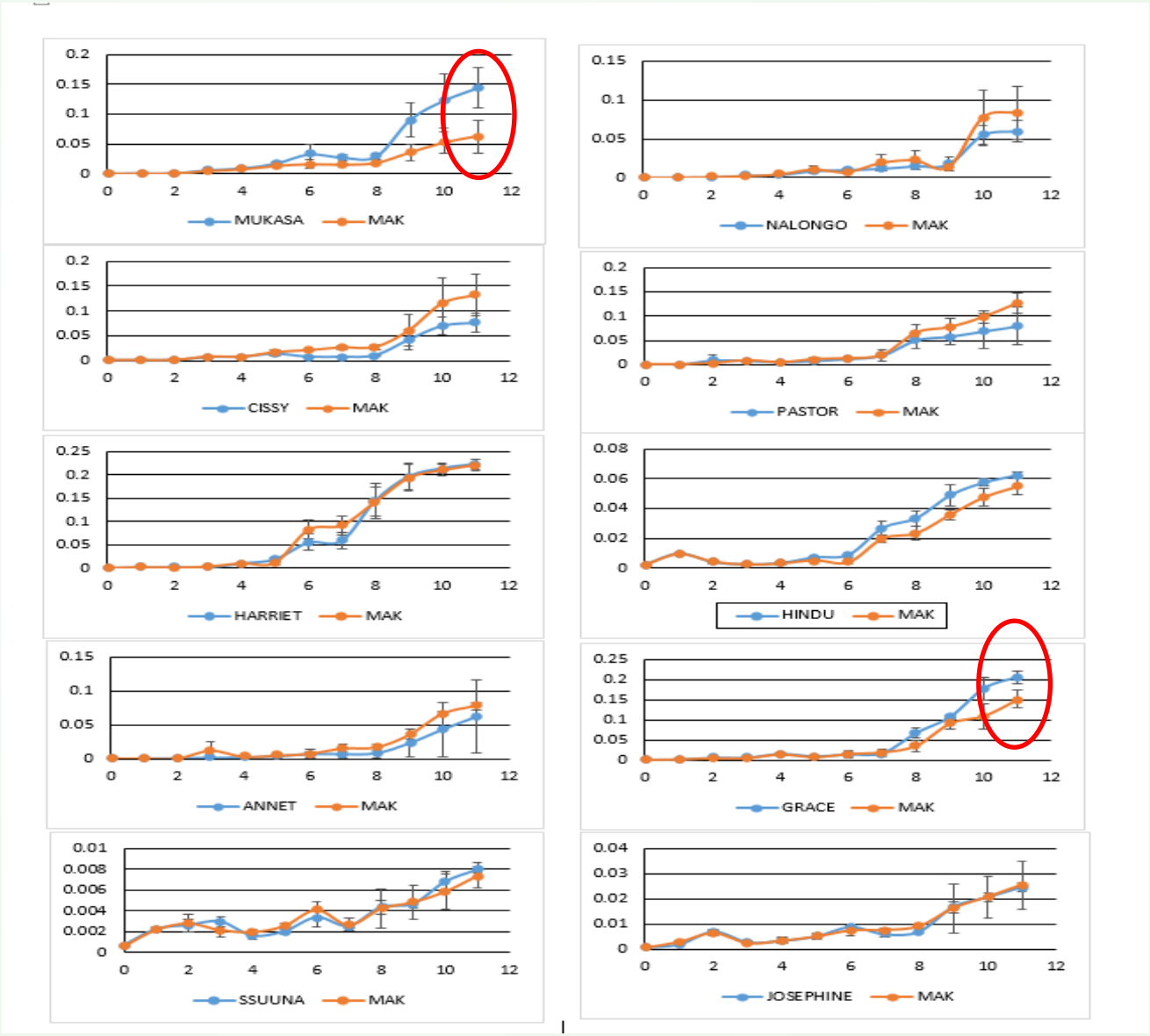
Amino acid	Fish Based	Caliphora Based	BSF Based	Plant Based
His	1.85 ± 0.12[a]	1.82 ± 0.05[a]	1.56 ± 0.24[a]	1.99 ± 0.10[a]
Ile	5.23 ± 0.18[a]	5.24 ± 0.09[a]	3.94 ± 0.19[b]	4.59 ± 0.34[a]
Leu	10.33 ± 0.43[a]	10.04 ± 0.01[a]	7.76 ± 0.58[b]	8.05 ± 0.27[b]
Lys	6.02 ± 0.49[a]	6.08 ± 0.21[a]	5.04 ± 0.27[a]	7.75 ± 0.26[a]
Phe	4.02 ± 0.42[a]	3.80 ± 0.02[a]	2.89 ± 0.41[b]	2.92 ± 0.04[b]
Met	1.74 ± 0.33[a]	1.70 ± 0.08[a]	1.35 ± 0.19[a]	1.28 ± 0.08[a]
Trp	0.67 ± 0.12[a]	0.67 ± 0.02[a]	0.54 ± 0.04[a]	0.62 ± 0.11[a]
Val	8.34 ± 0.54[a]	7.90 ± 0.36[a]	6.03 ± 0.14[b]	7.43 ± 0.21[a]
Thr	5.41 ± 0.00[a]	5.02 ± 0.15[a]	3.84 ± 0.20[b]	4.74 ± 0.18[b]
Met_Cyss	2.27 ± 0.40[a]	2.18 ± 0.07[a]	1.68 ± 0.24[b]	1.57 ± 0.07[b]
Phe_Tyr	9.04 ± 0.61[a]	9.17 ± 0.27[a]	6.81 ± 0.79[b]	7.30 ± 0.26[b]
Arg	5.15 ± 0.29[a]	4.96 ± 0.08[a]	4.36 ± 0.67[a]	5.35 ± 0.20[a]
Ser	6.59 ± 0.12[a]	6.24 ± 0.04[a]	4.75 ± 0.40[b]	5.81 ± 0.36[a]
Gly	11.32 ± 0.03[a]	11.12 ± 0.24[a]	9.07 ± 0.57[b]	11.05 ± 0.51[a]
Asp	9.17 ± 0.22[a]	9.08 ± 0.40[a]	6.45 ± 0.05[b]	8.66 ± 0.08[a]
Glu	12.64 ± 0.16[a]	11.76 ± 0.23[b]	9.65 ± 0.25[b]	11.46 ± 0.17[b]
Ala	15.19 ± 0.92[a]	15.51 ± 0.24[a]	12.64 ± 0.93[a]	14.69 ± 1.26[a]
Pro	9.11 ± 0.41[a]	9.36 ± 0.17[a]	7.29 ± 0.66[b]	8.24 ± 0.58[a]
Cyss	0.53 ± 0.07[a]	0.48 ± 0.01[a]	0.34 ± 0.05[b]	0.29 ± 0.01[b]
Tyr	5.02 ± 0.20[a]	5.37 ± 0.29[a]	3.92 ± 0.38[b]	4.39 ± 0.25[a]
E/N	0.58	0.57	0.56	0.56
E/(E+N)	0.37	0.36	0.36	0.36

