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Review

Beneficial Uses of Insects

Is the long-horned grasshopper *Ruspolia differens* (Orthoptera: Tettigoniidae) a novel, nutritious, functional, and safe alternative food product? A review

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Ruspolia differens Serville (Orthoptera: Tettigoniidae) is among the most widely consumed edible insect in Eastern and Central Africa, where it contributes to both household nutrition and income generation. As a nutrient-dense food source, it offers a promising alternative to curb food insecurity and malnutrition. Despite this, the consumption and use of the grasshopper is limited to its seasonal availability when it is collected from the wild. Coupled with this, is limited evidence on its domestication despite research advances to optimize conditions for mass production. This review was conducted to highlight research advances and gaps on production, processing, nutritional profile, and safety of *R. differens* as a food source. Findings from the review revealed that *R. differens* is widely consumed in Africa. It is rich in protein (28% to 54%), fat (33% to 49%), amino acids, fatty acids, micronutrients, and antioxidants; however, its nutrient quality and shelf life are influenced by diverse processing methods. Studies have reported the presence of pathogenic microorganisms in some market samples, highlighting the need for improved hygiene and processing standards. Therefore, enabling policies, captive rearing, and safe processing of *R. differens* would be revolutionary in increasing its availability, consumption, and commercialization for improved food and nutrition security.

Keywords: edible grasshopper, nutritional quality, biosafety, regulatory framework, food security

Introduction

The demand for alternative sources of animal proteins to curb the global rise in food insecurity has revitalized interest in the utilization of traditional foods, such as insects as food and feed (van Huis 2015). The use of insects as food dates back over 2,000 years (Dobermann et al. 2017), and today, this practice is gaining renewed interest as a sustainable solution to food and nutrition security. Similar to other animal proteins, insects are highly nutritious (Ssepuuya et al. 2019a, Hlongwane et al. 2020); furthermore, their high feed conversion efficiency, ease of production with minimal and low-cost resources, and low carbon footprint make them an environmentally and economically sustainable protein source compared to conventional animal protein sources (Sirimungkararat et al. 2010, van Huis and Oonincx 2017). However, insect consumption has been shunned as a traditional/cultural practice associated with

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resource-poor communities, and is further hindered by safety concerns, neophobia, and feelings of disgust (Schabel 2010, Melgar-Lalanne et al. 2019).

Among the many edible insect species consumed across Africa, *Ruspolia differens* Serville (1838) (Orthoptera: Tettigoniidae) is one of the most consumed (Bailey and Mccrae 1978, Matojo and Njau 2010, Ssepuuya et al. 2017, Leonard et al. 2021). It is highly nutritious (Fombong et al. 2017, Ssepuuya et al. 2019a) and constitutes a source of livelihood for many households (Agea et al. 2008, Kinyuru et al. 2010a , Mmari et al. 2017, Kababu et al. 2023). The grasshoppers are mainly harvested seasonally from the wild, but harvests are increasingly variable and influenced by climatic and ecological factors (Agea et al. 2008, Ssepuuya et al. 2016, Mmari et al. 2017, Okia et al. 2017, Leonard et al. 2021). The limited seasonal supply is further affected by the short shelf life and perishability of the harvested insects and their products. Several techniques have been developed to extend the shelf life (Ssepuuya et al. 2016, 2017, Ssepuuya 2019, Mugo 2020), however, their adoption and use has been limited. Regarding sustainable production, research has focused on understanding the host plant feed for *R. differens*, optimization of artificial rearing diets, and laboratory holding conditions. Despite this, there is limited evidence on the uptake of research outputs towards mass rearing of *R. differens* due to obscurity to such technology.

This review sought to collate the diverse outputs of research on *R. differens* in Africa and elsewhere, to optimize their adoption and enhance mass production of *R. differens* for a sustainable yearlong supply and utilization. The review focused on (i) identification of *R. differens* and its description, (ii) production (iii), processing, preservation, and storage, (iv) nutritional characteristics (v) consumer acceptability, perception, and sociocultural factors influencing consumption (vi) safety, (vii) marketing and economic impacts of *R. differens*, and (viii) regulations influencing the adoption and use of edible insects.

Methodology

Online databases, such as Web of Science, SCOPUS, and Google Scholar, were used to search for relevant peer-reviewed articles. Studies were included if they met the following criteria: (i) contained information on the identification and description of *R. differens*; rearing technologies; nutritional characteristics; safety; harvesting, processing, preservation, and storage; marketing and economic impacts; and resourceful utilization of *R. differens*; (ii) original research published in a peer-reviewed journal to avoid duplication of information that would be obtained from review papers and conference proceedings; (iii) published in English; (iv) available in full text; (v) published between the year 2000 to 2025 which is the period within which research on *R. differens* and other edible insects gained momentum; and (vi) contained information on regulations on the use of edible insects.

Studies were selected if they contained the following key search words "Edible Long-horned grasshopper, swarming cone-head, *nsenene, senene, Ruspolia differens* and *Ruspolia nitidula*" in the title or abstract. Articles from Eastern Africa that erroneously named *R. nitidula* for *R. differens* in their title were included following the corrections by Matojo, and Leonard and colleagues who showed that the swarming long-horned grasshoppers found in the Eastern Africa region are actually *R. differens* and not *R. nitidula* (Matojo 2017, Leonard et al. 2020). Owing to the lack of a regulatory framework on the use of *R. differens*, this information was gleaned from articles containing information on regulations on the use of edible insects that were included in the review.

A narrative synthesis approach was utilized in this review. All data presented in the review are expressed in terms of mean differences as reported in the original articles. Data on the nutritional characteristics of *R. differens* from different studies were tabulated and presented based on the country of origin, whether samples were collected from the wild or reared in the laboratory, color morphs, and raw or processed forms, to avoid bias that could arise from the differences in these variables. The mean quantities of nutritional content of *R. differens* have been expressed differently by diverse authors; therefore, the most widely used format was adopted for the synthesis. All values were rounded off to one decimal point, which was the least number of decimal points documented in the reviewed articles. All missing variables that were not reported in the original articles were marked as "not reported" (NR).

Results

Number of Publications

The literature search yielded 300 articles for potential inclusion in the review. After analysing the titles and abstracts, 201 articles were excluded because of duplication and did not meet the inclusion criteria. A total of 110 articles were selected for full-text reading, after which 11 were excluded due to duplication of information and lack of relevance. A total of 89 articles were included in the review (Fig. 1).

Species Description and Swarming Behaviour

R. differens is a swarming, cone-headed, long-horned grasshopper that occurs in sub-Saharan Africa and specifically widely consumed in Eastern and Central Africa (Matojo and Hosea 2013, Matojo 2017, Leonard et al. 2021) (Fig. 2). The grasshopper is a nocturnal species that exhibits color polymorphism with 6 morphs: brown, green, purple suffused green, purple suffused brown, purple stripped green, and purple stripped brown. However, the green and brown morphs are the most abundant (Matojo and Yarro 2010, Mmari et al. 2017, Opoke et al. 2019b). It displays sexual dimorphism; males are predominantly brown, possess dorsoventrally bi-lobed cerci, a pair of tongue-like metathoracic flaps, are smaller in size and possess longer antennae than females. Conversely, females are primarily green in color and possess a long, slender ovipositor (Matojo and Yarro 2010).

R. differens feeds on a wide variety of grasses, sedges, and crops. It consumes inflorescences of *Cynodon dactylon*, *Panicum maximum*, *Pennisetum purpureum*, *Hyparrhenia rufa*, *Brachiaria ruziziensis*, *Chloris gayana*, and *Sporobolus pyramidalis* (Opoke et al. 2019b). Additional host plants identified through molecular analysis of gut contents include *Ageratum conyzoides*, *Citrus depressa* Hayata, *Digitaria gayana*, *Eragrostis mexicana*, *Eucalyptus saligna*, *Indigofera arrecta*, *Persicaria nepalensis*, and *Sorghum halepense* (Leonard et al. 2020). *R. differens* is also associated with staple food crops such as *Sorghum bicolor*, *Zea mays*, *Phaseolus vulgaris*,

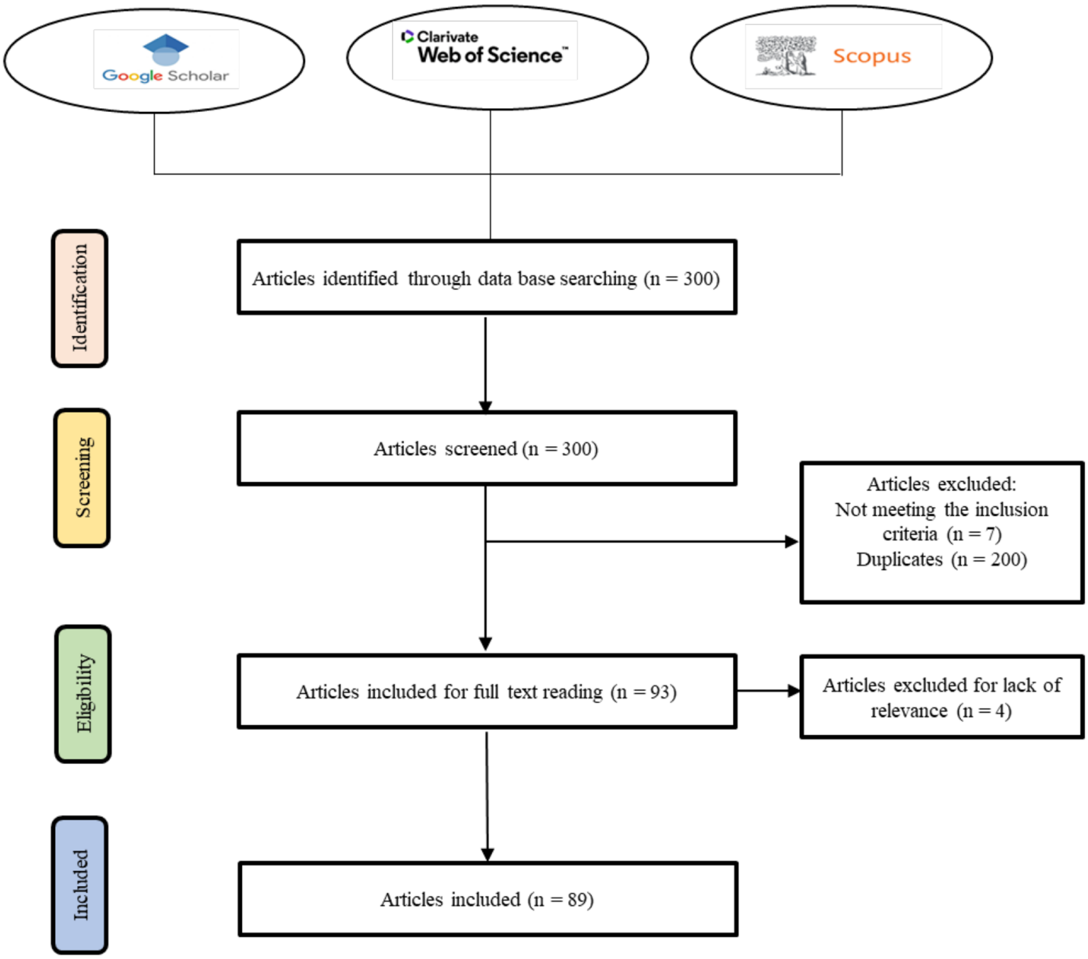

Fig. 1. Flow chart of the selection process of studies included in the review.

Oryza sativa, *Saccharum officinarum*, *Ipomea batatas* and *Arachis hypogaea* (Ishara et al. 2023).

R. differens has a hemimetabolous lifecycle of approximately 147 days and an adult longevity of 13- to 90 days (Leonard et al. 2021, Margaret et al. 2022, Fombong et al. 2023a). Females have a pre-oviposition and oviposition period of approximately 13 to 28 and 32 to 52 days, respectively, and can lay up to 247 eggs (Opoke et al. 2019b, Leonard et al. 2021, Margaret et al. 2022). Egg development can take up to 19 and 45 days at high (35°C) and low temperatures (20°C), respectively, with a post-oviposition period of 1 to 16 days (Opoke et al. 2019b, Leonard et al. 2021, Margaret et al. 2022).

R. differens has distinct swarming and non-swarming phases (Matojo 2017). The swarming phase occurs biannually in the wet season during long and short rains (March to April and November to December, respectively) (Mmari et al. 2017, Opoke et al. 2019a). Swarming grasshoppers are female-biased and hide in local bushes where they breed, and peak fecundity and maturity occur in the middle of the swarming season, with a mean clutch size of 71 to 72 eggs (Matojo and Njau 2010, Matojo and Yarro 2010). Traditionally, swarms were believed to emerge from Lake Victoria, the heavens, pine trees, or dense clouds; however, Opoke and colleagues opined that swarms observed in Uganda are recruited from non-swarming populations that arise from locally available reproductive sites (Matojo and Njau 2010, Mmari et al. 2017, Opoke et al. 2019a). Contrarily, recent evidence from hydrogen isotopes and genetic analysis suggests that a proportion of these swarms originate from other countries such as South Sudan, Kenya, and Ethiopia (Valtonen et al. 2025).

The non-swarming phase of *R. differens* is male-biased and occurs during dry seasons; the lowest fecundity occurs at the end of the phase, with a mean clutch of 7-18 eggs (Matojo and Njau 2010, Matojo and Yarro 2010). The population densities of the non-swarming phase vary across seasons, with higher and lower densities observed after the rainy and in dry seasons, respectively (Matojo and Njau 2010, Matojo and Yarro 2013). The low densities in the dry season is attributed to a large number of grasshoppers recruited into swarms, while the high density observed after the rainy season arises from increased fecundity and faster development due to the abundance of quality food (Matojo and Njau 2010, Matojo and Yarro 2010, Opoke et al. 2019a).

Production of *R. differens*

Wild Collection of *R. differens*

R. differens is obtained from wild harvesting during the two annual swarming seasons (Mmari et al. 2017, Okia et al. 2017). Traditionally, harvesting of *R. differens* for household consumption occurred in fields away from homes and around home security lights (Agea et al. 2008, Mmari et al. 2017, van Huis 2022). This is mainly carried out by women and children either

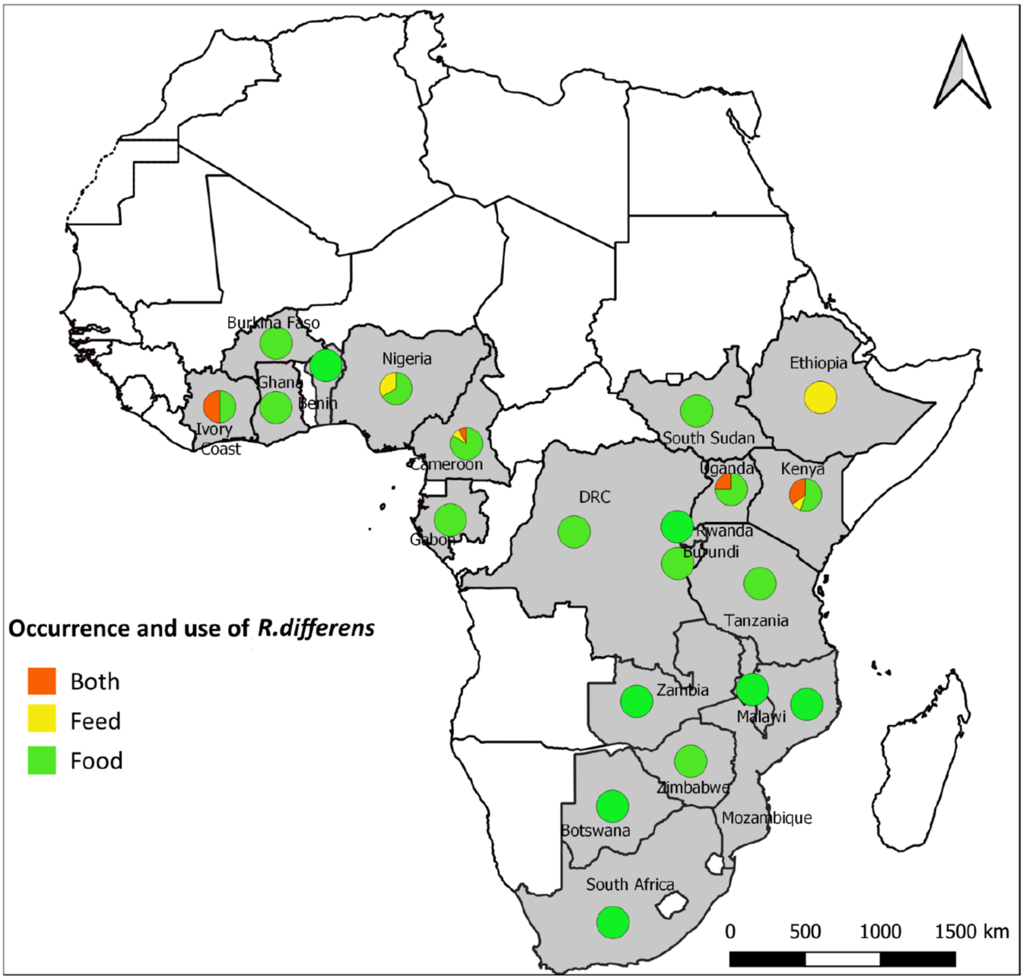

Fig. 2. Distribution of *R. differens* and their sustainable utilization for food and feed in Africa.

at night or during the early morning hours, when grasshoppers can be collected in large numbers (van Huis 2022). Collection is done by hand picking, use of nets made from shirts, and use of white bedsheets or blue tarping, painted white with torches and sometimes lanterns used to attract grasshoppers (Mmari et al. 2017, Ishara et al. 2023, Mmbone et al. 2023).

Commercial harvesters use locally assembled traps that comprise folded iron sheets, large buckets or drums, and very bright mercury lights for collection of *R. differens* (Agea et al. 2008, Mmari et al. 2017, Okia et al. 2017). Commercial harvesters set up open barrels/drums (150 to 200 liters) with metal sheets placed at the top inclined at an angle between 45° and 75° (Ssepuuya 2019). High voltage lights are placed in front of these metal sheets giving a very bright light when switched on. At night, the lights are switched on, attracting grasshoppers towards the lights in front of the metal sheets. Grasshoppers that hit or land on metal sheets, have a hard time obtaining traction, and slide down into barrels (Ssepuuya 2019). It is difficult for grasshoppers to fly vertically; therefore, they cannot easily fly out of the barrel. Some try to climb out, but the walls are deliberately made slippery with water, cassava/maize flour, or cooking oil to deter their escape (Ssepuuya 2019). Grasshoppers are collected in the morning from drums, packaged in aerated sisal, polythene, nylon, or cloth mesh bags, and delivered to the market (Ssepuuya 2019).

Recently, a safer and more energy-efficient *R. differens* trap compared to the current commercial trap was developed and tested (Sengendo et al. 2021b). The improved trap comprised collection drums fitted with a funnel to improve retention of the catch, meshes to filter by-catches, and light-emitting diode bulbs to replace potentially hazardous mercury lamps. Both the current commercial and newly improved techniques for trapping *R. differens* in Uganda are profitable ventures with positive net profit values and benefit–cost ratios greater than one (Sengendo et al. 2021a). However, the improved trapping technique was more effective than the current technique. The current commercial trapping technique is associated with high costs of electricity and harmful non-target insects, especially the Nairobi Fly (*Paederus* sp), which causes dermatitis; hence, the preferential recommendation of an improved technique for adoption (Sengendo et al. 2021a, 2021b).

Research Advances in Rearing Technologies of *R. differens*

Optimal rearing conditions

Insects require optimum environmental conditions to enhance their growth, development, survival, and reproductive performance (Cohen 2018). *R. differens* has been reared successfully under laboratory conditions at a temperature range of 22°C to 32°C, relative humidity of 40% to 78% and photoperiod of 12 h light:12 h dark (Lehtovaara et al. 2017, Malinga et al.

2018a, 2020, Rutaro et al. 2018c, Ssepuuya et al. 2018). Ssepuuya et al (2018) established that the shortest egg development time (14 days) and highest hatchability (89%) occurred at 30°C in eggs that were not detached from the leaf sheath (Ssepuuya et al. 2018), whereas Leonard and colleagues recorded the highest hatchability of 81% at the same temperature (Leonard 2021).

The optimal temperature range for rearing of *R. differens* with the shortest development time, maximal weight gain, and survival was 28°C to 30°C (Lehtovaara et al. 2018, Ssepuuya et al. 2018, Leonard et al. 2021). Lehtovaara et al. (Lehtovaara et al. 2018) recorded the shortest development time (49 days) and highest survival (87%) at 30°C, while the highest adult weight (0.62 g) at molting occurred at 28°C. Leonard et al. 2021 recorded the shortest development time (52 days) at 32°C.

Limited data were obtained on the effects of light and humidity on the performance of reared *R. differens*. One article, however, documented that rearing of *R. differens* under dark conditions (1 h of light per 24 h) resulted in shorter development time (58 days), fewer nymphal instars (7), higher fecundity (24 eggs) and higher adult longevity (39 days) compared to those reared under a light condition (12 h of light per 24 h) (Fombong et al. 2023a). These values were, however, lower than similar outcomes reported by other authors who reared *R. differens* at 12 h of light and 12 h of darkness (Malinga et al. 2020, Margaret et al. 2022). Limited data was obtained on the synergistic effects of environmental parameters on growth and reproductive performance of *R. differens*.