2.2 Developed alternative feeds

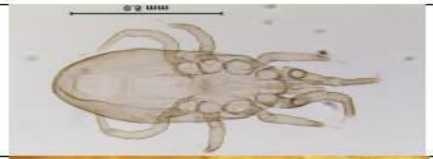


2.2 Developed alternative feeds

For 8/10 experimental farmer sites, the developed feed led to either a higher or similar performance to farmer formulated feed

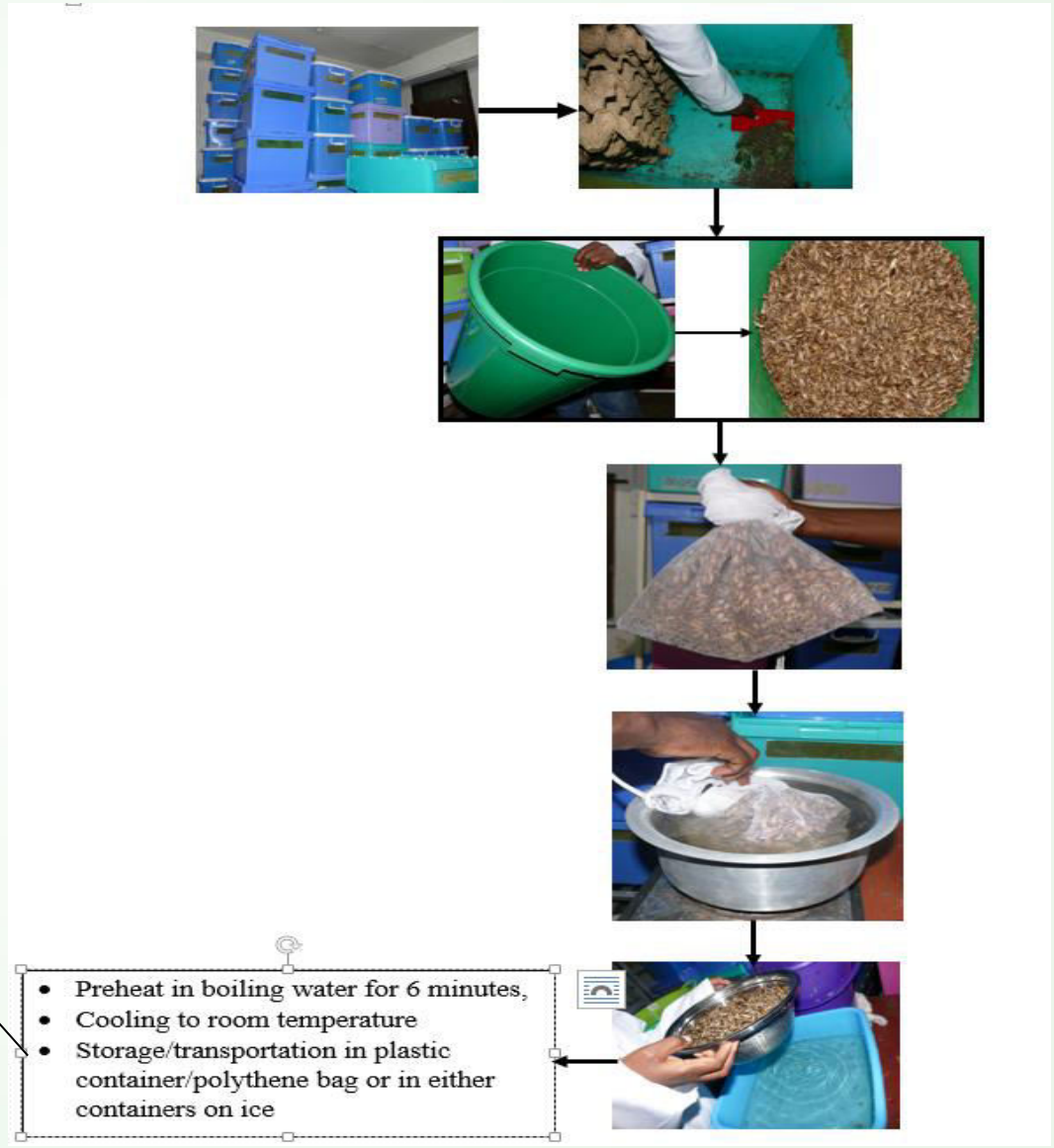


2.3 Identified predators of crickets

PREDATOR NAME			DRAWING/IMAGE
ENGLISH NAME	*SCIENTIFIC NAME*	*LOCAL LANGUAGE (LUGANDA) NAME*	
Snakes	Serpentes	Musota	
Spiders	Areneae	Nabubi	
Cockroaches	Blattodea	Kiyenje	
Geckoes	*Hemidactylus frenatus*	Konkome	
Moth	*Hofmannophila pseudospretella*		
Mites	*Dermanyscus gallinae*	Akaloolo	
Fruit flies	Drosophila	Kabu	

Black ants	*Monomorium minimum*	Munyeera	
Red ants	Dorylus	Nsanafu	
Lizards	Lacertilia	Munya	

2.4 Post-harvest handling protocol



Objective 3: Development and characterisation of ready-to-eat whole insects, insect flours and products

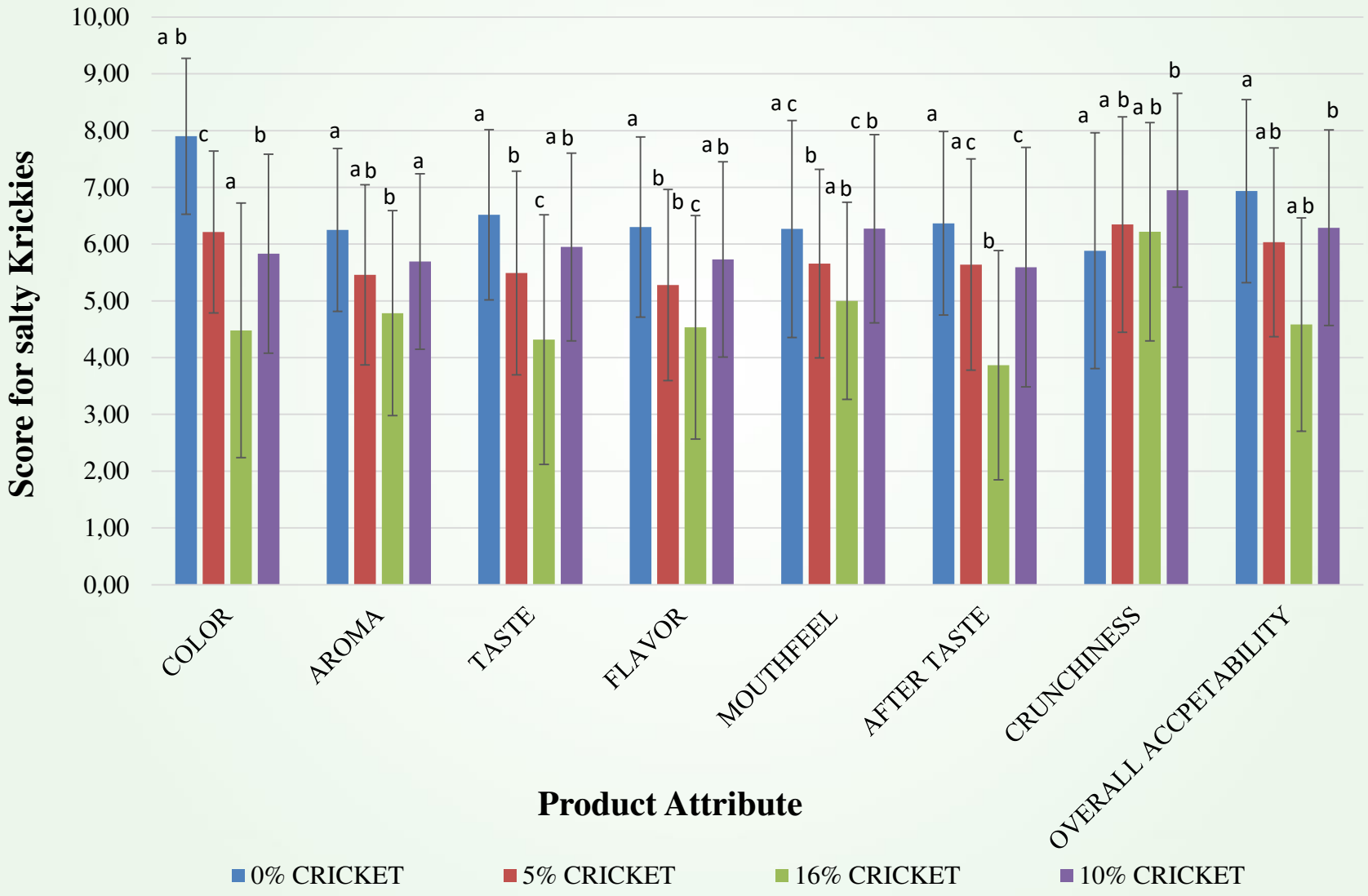
3.1 Nutrient composition confirmed

PROXIMATE ANALYSES							
Insect Species	Source	Moisture	Fat	Protein	Chitin	Ash	NFE
Gryllus bimaculatus	MAK insectary	74.0 ± 7.3	23.5 ± 1.2	55.6 ± 1.9	3.3 ± 0.3	5.0 ± 0.1	12.7 ± 1.3
	Literature[L]	NR	14.9 – 33.4	57.49 – 70.1	9.5	NR	NR
A. Domesticus (strain A)	MAK insectary	74.5 ± 1.1	19.6 ± 0.4	57.7 ± 1.6	2.1 ± 0.2	5.2 ± 0.2	15.5 ± 1.0
A. Domesticus (strain A)		70.4 ± 0.8	20.1 ± 0.4	50.6 ± 1.9	7.6 ± 0.5	6.9 ± 0.3	15.4 ± 0.9
Acheta domesticus	Literature[L]	NR	9.8 – 29.6	62.4 – 71.1	10.2	5.1 – 9.1	NR
Ruspolia differens	MAK insectary	42.9 ± 3.6	47.7±0.1	39.7 ± 0.4	3.4 ± 0.8	2.9 ± 0.2	6.4 ± 0.7
	Wild Harvested[X]	NR	42.2 – 54.3	34.2 – 45.8	3.93 – 5.34	1.8 – 2.7	4.29 - 6.03