As a zoophytophagous insect, mortality due to cannibalism is a major production constraint. Under unmanaged conditions, cannibalism, which mostly occurs at night, accounted for 49% mortality of lab-reared *R. differens*, most of which were adults and females (above 83% and 53%, respectively) (Egonyu et al. 2021). A low rate of cannibalism was recorded when *R. differens* was fed live insect prey (Fombong et al. 2023b). The authors attributed this to the high protein content of the prey; however, cannibalism was not completely eliminated, suggesting that this could be an innate behavioral pattern to enhance the survival of the species.

Rearing structures and oviposition substrates

Options for different rearing structures and cage types that can be used for rearing *R. differens* were inadequate. Nonetheless, suitable rearing densities and oviposition substrates for *R. differens* have been determined. According to Lehtovaara et al. (Lehtovaara et al. 2019), the appropriate rearing density of *R. differens* is ≤36 nymphs per cubic meter (liter); however, rearing environments that were fitted with nets, spikes, and oat sprouts were found to have minimal effects on the survival of nymphs. Testing of different egg-laying media for *R. differens* demonstrated that females laid significantly more eggs on the folded plastic cloth (artificial substrate) than on the natural substrate (elephant grass, *Pennisetum purpureum*), leading to the recommendation of its use over cotton wool or natural substrates (Malinga et al. 2019). Some studies demonstrated that *R. differens* preferred *Panicum maximum* and maize over cotton wool and *P. purpureum* for oviposition, with an increased egg hatchability following the opening of the leaf sheath and moistening of eggs (Egonyu et al. 2021).

Potential rearing diets and their effects on the performance of R. differens

Single diets or various blends of mixed diets based on known grasshopper host plants, by-products of food crops, and animal feed have been tested for rearing *R. differens* (Valtonen et al. 2018, Malinga et al. 2020, Leonard et al. 2022). Preference and acceptance test have shown that *R. differens* is a facultative oligophagous insect that feeds on the leaves and inflorescences of many host plants in the absence of its preferred host (Valtonen et al. 2018). Similarly, preferential acceptance of different artificial diets by *R. differens* was demonstrated (Malinga et al. 2018a, Margaret et al. 2022). Varied levels of acceptability were observed for wheat bran, finger millet heads, rice seed heads, chicken superfeed egg booster, germinated finger millet, crushed dog biscuit pellets, sorghum seed heads, and Simsim cake; however, rice seed heads, finger millet seed heads, wheat bran, chicken feed egg booster, sorghum seed heads, and germinated finger millet were most consumed (Malinga et al. 2018a). Assessment of acceptability of wheat bran, maize bran, *Moringa oleifera* leaf powder, *Cardina niloticus*, and soybean meal showed that maize bran and wheat bran were most eaten by *R. differens* (Margaret et al. 2022). A higher preference was observed for maize bran, wheat bran, and germinated finger millet (Malinga et al. 2018a, Margaret et al. 2022).

Field observations revealed that swarming populations preferred leaves of *Cyperus papyrus* and inflorescences of *P. maximum* and *Setaria sphacelata*, whereas non-swarming populations preferred leaves and inflorescences of *Setaria homonyma*, and *Echinochloa pyramidalis* and *Panicum maximum*, respectively (Valtonen et al. 2018). Furthermore, Ssepuuya et al. (2018) recorded the highest survivorship (53%) of *R. differens* on *P. maximum* and *C. dactylon* diets, whereas Malinga et al. (Malinga et al. 2020) reported the highest survival rate (40% to 60%) of *R. differens* on *P. purpureum*, *B. ruziziensis*, *C. gayana*, *S. sphacelata*, and *S. pyramidalis* when blended with both *P. maximum* and *C. dactylon*. A significantly shorter nymphal development time occurred in the most diversified diets compared to the least diversified diets; however, diet diversification did not influence the fresh adult weights.

Individual rearing of *R. differens* on single artificial diets (finger millet seed heads, fresh maize cob, sorghum seed heads, and germinated finger millet) yielded 87% to 100% survival; average development time and adult weight of approximately 60 days and 0.6 g, respectively; and average fecundity of 100 eggs (Malinga et al. 2022). Mixtures of artificial diets had diverse effects on the growth and reproductive performance of *R. differens*. Diet mixtures containing wheat bran, germinated finger millets, rice seed heads, finger millet seed heads, chicken feed egg booster, and sorghum seed heads produced 38% survival, an average development time and adult longevity of 100 and 88 days, respectively, and an average fecundity of 257 eggs (Malinga et al. 2018b).

Inclusion of host plants (*Digitaria gayana*, *C. dactylon*, *Megathyrsus maximus* and *Ageratum conyzoides)* in an artificial diet comprising ground black soldier fly (*Hermetia illucens*) larvae, ground bones, soybean flour, maize flour and vitamin premix produced 53.7% survival; average development time and adult weight of approximately 89 days and 0.51 g, respectively; average fecundity of 46 eggs and adult longevity of less than 50 days (Leonard et al. 2022).

Production of *R. differens* on Finnish plant-based byproducts (barley feed, barley mash, and potato protein diets) yielded 84% survival and average weight of 0.51 g (Sorjonen et al. 2020). Rearing *R. differens* on mixtures of plant based byproducts (wheat bran, maize bran, and soy bean meal), *M. oleifera* and *C. niloticus* led to 87% survival; average development time and adult weight of 57 days and 0.58 g, respectively; average fecundity of 247 eggs and adult longevity of 89 days (Margaret et al. 2022). When Acur and colleagues tested the performance of *R. differens* on Ugandan plant based byproducts (finger millet local brew waste, dry maize cob, cotton seed cake, soy bean cake, sunflower cake, pumpkin pulp and peelings of cassava, sweet potato, pumpkins, pineapple and unripe bananas), a survival of 0% to 17%, average development time of 138 to 205 days and fresh adult weight of 0.28 g to 0.4 g were recorded (Acur, Malinga, and Nyeko 2024). The poor performance of *R. differens* reared on the byproducts was attributed to nutrient deficiencies and the presence of feeding deterrents in some of the byproducts. However, supplementation of germinated finger millet with maize cob yielded better performance across diverse combinations. The highest survival (86%), fastest development (87 days) and higher weight (0.8 g), and highest hatchability of eggs (82%) was observed following supplementation with 25%, 50% and 75% of dry maize cobs respectively (Acur, Malinga, Eilenberg, et al. 2024).

Nutritional Characteristics of *R. differens* and Its Derived Products

The nutritional composition of *R. differens* collected from different regions has been analysed by different authors. Regarding the proximate composition of *R. differens* (Table 1), the protein, carbohydrate, fat, dietary fibre, ash, chitin, and moisture contents in *R. differens* were approximately 8% to 54%, 0.01% to 22%, 20% to 83%, 4% to 14%, 1% to 6%, 10% to 15%, and 1% to 71%, respectively (Kinyuru et al. 2010a, Siulapwa et al. 2012, Fombong et al. 2017, Ssepuuya et al. 2017, Nyangena et al. 2020, Ochieng et al. 2022).

The proximate composition of *R. differens* varied with geographical location, color morph, and swarming season (Ssepuuya et al. 2019a). The proximate composition of *R. differens* is influenced by the processing methods used. Boiled, freeze-dried, and oven-dried grasshoppers contain higher levels of crude protein than raw forms (Fombong et al. 2017, Nyangena et al. 2020). Toasted and dried grasshoppers recorded significantly lower protein digestibility (Kinyuru et al. 2010a, Yisa et al. 2023) whereas blanched and boiled grasshoppers exhibited higher digestibility (Ochieng 2023). Exceptionally high levels of crude fat have been reported in toasted *R. differens* (Ochieng et al. 2022). High moisture content has been recorded in freeze-dried, boiled, and blanched grasshoppers; however, other heat processing methods reduce their moisture content (Nyangena et al. 2020, Ochieng et al. 2022). The protein content of *R. differens* fortified products increased with an increase in inclusion level of the grasshopper (Ronoh et al. 2024a).

The quantities of essential and non-essential amino acids contained in *R. differens* (Table 2) indicate that tryptophan and methionine are the least abundant amino acids, whereas glutamic acid, aspartic acid, and alanine are the most abundant (Siulapwa et al. 2012, Fombong et al. 2017, Ssepuuya et al. 2019a). The amino acid content of *R. differens* was influenced by different drying methods (Yisa et al. 2023). Amino acid profile of *R. differens* derived products increased with an increase in the quantity of *R. differens* included (Ronoh et al. 2024a).

The most abundant fatty acids in the raw and processed forms of wild *R. differens* (Table 3) include oleic, palmitic, palmitoleic, and linoleic acids (Kinyuru et al. 2010a, Fombong et al. 2017, Rutaro et al. 2018c, Ssepuuya et al. 2019a). The most common fatty acids in lab-reared *R. differens* include palmitic, oleic, linoleic, stearic and palmitoleic acids (Rutaro et al. 2018a, 2018b, Sorjonen et al. 2020).

Several studies have demonstrated that the fatty acid composition of *R. differens* reared in the laboratory can be influenced by diet. Increasing the diversification of diets by varying the inclusion of 1 to 6 natural plants in the composite diet significantly altered the fatty acid composition of *R. differens*. The proportion of linoleic and α-linolenic acids increased with the increased types of plants in the diet (Rutaro et al. 2018a, 2018b). In contrast, some authors have found that rearing *R. differens* on different host plants singularly or in combination did not alter its fatty acid composition (Malinga et al. 2020). A similar trend was observed when *R. differens* was reared on artificial diet mixtures. Fatty acid content and composition differed significantly among *R. differens* reared on different artificial diet mixtures, although the variability did not follow a particular trend. The highest proportions of saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids were found in three-, two-, and nine-feed diets, respectively (Rutaro et al. 2018c).

The influence of diet on the fatty acid composition of *R. differens* was further elucidated by Lehtovaara et al., who demonstrated that manipulation of the diets of *R. differens* with diverse fatty acids yielded grasshoppers with fatty acids proportional to the insect diet (Lehtovaara et al. 2017). Similarly, Malinga et al. established that the fatty acid composition of *R. differens* resembled that of the grasses they were fed on (Malinga et al. 2020).

The fatty acid profiles of *R. differens* are affected by the processing methods (Kinyuru 2021, Ochieng et al. 2022, Yisa et al. 2023). Frying and solar drying reduced unsaturated fatty acids (palmitoleic acid) to undetectable levels in *R. differens* oil, whereas blanching increased the levels of sterols and polyunsaturated fatty acids (α linolenic, linoleic, and arachidonic acids) (Kinyuru 2021, Ochieng et al. 2022). Boiling and toasting increased the levels of saturated fatty acids but decreased the levels of unsaturated fatty acids in *R. differens* oil (Nyangena 2022). However, some studies have found that heat processing does not affect the fatty acid profile of *R. differens* (Ssepuuya et al. 2020).