3.1 Nutrient composition confirmed

Amino acid	*G. Bimaculatus*	*[L]G. Bimaculatus*	*A. domesticus (strain A)*	*A. domesticus (Strain B)*	*[L]A. domesticus*	*R. differens*	*[W]R. differens*
His	1.48 ± 0.02	0.52 - 1.57	1.32 ± 0.11	1.45 ± 0.10	0.38 – 2.25	1.64 ± 0.05	2.09 – 2.65
Ile	3.84 ± 0.07	0.92 - 2.35	3.72 ± 0.12	3.61 ± 0.13	0.69 – 4.45	3.67 ± 0.06	4.65 – 4.90
Leu	7.09 ± 0.27	1.65 – 3.97	7.04 ± 0.15	6.97 ± 0.11	1.22 – 9.75	7.15 ± 0.07	8.09 – 8.85
Lys	5.12 ± 0.15	1.14 - 2.89	4.72 ± 0.99	4.72 ± 0.49	0.97 – 5.40	5.16 ± 0.34	6.98 – 5.40
Phe	2.80 ± 0.09	0.74 - 2.24	2.60 ± 0.04	2.62 ± 0.28	0.63 – 3.00	2.15 ± 0.19	3.61 – 3.80
Met	1.23 ± 0.03	0.27 - 0.86	1.12 ± 0.03	1.14 ± 0.15	0.30 – 1.40	0.93 ± 0.04	1.60 – 1.99
Trp	0.62 ± 0.04	0.22 - 0.43	0.51 ± 0.05	0.57 ± 0.06	0.14 - 0.55	0.38 ± 0.05	0.68 – 0.97
Val	5.53 ± 0.07	1.36 - 3.50	5.66 ± 0.49	5.35 ± 0.03	1.07 - 4.50	5.77 ± 0.12	5.81 – 6.18
Thr	3.89 ± 0.04	0.81 – 2.00	3.73 ± 0.22	3.90 ± 0.14	0.66 – 3.60	3.65 ± 0.17	3.97 – 4.31
Met_Cyss	1.66 ± 0.01	0.43 - 5.96	1.46 ± 0.11	1.53 ± 0.21	0.45-2.2	1.09 ± 0.07	2.32 – 2.76
Phe_Tyr	5.62 ± 0.18	1.74 - 5.01	5.60 ± 0.42	5.66 ± 0.43	1.63-5.71	5.04 ± 0.27	8.48 – 10.40
Arg	4.23 ± 0.01	1.93 – 6.10	4.28 ± 0.21	4.53 ± 0.20	0.89 – 6.10	3.57 ± 0.24	5.21 – 6.59
Ser	4.69 ± 0.01	1.05 – 2.73	4.51 ± 0.04	4.55 ± 0.21	0.68 - 1.59	4.52 ± 0.34	4.21 – 4.77
Gly	8.36 ± 0.79	1.24 – 3.32	8.10 ± 0.18	8.05 ± 0.28	0.93 - 2.60	8.65 ± 0.11	5.23 – 5.82
Asp	6.52 ± 0.50	1.97 – 7.75	6.88 ± 0.46	6.76 ± 0.35	1.37 - 4.61	6.67 ± 0.25	9.03 – 9.60
Glu	8.50 ± 0.64	2.44 - 6.77	9.00 ± 0.14	8.78 ± 0.33	1.98 - 10.45	8.18 ± 0.47	12.40 – 13.00
Ala	10.32 ± 0.07	1.93 - 4.69	10.92 ± 0.64	10.69 ± 0.29	1.35 – 8.85	12.50 ± 1.15	9.37 – 11.00
Pro	6.55 ± 0.07	1.25 - 2.81	6.57 ± 0.55	6.91 ± 0.46	1.00 - 3.04	6.41 ± 0.42	6.46 – 8.27
Cyss	0.43 ± 0.02	0.16 – 5.10	0.34 ± 0.08	0.40 ± 0.05	0.15 - 0.80	0.17 ± 0.05	0.63 – 0.79
Tyr	2.82 ± 0.09	1.00 - 2.77	3.00 ± 0.46	3.05 ± 0.15	1.00 - 2.71	2.89 ± 0.08	4.83 – 6.76
E/N	0.60		0.57	0.56		0.57	0.58 – 0.66
E/(E+N)	0.38		0.36	0.36		0.36	0.37 – 0.40

3.2 Insect products developed



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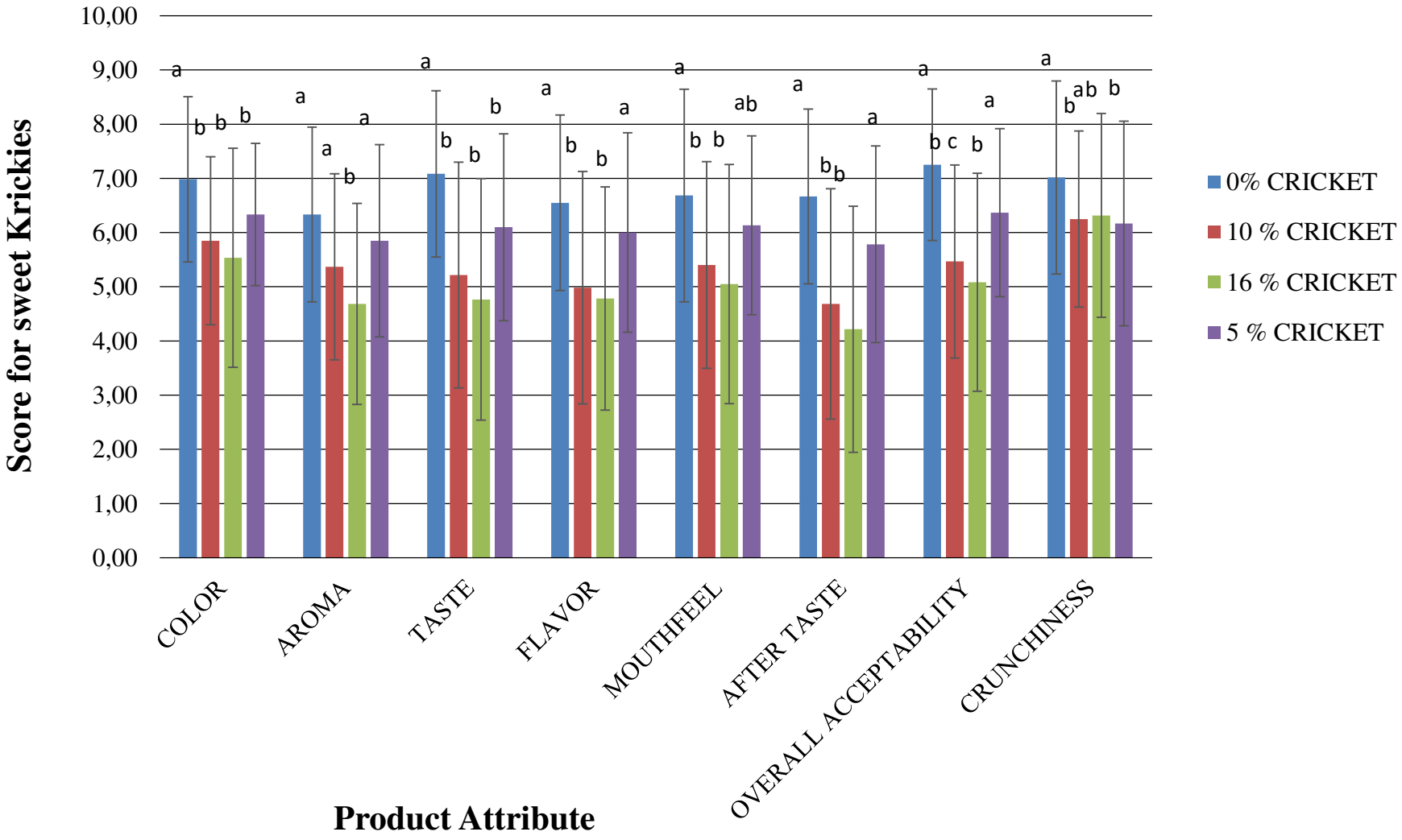