R. differens contains sterols such as cholesterol, camposterol, ß sitosterol, cholest-4-ene-3-one and (22Z)-27-Norergosta-5,22-dien-3ß-01 (Nyangena 2022, Ochieng et al. 2022). According to Kinyuru (2021), oil extracted from *R. differens* has a saponification value of 229.67 to 234.4 mgKOH/Kg, 86.97 g/100g Iodine, 0.13 to 0.14 mEq/Kg Peroxide and 27.51 to 31.4 mg/100 ml cholesterol. The author opined that the levels of peroxide and iodine in the oil ensure stability during processing, while the low levels of cholesterol renders it a healthier choice for human consumption than animal oils (Kinyuru 2021). Processing increased the peroxide and saponification values but decreased the iodine value of the grasshoppers. Boiling and toasting significantly lowered cholesterol levels in oils extracted from grasshoppers (Nyangena 2022).

Table 1. Proximate composition of *R. differens* and its derived products reported in different studies

Source of samples/processing method/ inclusion level	*Morph*	Proximate composition (%) Moisture	Ash	Crude protein	Crude fat	Crude fiber	Carbohydrate/NFE	Chitin	Energy (kcal/100g)	Reference
Raw/unprocessed *R. differens*										
Wild, Kenya	Green	66.4	2.8	43.1	48.3	4.0	NR	NR	NR	(Kinyuru et al. 2010a, Kinyuru 2021)
	Brown	71.2	2.6	44.3	46.2	5.0	NR	NR	NR	
Wild, Zambia	Green	4.5	2.2	44.6	49.0	NR	8.4	NR	618.2	(Siulapwa et al. 2012)
Wild, Uganda	Mixed	-	3.3	40.8	46.3	5.9	3.7	NR	494.6	(Bbosa et al. 2019)
Wild, Uganda	Green	50.4	3.2	39.4	41.9	12.7	2.8	NR	NR	(Ssepuuya et al. 2017)
	Brown	53.1	3.2	38.9	42.2	12.6	3.0	NR	NR	
Wild, Uganda	Mixed	65.4	3.1	43.8	28.4	4.2	20.4	NR	NR	(Nyangena et al. 2020)
Wild, Uganda	Mixed	3.0-5.3	1.4-2.8	28.2-44.8	41.0-54.3	4.5-5.3	7.5-16.2	NR	582-644	(Kababu et al. 2023)
Wild, Kenya	Mixed	55.0	2.8	16.2	24.9	3.9	NR	NR	NR	(Gachihi et al. 2023)
Processed *R. differens* using different methods										
Oven-dried, Kenya	Green	4.3	3.9	45.5	35.0	NR	1.4	14.9	NR	(Fombong et al. 2017)
Oven-dried, Kenya	Brown	4.5	5.4	52.9	36.1	NR	0.0	14.2	NR	
Freeze-dried, Kenya	Green	4.6	4.9	45.0	33.3	NR	4.0	9.8	NR	
Freeze-dried, Kenya	Brown	4.9	4.7	47.8	36.8	NR	0.0	10.8	NR	
Freeze-dried, Kenya	Purple	4.2	4.3	50.5	38.8	NR	0.0	11.2	NR	
Freeze-dried, Uganda	Mixed	76.5	2.7	48.8	24.9	3.9	19.7	NR	NR	(Nyangena et al. 2020)
Boiled, Uganda	Mixed	46.1	4.3	53.5	20.1	4.5	17.7	NR	NR	
Toasted, Uganda	Mixed	9.8	3.8	42.3	27.5	4.2	22.2	NR	NR	
Solar-dried, Uganda	Mixed	8.3	3.7	44.4	26.7	4.1	21.2	NR	NR	
Oven-dried, Uganda	Mixed	1.8	2.2	40.1	43.8	11.2	NR	NR	NR	(Ochieng et al. 2022)
Blanched, Uganda	Mixed	14.5	2.3	43.1	36.3	10.9	NR	NR	NR	
Boiled, Uganda	Mixed	1.6	2.4	44.7	46.0	9.0	NR	NR	NR	
Toasted, Uganda	Mixed	0.8	1.2	7.8	83.0	8.7	NR	NR	NR	
Sun-dried, Kenya	Mixed	7.1	3.8	42.3	27.5	4.2	NR	NR	NR	(Gachihi et al. 2023)
Oven-dried, Kenya	Mixed	4.0	4.0	45.5	26.7	4.2	NR	NR	NR	
Defatted sun-dried, Kenya	Mixed	6.7	3.1	44.1	2.2	3.6	NR	NR	NR	
Defatted oven-dried, Kenya	Mixed	3.4	2.3	46.0	2.3	4.3	NR	NR	NR	
Novel food products enriched with *R. differens*										
Extruded composite flour enriched with *R. differens*										
ECF (0%), Uganda	Mixed	0.5	1.2	8.1	1.6	0.8	87.8	NR	397.2	(Shabo et al. 2022)
ECF (5%), Uganda	Mixed	1.8	1.2	9.2	1.7	0.9	85.2	NR	392.7	
ECF (15%), Uganda	Mixed	2.8	1.3	11.5	6.0	1.0	78.1	NR	411.6	
ECF (25%), Uganda	Mixed	2.8	1.5	12.9	6.8	1.2	74.8	NR	413.5	
Cookies prepared with *R. differens* oil										
Lab reared, Kenya	Mixed	3.5	1.5	7.8	NR	0.1	71.4	NR	NR	(Cheseto et al. 2020)
Cookies enriched with *R. differens* processed using different methods										
Blanched, Uganda	Mixed	2.8	2.1	11.1	19.6	0.2	64.2	NR	477.8	(Ochieng et al. 2023a)
Boiled, Uganda	Mixed	3.0	2.2	10.9	20.7	0.2	63.0	NR	481.6	
Toasted, Uganda	Mixed	2.3	2.6	11.0	19.8	0.1	64.0	NR	479.4	
Deep fried, Uganda	Mixed	1.3	2.2	6.8	25.8	0.1	63.8	NR	514.7	

(Continued)

Table 1. Continued.

Source of samples/processing method/ inclusion level	*Morph*	Proximate composition (%) Moisture	Ash	Crude protein	Crude fat	Crude fiber	Carbohydrate/NFE	Chitin	Energy (kcal/100g)	Reference
Wheat based biscuits enriched with *R. differens*										
RDP (5%), Uganda	Mixed	4.3	0.8	14.9	21.0	1.4	57.6	NR	NR	(Ronoh et al. 2024a)
RDP (15%), Uganda	Mixed	4.1	1.0	18.3	23.9	2.6	50.3	NR	NR	
RDP (25%), Uganda	Mixed	3.7	1.2	25.1	24.7	3.5	41.8	NR	NR	
RDP (40%), Uganda	Mixed	3.2	1.3	28.0	26.4	5.7	35.8	NR	NR	
Sorghum and wheat based cookies fortified with *R. differens*										
RDP (5%), Uganda	Mixed	4.5	1.2	13.9	23.3	2.2	55.0	NR	NR	(Ronoh et al. 2024a)
RDP (15%), Uganda	Mixed	3.8	1.2	17.4	23.9	3.5	50.4	NR	NR	
RDP (25%), Uganda	Mixed	3.5	1.5	20.3	23.9	4.3	46.4	NR	NR	
RDP (40%), Uganda	Mixed	3.2	1.8	29.3	24.5	5.6	39.7	NR	NR	

ECF (%), extruded composite flour and percentage of *R. differens* included; RDP (%): percentage of *R. differens* powder.

R. differens is rich in flavonoids, such as Quercetin, Luteolin, Kaempferol, and Orientin (Cheseto et al. 2020, Kababu et al. 2023). The total flavonoids (3.02 ± 0.21 QE/g) and phenolic (11.14 ± 0.18 GAE/g) amounts of *R. differens* is higher than that of several fruits and vegetables (Ssepuuya et al. 2021a). Flavonoid values increased with blanching but decreased with deep frying (Ochieng et al. 2022). The highest total antioxidant activity (87.00 ± 2.59%) expressed as radical scavenging activity of the grasshopper is comparable to that of many fruits and vegetables consumed worldwide (Ssepuuya et al. 2020). An assessment of suitable methods for the extraction of antioxidant compounds from *R. differens* revealed that defatting led to a reduction in total flavonoids, phenolic compounds, and antioxidant activity (Ssepuuya et al. 2021a). The authors determined that non-defatting, the use of acetone, and sonication for 1 h were the most suitable conditions for the extraction of antioxidant compounds from *R. differens*.

The amounts of different vitamins in *R. differens* clearly indicate that it is an excellent source of vitamins (Kinyuru et al. 2010a, Ssepuuya et al. 2019a). Grasshoppers contain various quantities of retinol, niacin, riboflavin, ascorbic acid, folic acid, pantothenic acid, pyridoxine, tocopherol, and vitamin B12 (Table 4). However, the levels of vitamins (niacin, retinol, and riboflavin) decreased after toasting and drying (Kinyuru et al. 2010b).

R. differens contains minerals that are crucial to human health and nutrition. However, some minerals exceeded the recommended daily allowance for adults (Table 5). The macro-minerals included potassium (9 to 834 mg/100 g), phosphorous (38 to 694 mg/100 g), and calcium (9 to 1,124 mg/100 g). The highest trace minerals include iron (2 to 259 mg/100 g) and zinc (8 to 18 mg/100 g) (Kinyuru et al. 2010a, Siulapwa et al. 2012, Fombong et al. 2017, Ssepuuya et al. 2019a, Ochieng et al. 2022). Raw grasshoppers collected from Zambia had a lower mineral content compared to the other countries; while the quantity of iron in grasshoppers collected from Kenya was above 15-fold higher compared to Zambia (Kinyuru et al. 2010a, Siulapwa et al. 2012). The levels of calcium, magnesium, and zinc increased in boiled, blanched, and toasted *R. differens*, whereas the levels of iron decreased after toasting (Ochieng et al. 2022). According to Fombong and colleagues (Fombong et al. 2017) the quantity of calcium in processed *R. differens* was above 27 times higher than quantities reported by Ochieng et al. (2022) and exceeded the recommended daily allowance for adults (van Huis et al. 2013). Similarly, the authors reported higher contents of magnesium and zinc compared to those reported by Ochieng et al. (2022). However, the quantity of Zn reported by both authors exceeded the recommended daily allowance (Belluco et al. 2013, van Huis et al. 2013). The mineral content in *R. differens* fortified products increased with its inclusion level, with the quantities of zinc and iron in some cases meeting the recommended daily requirements for adults (Ronoh et al. 2024a)

The nutritional profile of novel food products fortified with *R. differens* was assessed. Cookies baked with *R. differens* oil contained high quantities of monounsaturated fatty acids and polyunsaturated fatty acids compared to those prepared using other types of oils (Cheseto et al. 2020). Similarly, inclusion of *R. differens* in cookies resulted in higher levels of fats, proteins, PUFA, and energy, but reduced calcium levels and protein digestibility. Cookies fortified with boiled, blanched, and toasted *R. differens* are rich in proteins, amino acids (valine,

Table 2. Amino acid composition of *R. differens* and *R. differens* derived products reported in different studies