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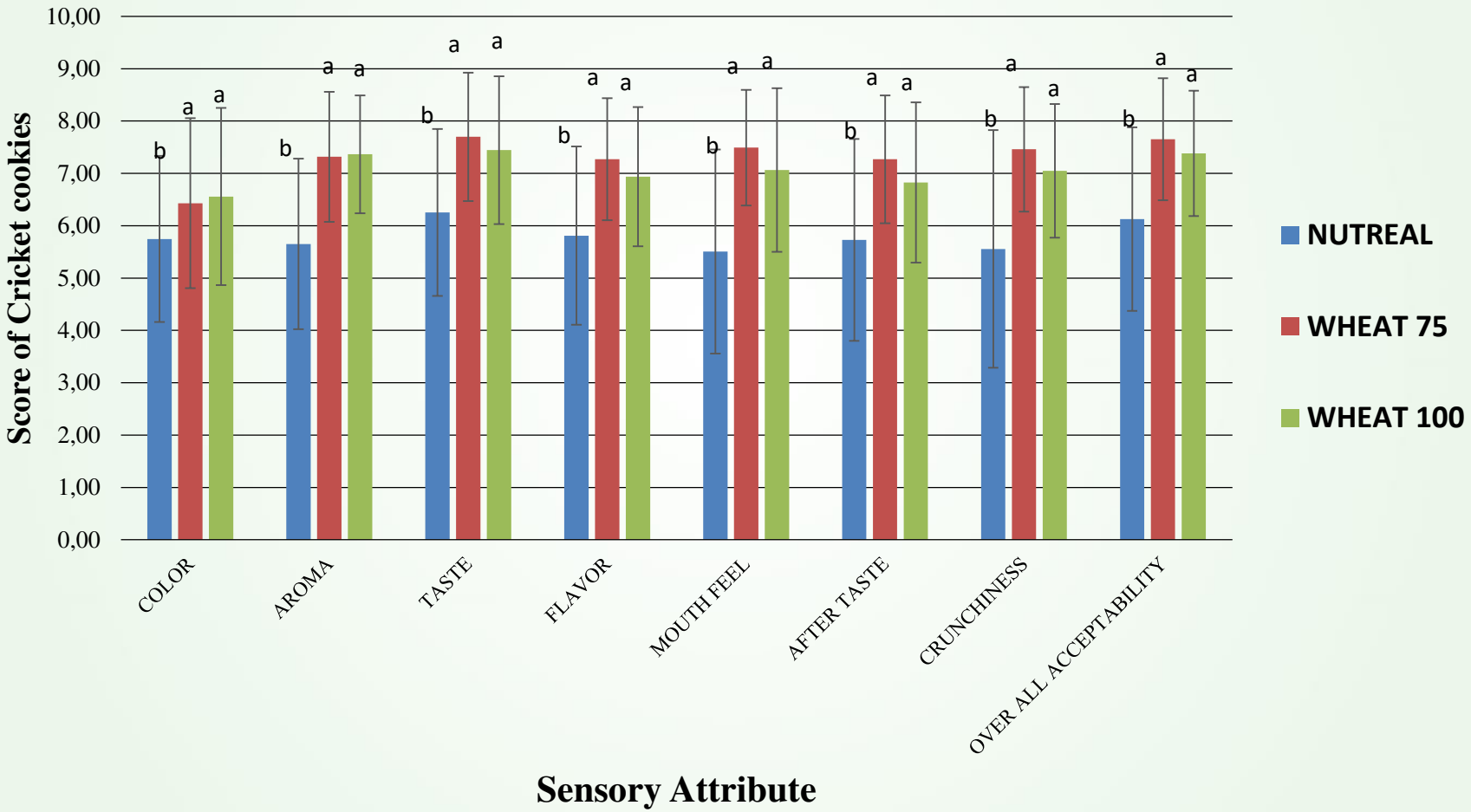

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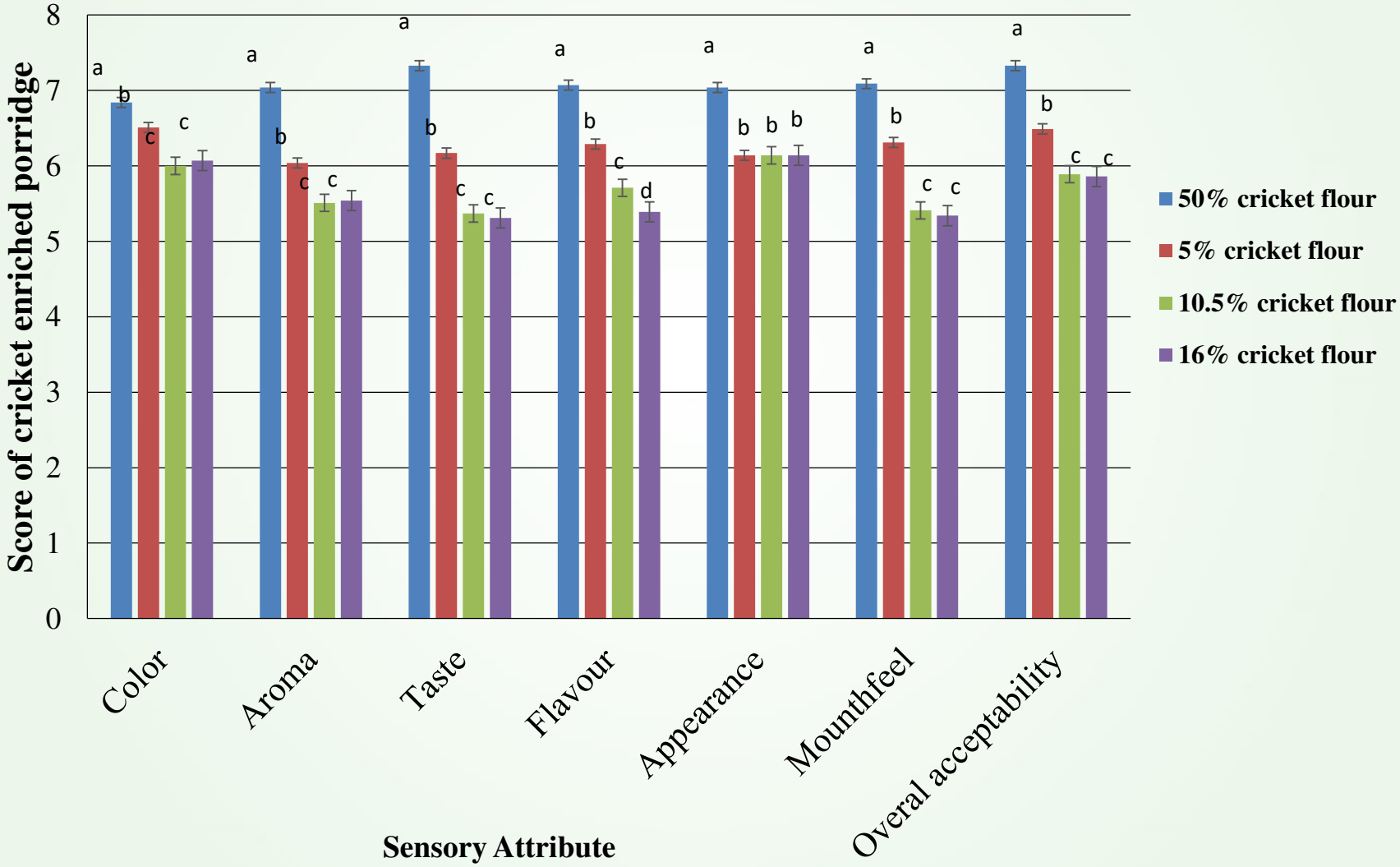