	Amount (mg/g)												
	Country source and color morph					*R. differens* fortified products/*R. differens* in inclusion level							
	Zambia	Kenya		Uganda		Wheat-based biscuits				Sorghum and wheat-based biscuits			
Amino acid	Green	Green	Brown	Mixed		RDP (5%)	RDP (15%)	RDP (25%)	RDP (40%)	RDP (5%)	RDP (15%)	RDP (25%)	RDP (40%)
Essential													
Histidine (His)	44.1	24.7	25.8	23.7	1.7 to 3.4	24.8	26.6	29.4	33.6	25.3	27.6	30.6	36.0
Leucine (Leu)	26.7	92.5	95.2	86.3	52.8 to 99.4	117.8	120.2	122.7	127.3	115.4	118.4	121.9	126.0
Isoleucine (Ile)	26.1	47.6	49.2	47.7	5.3 to 9.9	39.4	41.4	43.2	46.6	38.6	42.6	46.8	50.7
Lysine (Lys)	57.4	54.8	53.8	63.9	4.0 to 10.5	26.5	27.6	31.2	34.5	24.9	27.6	31.4	34.6
Methionine (Met)	4.3	7.0	1.4	18.5	1.0 to 2.7	NR	NR	NR	NR	NR	NR	NR	NR
Tryptophan (Trp)	0.3	8.7	8.3	8.3	NR	15.1	16.3	18.5	19.3	15.9	17.9	23.0	25.2
Valine (Val)	16.4	65.8	67.1	59.6	3.0 to 5.5	52.6	55.9	56.9	60.3	51.4	56.9	61.9	64.6
Threonine (Thr)	28.6	41.8	43.0	41.5	1.2 to 4.2	38.5	39.8	42.5	43.3	37.6	39.3	42.9	46.4
Phenylalanine (Phe)	26.1	33.8	35.5	37.0	2.8 to 8.7	NR	NR	NR	NR	NR	NR	NR	NR
Non-essential													
Glutamic acid (Glu)	84.3	123.3	124.7	NR	1.2 to 2.9	NR	NR	NR	NR	NR	NR	NR	NR
Aspartic acid (Asp)	49.0	96.8	93	NR	3.1 to 5.2	NR	NR	NR	NR	NR	NR	NR	NR
Alanine (Ala)	26.6	117.0	117.3	102.7	0.6 to 2.2	NR	NR	NR	NR	NR	NR	NR	NR
Cysteine (Cys)	0.7	5.2	2.9	7.0	0.3 to 0.4	NR	NR	NR	NR	NR	NR	NR	NR
Arginine (Arg)	49.8	57.3	55.0	58.3	2.9 to 5.6	NR	NR	NR	NR	NR	NR	NR	NR
Glycine (Gly)	26.0	60.7	64.9	56.3	2.1 to 3.4	NR	NR	NR	NR	NR	NR	NR	NR
Proline (Pro)	19.0	62.6	64.6	72.7	3.3 to 5.7	NR	NR	NR	NR	NR	NR	NR	NR
Serine (Ser)	25.9	48.1	48.9	44.8	1.6 to 2.6	NR	NR	NR	NR	NR	NR	NR	NR
Tyrosine (Tyr)	25.3	52.5	49.6	52.0	2.2 to 5.9	NR	NR	NR	NR	NR	NR	NR	NR
Reference	(Siulapwa et al. 2012)	(Fombong et al. 2017)		(Ssepuuya et al. 2019a)	(Kababu et al. 2023)	(Ronoh et al. 2024a)							

RDP (%), percentage of *R. differens* powder.

Table 3. Fatty acid composition of wild, reared, and raw *R. differens* reported in different studies

	Amount (%), country source, and color morph							
	Kenya				Uganda			
	Wild, Raw		Wild, processed		Wild, raw	Reared, raw		
Fatty acid	Green	Brown	Mixed, BFD	Mixed, BOD	Mixed			
Capric acid	0.4	0.2	0.1	0.1	NR	NR	0.1	NR
Lauric acid	NR	NR	0.2	0.2	NR	NR	0.0-0.1	NR
Myristic acid	1	0.8	1.1	1.1	2.9	0.3 to 0.5	0.6 to 0.9	2.8 to 11.9
Myristoleic acid	NR	NR	NR	NR	2.2	NR	0.1	2.1 to 7.7
Palmitic acid	31.5	32.1	28.2	27.8	20.9	15.2 to 20.1	19.6 to 22.3	20.9 to 32.7
Palmitoleic acid	2	1.4	1.7	1.6	21.3	0.3 to 1.1	0.7 to 1.3	15.8 to 21.3
Stearic acid	5.5	6	7.9	8.5	6.7	6.2 to 9.0	7.7 to 9.2	5.7 to 7.9
Oleic acid	24.6	24.9	44.3	44	25	24.6 to 36.8	19.5 to 28.6	15.1 to 25.7
Linoleic acid	31.2	29.5	14	14.1	19.6	28.1 to 37.6	21.0 to 28.5	9.0 to 19.6
A-linolenic acid	NR	NR	NR	NR	0.9	NR	12.4 to 16.3	NR
Linolenic acid	3.2	4.2	1.4	1.5	NR	3.8 to 16.8	NR	0.9 to 2.6
Arachidic acid	NR	NR	NR	NR	0.5	0.5 to 2.1	0.9 to 1.4	0.5 to 2.3
Decanoic acid	NR	NR	0.1	0.1	NR	NR	NR	NR
Kyriologic acid	NR	NR	0.1	0.1	NR	NR	NR	NR
Arachidonic acid	NR	NR	0.6	0.7	NR	NR	NR	NR
Pentadecanoic	NR	NR	0.1	0.1	NR	0.1	0.2 to 0.4	NR
Heptadecanoic	NR	NR	0.2	0.1	NR	NR	NR	NR
Hexadecanoic	NR	NR	NR	NR	NR	0.0 to 0.1	NR	NR
Heptadecenoic	NR	NR	NR	NR	NR	0.0 to 0.1	0.3 to 0.5	NR
Margaric	NR	NR	NR	NR	NR	0.3 to 0.5	NR	NR
Vaccenic	NR	NR	NR	NR	NR	0.0 to 0.3	NR	NR
Nanodecanoic	NR	NR	NR	NR	NR	0.0 to 0.1	NR	NR
Heneicosanoic	NR	NR	NR	NR	NR	0	NR	NR
Eicosatetraenoic	NR	NR	NR	NR	NR	NR	NR	NR
Behenic	NR	NR	NR	NR	NR	0.1 to 0.6	0.4 to 0.5	NR
Tricosanoic acid	NR	NR	NR	NR	NR	NR	0	NR
Lignoceric acid	NR	NR	NR	NR	NR	NR	0.0 to 0.1	NR
Cerotic acid	NR	NR	NR	NR	NR	NR	0.1 to 0.3	NR
Total SFA	38.3	39.1	37.7	37.8	31	24.6 to 29.8	32.1 to 43.0	31.0 to 48.4
MUFA	26.6	26.3	46.1	45.7	48.4	25.7 to 38.3	45.7 to 55.2	38.6 to 46.4
PUFA	34.4	33.8	16.2	16.5	20.6	31.9 to 47.4	4.7 to 21.5	11.5 to 20.6
Reference	(Kinyuru et al. 2010a)		(Fombong et al. 2017)		(Rutaro et al. 2018c)	(Malinga et al. 2020)	(Rutaro et al. 2018c)	(Rutaro et al. 2018c)

SFA, saturated fatty acid; USFA, unsaturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, Polyunsaturated Fatty acid; BFD, blanched freeze-dried; BOD, blanched oven-dried.

alanine, and glutamic acid), and minerals (Zn, Fe, Mn and Cu) (Ochien et al. 2023a). Similarly, the crude protein, amino acid and mineral profile of *R. differens* fortified biscuits increased with an increase of quantity of *R. differens* incorporated (Ronoh et al. 2024a).

Consumer Acceptability, Perception, and Sociocultural Factors Influencing Consumption of *R. differens*

Traditionally, *R. differens* is widely consumed as a main dish or snack (Shabo et al. 2022). Limited neophobia was observed for *R. differens* compared to other edible insects in Uganda where it is widely consumed, its consumption was influenced by factors such as age and education where younger and less educated individuals were more likely to consume the grasshoppers (Olum et al. 2021).

High consumer acceptability score was recorded for whole sautéed and dried grasshoppers compared to sautéed and boiled, and boiled and dried grasshoppers (Ssepuuya et al. 2017). Similarly, high consumer acceptance was demonstrated for *R. differens* fortified products, in some cases, however, this was influenced by the proportion of grasshoppers included in the diverse food products (Cheseto et al. 2020, Ochieng et al. 2023a, Ronoh et al. 2024a, 2025). A higher consumer acceptability was expressed for wheat-based biscuits containing 5% *R. differens* compared to those that exceeded this quantity (Ronoh et al. 2025). However, the acceptability of extruded composite porridge flour fortified with varied proportions of *R. differens* (0%, 5%, and 15% of *R. differens*) did not differ (Shabo et al. 2022).

The high consumer acceptance of these products is attributed to production of volatile compounds. Ochieng et al. (2023), documented the production of volatile compounds that increased the acceptability of *R. differens* fortified cookies while Ronoh et al. (2024) found that compositing of biscuits with *R. differens* powder yielded positive baked aroma and consumer attributes (Ochieng et al. 2023b, Ronoh et al. 2024b). Cookies based on toasted, deep-fried, and blanched *R. differens* were

Table 4. Vitamin composition of *R. differens* reported by different authors

Source	*R. differens* morph	Type of vitamin										Reference
		Retinol (μg/g)	Gamma tocopherol(μg/g)	α-tocopherol (μg/g)	Niacin (mg/100g)	Riboflavin (mg/100g)	Ascorbic acid (mg/100g)	Folic acid (mg/100g)	Pyridoxine (mg/100g)	Vit B12 (μg/g)	Pantothenic acid	
Raw *R. differens*												
Wild, Kenya	Green	1.1	NR	161.5	3.6	1.2	0.6	1.0	0.4	NR	NR	(Kinyuru et al., 2010b)
	Brown	2.2	NR	170.6	3.2	1.4	0.2	0.9	0.2	NR	NR	
Wild, Uganda	Mixed	NR	NR	NR	NR	NR	NR	NR	NR	1.0	NR	(Ssepuuya et al. 2019a)
Wild, Uganda	Mixed	3.0 to 10.0	11.0	1.0 to 5.0	21.0 to 29.2	1.1 to 6.3	NR	79.0 to 137.6	87.9 to 151.5	20.0 to 33.0	165.2 to 248.1	(Kababu et al. 2023)
Processed *R. differens*												
Toasted, Kenya	Green	0.8	NR	139.2	3.3	0.9	0.5	0.6	0.4	NR	NR	(Kinyuru et al., 2010b)
Toasted, Kenya	Brown	1.8	NR	160.1	3.0	1.1	0.1	0.5	0.2	NR	NR	
Dried, Kenya	Green	0.7	NR	135.9	3.2	0.8	0.4	0.3	0.4	NR	NR	
Dried, Kenya	Brown	1.6	NR	155.5	3.0	1.0	0.1	0.4	0.1	NR	NR	
Toasted dried, Kenya	Green	0.6	NR	136.0	3.1	0.7	0.3	0.3	0.4	NR	NR	
Toasted dried, Kenya	Brown	0.9	NR	154.7	2.2	0.4	0.1	0.3	0.1	NR	NR	

associated with volatile organic compounds such as nonanal, hexanal, and pentanal, among others, which produced an attractive aroma, leading to increased consumer acceptability. The overall acceptability assessment was similar between the control and deep-fried *R. differens*-based cookies (Ochieng et al. 2023b).