3.2 Insect products developed

Parameter (%)	Product								
	Porridge		Cookies		Krickies_sweet		Krickies _Salty		Nseene ne
	0 %	5 %	0 %	5 %	0 %	5 %	0 %	5 %	
Moisture	6.38 ± 0.37	6.61 ± 0.13	5.80 ± 0.09	5.04 ± 0.05	6.97 ± 0.25	5.51 ± 0.10	9.05 ± 0.07	11.73 ± 0.06	8.70±0.39
Fat	0.27 ± 0.05	0.44 ± 0.18	19.48 ± 0.74	21.90 ± 0.42	0.16 ± 0.02	0.67 ± 0.16	0.28 ± 0.02	0.32 ± 0.24	46.54±1.60
Protein	8.61 ± 0.69	11.19 ± 0.16	8.05 ± 0.49	12.50 ± 0.25	5.48 ± 0.16	8.35 ± 0.63	7.52 ± 0.38	11.50 ± 0.73	29.99 ± 0.83
Chitin	2.92 ± 0.31	2.43 ± 0.32							5.62 ± 0.41
Ash	1.03 ± 0.03	0.94 ± 0.01	1.46 ± 0.03	2.01 ± 0.31	0.48 ± 0.09	0.50 ± 0.07	1.57 ± 0.03	1.87 ± 027	4.49±0.06
Carbohydrate	87.17 ± 0.96	85.01 ± 0.18							13.35 ± 1.30

3.3 Sensory xtics described

ATTRIBUTES	QUALITATIVE DESCRIPTIVE ANALYSES OF PRODUCTS				
	SALTY KRICKIES	***SWEET KRICKIES***	***COOKIES***	***PORRIDGE***	***NSEENENE***
COLOR	Ginger Flesh yellow	White sorghum Khaki	Ginger skin brown	Milky millet porridge	Dry ginger flesh yellow
TASTE	Puffed corn	Sweet	sweet	Plain millet porridge flour	Moderately Meaty
FLAVOR	Mild tumeric	Mild Cinnamon	Whole milk powder	Plain maize porridge	Meaty
AFTER-TASTE	Bitter whole maize meal	Bitter Cassava	Saccharin	Bitter whole maize meal	None
TEXTURE	Crunchy	Crunchy	Crumbly	N/A	Moderately crunchy
MOUTH FEEL	N/A	N/A	N/A	Smooth	N/A

3.3 Safety Xtics determined

Heavy metals (mg/Kg)					
Parameter	Porridge	Cookies	Krickies sweet	Krickies Salty	Ready-to-eat grasshoppers (Nseenene)
Cadmium	<0.001	0.0002	<0.001	<0.001	<0.001
Chromium	0.002 ± 0.000	<0.001	0.01 ± 0.000	<0.001	0.018 ± 0.000
Lead	0.087 ± 0.002	0.007 ± 0.00	0.040 ± 0.000	0.014 ± 0.000	0.069 ± 0.000
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001

3.3 Safety xtics determined

Aflatoxins					
Type	Porridge	Cookies	Krickies_swee t	Krickies_Salty	Nseenene
B1	ND	ND	ND	ND	ND
B2	ND	ND	ND	ND	ND
G1	ND	ND	ND	ND	ND
G2	ND	ND	ND	ND	ND

3.3 Safety xtics determined

Herbicides and Pesticide residues					
Parameter	Porridge	Cookies	Krickies_sweet	Krickies_Salty	Nseenene
2,4-D	ND	ND	ND	ND	ND
Glyphosate	ND	ND	ND	ND	ND
Cypermethrin	ND	ND	ND	ND	ND
Deltamethrin	ND	ND	ND	ND	ND
Cyhalothrin	ND	ND	ND	ND	ND
Profonofos	ND	ND	ND	ND	ND
Chloropyrifos	ND	ND	ND	ND	ND
Chloroverifivos	ND	ND	ND	ND	ND
Dimethoate	ND	ND	ND	ND	ND
Diazion	ND	ND	ND	ND	ND
Dichlorovos	ND	ND	ND	ND	ND
Fungicides*					
Mancozeb	ND	ND	ND	ND	ND

3.4 Branded products

Objective 4: Creating a favourable enabling environment for insect based food through policy, advocacy and awareness

4.2 Awareness created

- Radio Programs held
- Promotional materials developed
  - Promotional kit
  - Adverts developed
  - Stakeholder meetings held
  - Etc.

- INSFOOD KRICKIES ENG AD.mp3
- INSFOOD NSENENE ENG AD.mp3

THE END

Any questions?