When compared with other edible insects, lower acceptability was demonstrated for products that were fortified with *R. differens* in Poland. A comparison between muffins fortified with sweet and salted *R. differens* and other edible insects (mealworms, crickets and buffalo worms), however, revealed a lower consumer acceptability and least rating for *R. differens* based muffin in terms of texture, taste, smell and appearance (Mazurek et al. 2024). Similarly, a lower acceptance was observed in soups fortified with *R. differens* in comparison to other edible insects (Skotnicka et al. 2023). The low acceptance of *R. differens* based product in these studies could be due to limited use and consumption of *R. differens* in the region (Szulc 2023).

Consumption of *R. differens* is influenced by several cultural beliefs and taboos. Pregnant women were prohibited from eating *R. differens* based on the belief that they would deliver cone-headed children, whereas children who ate *R. differens* would be unable to speak for the rest of their lives, thus children were barred from eating the grasshoppers. Some communities believed that *R. differens* is an aphrodisiac while others believed that it cemented and made marriages happier, this belief led women to collect and prepare the grasshoppers for their husbands who in return showered them with traditional gifts (Mmari et al. 2017).

Safety of *R. differens*

Microbial Quality

Opportunistic and pathogenic bacteria (Fig. 3) and fungi (Fig. 4) which are of major health concerns were detected in *R. differens*. The sources of contamination are largely from post-harvest handling conditions (Mugo-Kamiri et al. 2024, Rutaro et al. 2024). For instance, a comparative analysis of microbial contamination of *R. differens* revealed a higher number of bacterial and fungal species in samples collected from harvesting drums and markets than in those collected from wild vegetation (Labu et al. 2021). This is an indicator that contamination of *R. differens* is not intrinsic to the species but emanates from post-harvest handling.

Metagenetic sequencing of *R. differens* samples from Uganda showed the potential presence of pathogenic microorganisms such as *Clostridium*, *Bacillus*, *Staphylococcus*, *Acinetobacter*, *Campylobacter*, *Buttiauxella*, *Pseudomonas, Serratia*, and *Neissera* that are capable of causing food-borne diseases (Ssepuuya et al. 2019b, Labu et al. 2021, Mugo-Kamiri et al. 2024). The quantity and type of microbial contaminants varied between the raw and processed samples of *R. differens* from diverse sources.

Overall, *R. differens* collected from Uganda exhibited total aerobic count ranging from 8.38 to 9.41 log cfu/g; 6.89 to 7.83 log cfu/g for *Enterobacteriaceae*; 7.99 to 9.11 log cfu/g for lactic acid bacteria; 3.75 to 5.9 log cfu/g for aerobic bacterial spores, and 5.77 to 8.2 log cfu/g of yeasts and molds (Ssepuuya et al. 2019b, Nyangena et al. 2020). These counts are either similar or slightly higher than those observed by Ng'ang'a and colleagues in raw grasshoppers obtained in Tanzania (Ng'ang'a et al. 2018).

Table 5. Mineral content of *R. differens* reported in different studies

Source	*R. differens* morph	Mineral (mg/100g) Calcium	Magnesium	Potassium	Sodium	Phosphorus	Iron	Zinc	Manganese	Copper	Selenium	Reference
Raw *R. differens*												
Wild, Kenya	Green	27.4	33.9	370.6	358.7	140.9	16.6	17.3	5.3	0.6	NR	(Kinyuru et al. 2010a)
	Brown	24.5	33.1	259.7	229.7	121.0	13.0	12.4	2.5	0.5	NR	
Wild, Uganda	Mixed	69.6	54.2	538.0	28.1	516.7	48.6	11.2	3.3	1.9	NR	(Ssepuuya et al. 2019a)
Wild, Zambia	Mixed	9.0	5.2	9.1	14.6	NR	2.0	NR	0.0	0.1	NR	(Siulapwa et al. 2012)
Wild, Uganda	Mixed	19.3 to 58.9	16.1 to 54.6	198.0 to 641.0	27.4 to 129.0	38.8 to 510.0	7.2 to 155.0	6.3 to 17.2	1.1 to 4.7	1.7 to 2.8	NR	(Kababu et al. 2023)
Wild, Kenya	Mixed	61.1		341.3	300.3	NR	8.6	19.1	NR	NR	NR	(Gachihi et al. 2023)
Wild, DRC		25.7	32.3	272.7	257.8	NR	16.3	13.3	NR	NR	NR	(Ishara et al. 2024)
Processed *R. differens*												
Freeze dried, Kenya	Green	1023.0	160.0	806.0	78.0	680.0	217.0	13	8	1	NR	(Fombong et al. 2017)
Freeze dried, Kenya	Brown	1047.0	161.8	826.5	60.2	692.1	222.8	15.2	8.4	1.8	0	
Oven dried, Kenya	Green	967.6	123.0	724.0	57.2	610.7	174.4	15.0	6.0	1.6	NR	
Oven dried, Kenya	Brown	1124	168.5	834.4	50.8	693.9	258.7	14.2	8.8	1.7	0.1	
Blanched, Uganda	Mixed	47.9	52.8	NR	NR	427.8	140.9	16.8	NR	1.9	NR	(Ochieng et al. 2022)
Boiled, Uganda	Mixed	54.5	56.5	NR	NR	427.7	179.1	18.4	NR	2.3	NR	
Toasted, Uganda	Mixed	55.0	53.2	NR	NR	496.8	22.2	13.2	NR	2.2	NR	
Deep fried, Uganda	Mixed	35.8	33.3	NR	NR	305.4	12.9	8.5	NR	1.6	NR	
Sun to dried, Kenya	Mixed	54.4	NR	341.9	301.6	NR	22.1	22.1	NR	NR	NR	(Gachihi et al. 2023)
Oven to dried, Kenya	Mixed	43.2	NR	342.3	300.5	NR	14.8	14.8	NR	NR	NR	
Defatted oven to dried, Kenya	Mixed	43.5	NR	341.2	290.4	NR	22.2	22.2	NR	NR	NR	
Defatted sun to dried, Kenya	Mixed	54.1	NR	283.0	300.2	NR	27.4	27.4	NR	NR	NR	
R. differens fortified products												
Wheat-based biscuits fortified with *R. differens*												
RDP (5%), Uganda	Mixed	36.0	136.7	0.7	NR	0.3	4.1	3.3	3.9	NR	NR	(Ronoh et al. 2024a)
RDP (15%), Uganda	Mixed	37.4	142.6	0.7	NR	0.3	6.9	5.3	4.1	NR	NR	
RDP (25%), Uganda	Mixed	39.9	144.6	0.8	NR	0.3	7.3	7.7	4.5	NR	NR	
RDP (40%), Uganda	Mixed	43.9	151.6	1.7	NR	0.4	9.5	8.9	4.7	NR	NR	
Sorghum- and wheat-based biscuits fortified with *R. differens*												
RDP (5%), Uganda	Mixed	52.1	173.6	1.0	NR	0.3	9.5	5.8	2.8	NR	NR	(Ronoh et al. 2024a)
RDP (15%), Uganda	Mixed	55.8	176.0	0.9	NR	0.3	11.1	7.7	3.1	NR	NR	
RDP (25%), Uganda	Mixed	56.0	181.6	1.17	NR	0.3	12.8	8.6	3.2	NR	NR	
RDP (40%), Uganda	Mixed	61.5	186.3	1.26	NR	0.4	14.0	11.5	3.6	NR	NR	
RDA (mg/day)		1,000	400	4,700	1,500	1,000	10	10	1	0.9	0.1	(Belluco et al. 2013, van Huis et al. 2013)

RDP (%), percentage of *R. differens* powder; RDA, recommended daily allowance for adult.

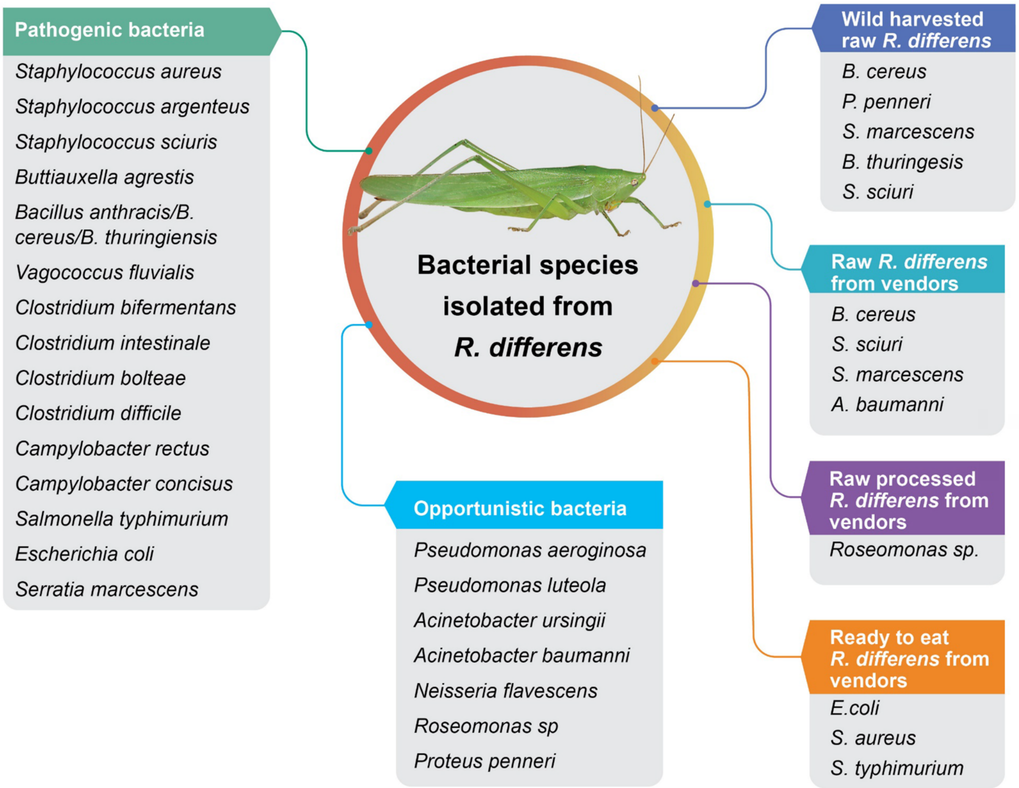

Fig. 3. Bacterial species commonly associated with spoilage of *R. differens* food-based products sold in the markets.

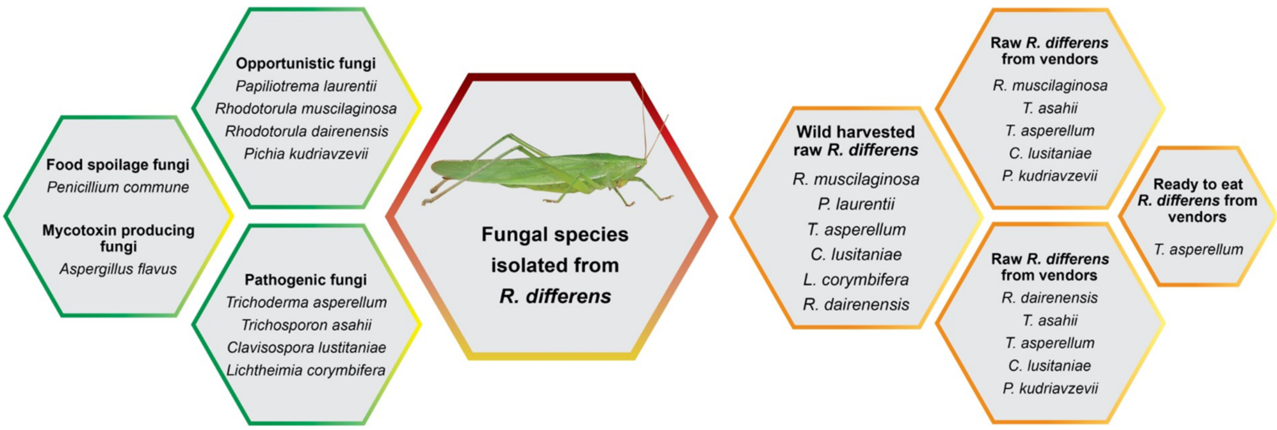

Fig. 4. Fungal species commonly associated with spoilage of *R. differens* food-based products sold in the markets.

Upon processing (boiling, toasting, smoking, and deep frying), there was a significant reduction in microbial loads to food safety levels, except for bacterial endospores (Ng'ang'a et al. 2018, Nyangena et al. 2020, Labu et al. 2021). Pathogenic bacterial species such as *E. coli*, *S, aureus* and *Salmonella* were not detected in biscuits fortified with *R. differens*, however, mesophilic bacterial counts were recorded (Ronoh et al. 2025).

There are limited data on diseases affecting *R. differens* despite evidence of disease infestation in other reared orthopterans, which can annihilate reared insect colonies (Verner et al. 2021, Kemsawasd et al. 2022). However, inoculation of lab reared *R. differens* with the fungal species *Clavispora lusitaniae*, *Lichtheimi corymbifera, Trichoderma koningii, Fusarium equiseti*, *M. fragilis*, *Aspergillus niger*, *Epicoccum sorghinum*, *Clonostachys rosea*, and *Penicillium commune*, and bacterial species *Proteus penneri*, *Serratia marcescens*, *Bacillus thuringiensis*, *Staphylococcus sciuri*, and *Enterococcus faecalis* isolated from the wild collection of *R. differens* established that these microorganisms were 4-7-fold more lethal to third instar nymphs than the untreated nymphs (Leonard et al. 2023).

Chemical Quality

High concentrations of some heavy metals such as lead, chromium, and cadmium, were reported in *R. differens* samples, with carcinogenic levels being 10-folds than the recommended levels (Kasozi et al. 2019). These heavy metals are significantly more concentrated on the head than on the abdomen of grasshoppers. Estimated daily intake showed that lead ingestion levels in *R. differens* collected from central Uganda exceeded the recommended levels in food products and posed 3-fold higher toxicity in children than in adults. Screening of raw and fried samples of *R. differens* by Labu et al. revealed that *R. differens* did not contain pesticide residues; however, herbicide and fungicide residues were detected in both raw and fried *R. differens* samples (Labu et al. 2022).

Phytophagous insects are known to acquire and retain detectable levels of anti-nutritional factors present in plant materials (Ghosh et al. 2016). Analysis of the quantity of oxalate, tannins, and phytate in *R. differens* found that the grasshopper contained lower quantities of these anti-nutrients than some foods of plant origin (Fombong 2022). Shabo et al. (2022) found that the phytate content of extruded composite flour enriched with *R. differens* did not differ from that without *R. differens*. However, the tannin content of extruded composite flour enriched with *R. differens* were significantly higher than that without *R. differens* (Shabo et al. 2022). Quantities of tannins, oxalates and phytates in *R. differens* were significantly reduced following sun drying and oven drying (Gachihi et al. 2023).

Processing, Preservation, and Storage of *R. differens*

Processing

R. differens can be eaten raw, boiled, sun-dried, fried, and flavored with onions or soups (Agea et al. 2008). Processing of the grasshopper entails removal of unwanted body parts such as appendages, wings, and ovipositors in females, and sorting out non-target insects and waste materials (grasses, wood ash, and cassava, and maize flour used during the process) from wild harvesting. This is commonly performed manually by women and children (Mmari et al. 2017, Ssepuuya et al. 2019b, Ishara et al. 2023). The grasshoppers are cleaned with water, and processed by sautéing, boiling, smoking, toasting, deep frying, sun drying, and freezing (Ssepuuya et al. 2016, 2017, Mmari et al. 2017, Ishara et al. 2023). Freeze and oven drying of grasshoppers under laboratory conditions were also reported (Fombong et al. 2017).

Boiling is performed by placing grasshoppers (*nsenene*) in boiling salted water, with or without spices (Mmari et al. 2017). Toasting is achieved by placing boiled or raw *nsenene* in a hot pan and stirring until it turns brownish in color and produces a meat-like smell. When the swarms are extensive, the grasshoppers are boiled with salt, sun-dried until deemed dry by the local processor, and stored in plastic buckets and sacks ready for consumption (Mmari et al. 2017, Ssepuuya 2019). Deep-fried grasshoppers are cooled, packed in cardboard boxes, and stored in clean and dry places free of contaminants such as rodents and other insects (Mmari et al. 2017, Ssepuuya et al. 2019b).

To minimize neophobia and disgust for whole insects, whole *R. differens* have been dried, ground, and used in the formulation of novel food products such as fortified flour (porridge flour) and baked products such as cookies, biscuits, bread, and muffins (Fig. 5), whereas oil extracted from grasshoppers has been tested for the production of baked products (Cheseto et al. 2020, Ochieng et al. 2023a, Ronoh et al. 2024a, 2025).

Preservation and Storage

The shelf life of raw grasshoppers is less than 24 h post-harvest (Ssepuuya et al. 2017). Therefore, traders have devised a means of further increasing the shelf life of grasshoppers by applying several dehydration mechanisms. According to community members, boiled and sun-dried *R. differens* have an extended shelf life of approximately one year (Mmari et al. 2017).

The shelf life of processed grasshoppers, however, remains a matter of ongoing research. Spoilage of *R. differens* with high water activity results from microbial and fat deterioration, whereas the spoilage of grasshoppers with low water activity emanates from enzymatic protein degradation (Ssepuuya et al. 2021b). Short-term storage of preheated grasshoppers at room temperature can occur for a maximum of 9 h without compromising microbial and sensorial quality (Ssepuuya et al. 2023). Studies to increase the shelf life of grasshoppers indicated that dehydration of grasshoppers to approximately 5% moisture content followed by either vacuum packaging or chilled storage increased their shelf life by about 3 to 5.5 months (Ssepuuya et al. 2016, 2017). Cold storage resulted in the preservation of flavors and more sensorially acceptable grasshoppers compared to room-temperature storage (Ssepuuya et al. 2016). Further studies have demonstrated that drying of roasted and preheated grasshoppers coupled with vacuum packaging can increase their shelf life stability to a minimum of 20 weeks at room temperature (Ssepuuya et al. 2023).

Existing Value-Chain, Marketing, and Economic Impact of *R. differens*

Both men and women dominate commercial wild harvesting, and thereafter, the processing and trade of *R. differens* on a small-scale (Agea et al. 2008, Mmari et al. 2017). The wild-caught populations of *R. differens* are either sold fresh or fried, smoked, toasted, and sun-dried (Agea et al. 2008, Okia et al. 2017). Subsistence collectors operate on small scale, and most of their collections are sold to household consumers within their localities. Generally, the price of processed *R. differens* is twice that of the unprocessed grasshopper, partly because of the processing costs, but also because of its demand in urban areas. Currently, one kilogram of *R. differens* retails at USD 2.2 to 2.7 and USD 10 in parts of Cameroon and Uganda, respectively (van Huis 2022). *R. differens* retailed between 9,708 and 10,401 Tanzanian shillings (Tsh) (USD 4.2 to 4.5) per kg in different parts of Tanzania (Mmari et al. 2017). The differences in price could be due to socioeconomic demographics of different locations, availability of *R. differens* during the season, and demand. In Uganda, the average retail price for ready-to-eat *R. differens* is USD 2.80 [10,055 Uganda shilling (UGX)] per kilogram, which is comparable to that of beef and chicken. Locally packed *R. differens* is commonly sold on roadsides and marketplaces, while processed and well packaged *R. differens* can be found in large stores and supermarkets (Agea et al. 2008, Matojo and Njau 2010, Ssepuuya et al. 2016, Mmari et al. 2017).

In Tanzania, the trade of *R. differens* has been reported to contribute significantly to household income, accounting for almost half of their basic needs (Mmari et al. 2017). Similarly, in Uganda, traders generate an average of USD 224 (804,423 UGX) from the sale of *R. differens* every season (Agea et al. 2008), thereby contributing to household food and nutritional security. Generally, the seasonal availability of *R. differens* serves as a source of income and employment for individuals involved in collection, processing, and trade (Agea et al. 2008, Mmari et al. 2017, Opoke et al. 2019a).

Fig. 5. *R. differens* and its derived food products (oven baked *nsenene* garnished with red and yellow pepper; *nsenene* fortified cookies; *nsenene* fortified bread and *nsenene* omelet garnished with tomatoes and lettuce).

Regulatory Framework on the Use of *R. differens* as Food and Feed

In Africa, more than 44, 16, and 36 countries, respectively, consider insects as non-conventional meat source, have legal text that support their use as native edible species, and tolerate edible insect species as suitable food stuffs (Grabowski et al. 2020, Nakimbugwe et al. 2021). For example, the National Guidelines on Nutrition and HIV/AIDS in Kenya acknowledge edible insects as a source of animal protein and, therefore, promote their consumption (Halloran et al. 2015). Legislation on the use of edible insects is gradually increasing, especially in Eastern Africa, where *R. differens* is dominant (Tanga et al. 2021, Verner et al. 2021, Niassy et al. 2022).

Many countries have not explicitly accepted insects as a food source; however, they are considered food when they are produced according to the current good manufacturing practices set out for human food (Marone 2016). Other countries, especially China, where insect consumption is commonplace, have no mention of insect consumption in their legislation, but they adhere to the strict food processing and safety guidelines prescribed by the Chinese Ministry of Health (Ai-Jun et al. 2020). In Europe, although insect consumption is new, the European Commission has approved the use of three insect types (locust, grasshopper, and crickets) for human food (European Commission 2015, 2022).

Discussion

Ruspolia differens is one of the most consumed edible insect species in sub-Saharan Africa, where it is consumed as a snack or a main dish (Okia et al. 2017, van Huis 2022, Ishara et al. 2023). Like most edible insects, *R. differens* is largely collected from the wild. Availability of wild collected edible insects such as *R. differens* is influenced by changes in land use, uncontrolled harvesting, and climate change which leads to their decline over time (Hlongwane et al. 2021, Tanga et al. 2025). The peak fecundity in *R. differens* occurs during the swarming season, however, uncontrolled harvesting inhibits their reproductive capacity which may in turn reduce their population and swarm sizes during their seasonal availability (Matojo and Yarro 2010, Opoke et al. 2019a). Domestication of the grasshopper will therefore provide an avenue for sustainable production and use. Although wild harvesting remains the single source of *R. differens*, alternative harvesting technologies for the collection of the grasshoppers remain limited despite the safety concerns attributed to the local trapping technology (Sengendo et al. 2021b, van Huis 2022). Thus, the need for development, testing, and adoption of safer alternative harvesting techniques.

Although mass rearing presents an avenue for sustainable production and use of *R. differens*, there was limited evidence on the domestication of the grasshopper. Artificial insect rearing systems require optimum environmental conditions aimed at enhancing the growth, development, survival, and reproductive performance of insects (Cohen 2018). Several advances have been made in the determination of the optimal rearing conditions for *R. differens*. The optimal temperature for the production of *R. differens* has been established; however, there are limited data on humidity and light parameters. Most insects show better performance under higher temperatures and lower humidity conditions, highlighting the need for research on the synergistic effects of these parameters on the production of *R. differens* (Jaworski and Hilszczański 2013, Ngonga et al. 2021). As a nocturnal species, there is a need for research on the effects of light parameters on *R. differens* to optimize the rearing environment (Matojo 2017, Fombong et al. 2023a).

Cannibalism was reported as a major constraint in rearing *R. differens*, however, in most experiments, *R. differens* was reared individually (Malinga et al. 2018b, 2020, 2022, Leonard et al. 2021). This is despite evidence that *R. differens* is a non-aposematic species that is not adapted to solitary living (Matojo and Njau 2010). There is a need to implement laboratory generated research evidence under semi-field conditions to establish optimal conditions that will be appropriate for the scale-up of mass production of *R. differens*.

Despite rearing containers forming an integral part of artificial insect rearing systems that can induce significant changes on their growth and survival, there was limited evidence on the efficacy of rearing containers on production of *R. differens* (Bueno et al. 2006, Jose et al. 2014, Cohen 2018). Options for different cage types that can be used for rearing *R. differens* are inadequate. Therefore, the design, development, and evaluation of different rearing structures and cage types for the domestication of *R. differens* are paramount. Suitable rearing densities and oviposition substrates for *R. differens* have been determined, both of which are vital for the growth and reproductive success of insects (Jensen et al. 2017, Boaru et al. 2019, Tait et al. 2020). However, the uptake of these findings remains limited under laboratory conditions.

A myriad of artificial and natural diets has been used to successfully rear *R. differens* under laboratory conditions; however, limited evidence exists on an optimal diet that can be utilized for rearing the grasshopper. Among these, diets based on human food groups yielded the best performance; nevertheless, the use of such diets will exacerbate the food insecurity situation across sub-Saharan Africa. The use of agro by-product-based diets presents a cheap, affordable, and nutrient-dense alternative that can be exploited in the formulation of an optimal diet for the production of *R. differens* (Sorjonen et al. 2019, Kuo and Fisher 2022). Agro by-product-based diets enriched with dried *Moringa* leaves and lake shrimps enhanced the growth, development, survival, and reproductive performance of grasshoppers compared to other diet types (Margaret et al. 2022). Thus, such diets can be optimized and utilized for domestication and mass production of *R. differens*. The use of agro-industrial by-products in the diets of *R. differens* would go a long way in increasing the reuse of local resources and enhancing circular economy (Sorjonen et al. 2020, Kuo and Fisher 2022).

Like other edible insect species, *R. differens* is nutrient-dense with a rich profile of macro and micro molecules that are crucial for human health and nutrition (Govorushko 2019, Hlongwane et al. 2020, van Huis 2022). Proximate composition, fatty acids, amino acids, minerals, vitamins, and antioxidants were determined with considerable variations between geographic location of collection, subtype/color morph, diet in case of reared grasshoppers, and processing methods. These variables are implicated in variation of nutritional profile of edible insects (Kouřimská and Adámková 2016, Govorushko 2019, Salama 2020). For instance, *R. differens* is known to feed on the most dominant host plant in its habitat, it is probable that the available host plants varied from region to region leading to the differences recorded in the diverse studies (Opoke et al. 2019b).

Mono- and polyunsaturated fatty acids contained in *R. differens* are implicated in the prophylaxis of human diseases such as diabetic neuropathy, cancer, and cardiovascular diseases (Yorek 2018, Govorushko 2019). *R. differens* contains all essential amino acids, some of which are not found in some animal and plant protein sources; thus, they can be utilized as an alternative source of protein for food fortification (Zielińska et al. 2015, Hlongwane et al. 2020). Their rich mineral and vitamin profiles can be exploited to curb micronutrient deficiencies that lead to adverse health outcomes and account for more than a million deaths worldwide annually (Williams et al. 2016, Zhou et al. 2022). Antioxidants such as flavonoids found in *R. differens*, provide pharmacological advantages such as antibacterial, antiviral, anti-allergenic, anti-inflammatory, and anticancer properties in humans (Williams et al. 2016, Cheseto et al. 2020).

Although *R. differens* is widely consumed as a traditional delicacy, consumption of edible insects is largely influenced by consumer acceptability, neophobia, disgust for whole insect and sociocultural factors (Melgar-Lalanne et al. 2019, Shabo et al. 2022). Neophobia is widely driven by unfamiliarity with edible insects which can be circumvented by the inclusion of edible insects as ingredients in other processed food products (Melgar-Lalanne et al. 2019, Ghosh et al. 2020). The heightened consumer acceptability of the grasshopper and its derived products coupled with its rich nutrient profile makes it a potential food source to enhance nutrition outcomes in sub-Saharan Africa.

Safety is one of the major challenges faced by the edible insect industry (Murefu et al. 2019, Mutungi et al. 2019). This is further exacerbated by wild collection of insects and contamination that occurs along the insect value chain (Mutungi et al. 2019). Microbial contamination of wild collected insects also emanate from the soil, usually arising from the fecal matter of the animals found in a given area (Klunder et al. 2012). Edible insects also obtain microflora from the food they consume which can enhance their microbial load (Murefu et al. 2019).

The high microbial load recorded in raw and processed *R. differens* highlights the need to improve sanitation and hygiene along the insect value chain. The presence of pathogenic species needs to be further confirmed by classical microbiological examinations to assess whether the microbial loads are sufficiently harmful to consumers. There is an urgent need to process *R. differens* carefully and significantly reduce different types of microbial agents before consumption (Ng'ang'a et al. 2018, Nyangena et al. 2020, Labu et al. 2021).

The presence of heavy metals and chemical contaminants in raw-wild collected *R. differens* is concerning. Agrochemical contamination is a major safety concern in the consumption of wild edible insect herbivores (Mutungi et al. 2019). These substances present a risk of bioaccumulation in insect tissues which in turn increases their toxicity to humans (Fernandez-Cassi et al. 2019). There is a need to screen for the level of chemical contamination processed *R. differens*. Assessment of the bioaccumulation of chemical contaminants in the insect tissues is paramount. Anti-nutritional factors in *R. differens* decreased with processing highlighting the importance of processing in increasing the safety of edible insects (Melgar-Lalanne et al. 2019, Mutungi et al. 2019).

Individuals involved in rearing other grasshopper species have reported problems of rhinitis, asthma, and dermatitis, whereas cases of anaphylaxis have been reported from the consumption of grasshoppers (Pener 2014, Ayensu et al. 2019). However, there are limited data related to such reactions among individuals handling *R. differens*. More research is therefore required to study the mechanism of the physiological reaction of such sensitive individuals towards the chemical components that *R. differens* either produce or contain (proteins, etc.) (Paul et al. 2016). Similarly, there are limited data on diseases affecting *R. differens* despite evidence of disease infestation in other reared orthopterans, which can annihilate reared insect colonies (Verner et al. 2021, Kemsawasd et al. 2022). Such evidence will provide useful information that is paramount for successful domestication of this species.

Other than traditional processing techniques, conventional processing technologies for *R. differens* remain suboptimal despite new emerging technologies used in the processing of edible insects globally (Lee et al. 2021, Ojha et al. 2021). As such, the development and evaluation of processed *R. differens*-based products remain negligible. The adoption of conventional processing techniques may increase the safety and preservation of *R. differens* and improve its quality (Ojha et al. 2021). Therefore, conventional processing technologies should be explored to increase the use of *R. differens* between seasons.

R. differens has a high market value and can improve the livelihoods of individuals involved in the trade (Tanga et al. 2021, van Huis 2022). However, similar to other orthopterans, *R. differens* value chains are still underdeveloped (Verner et al. 2021). This is mainly due to the seasonality of the insect and the lack of mass rearing to bridge the gap between seasons. This highlights the need for development of mass rearing protocols and domestication of the species to improve livelihoods.

A legislative framework regarding insects as food is crucial to ensure safety and sustainability (Niassy et al. 2022). There is a need for accurate information on regulatory instruments that govern the production, utilization, and marketing of whole insects such as *R. differens* and insect products along edible insect value chain to overcome potential barriers restricting their use, especially in SSA (Kelemu et al. 2015). Many countries are making efforts to regulate and develop standards for insect-derived products; however, this process is still in its infancy (Halloran et al. 2015, Lähteenmäki-Uutela et al. 2021).

Despite the gradual increase in legislation on the use of edible insects especially in Eastern Africa, where *R. differens* is dominant (Tanga et al. 2021, Verner et al. 2021, Niassy et al. 2022); such policies may not influence the production, utilization, and trade of the grasshopper because of its limited supply influenced by seasonality. Similarly, the health and nutritional benefits of *R. differens* will remain underutilized, pending the sustainable production of grasshoppers. There is therefore need for initiation and scale up of *R. differens* production in the region.

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Conflicts of Interest

The authors declare no conflict of interest.

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