# Circular economy with high-fibre side-streams as feed for crickets

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## Problem

Utilizing a circular economy approach when sourcing feed for livestock has dual benefits: Production can be made more sustainable by utilizing side-streams that would otherwise have been wasted, and production costs can be lowered since the side streams can often be acquired at a lower cost than traditional feed ingredients.
However, a common nutritional limitation of using side-streams as feed for monogastric animals (e.g., poultry and pigs) is the dietary fibre content. Side-streams are often richer in fibre compared to traditional feed for monogastric animals and are therefore often associated with decreased nutrient digestibility and reduced growth.
For instance, nutritional recommendations for broilers and growing pigs are around 5% fibre in the feed and studies show that an intake above 10% might reduce the growth.
High-fibre ingredients can be fed to ruminants, however, the low ability of cattle to convert feed into biomass makes this a less attractive option in terms of sustainability. Also, it is possible to blend high- and low-fibre ingredients to produce a feed blend with an attractive fibre content, but this frequently necessitates compromise on other nutrient parameters (e.g., amino acid profile).
A more attractive option may be to utilize high-fibre feed sources as feed for insects, for at least some species of crickets.

## Solution

House crickets (*Acheta domesticus*) and field crickets (*Teleogryllus testaceus*) display an attractive combination of high feed conversion into biomass and a tolerance of a wide array of feed sources. In terms of fibre, they seem to be able to utilize side-streams containing up to 26% fibre without negatively influencing their growth, making them uniquely suited at efficiently converting high-fibre biomass into animal protein. For instance, field crickets fed cassava plants (18% fibre) or the weed *C. ruditosperma* (26% fibre) displayed similar or higher growth rates than crickets raised on chicken feed (CF; 5% fibre), a common control in cricket feeding experiments. Similarly, house crickets reared on rabbit chow containing low-to-moderate protein levels (14%) and high fibre (20%) resulted in similar growth compared to a commercial cricket diet containing 17% protein and 4% fibre. In experiments performed at Bugging Denmark (Figure 1), it was found that house crickets fed on sunflower seed meal (SSM; 33% protein and 17% fibre) demonstrated similar growth as when fed on chicken feed (Figure 1).



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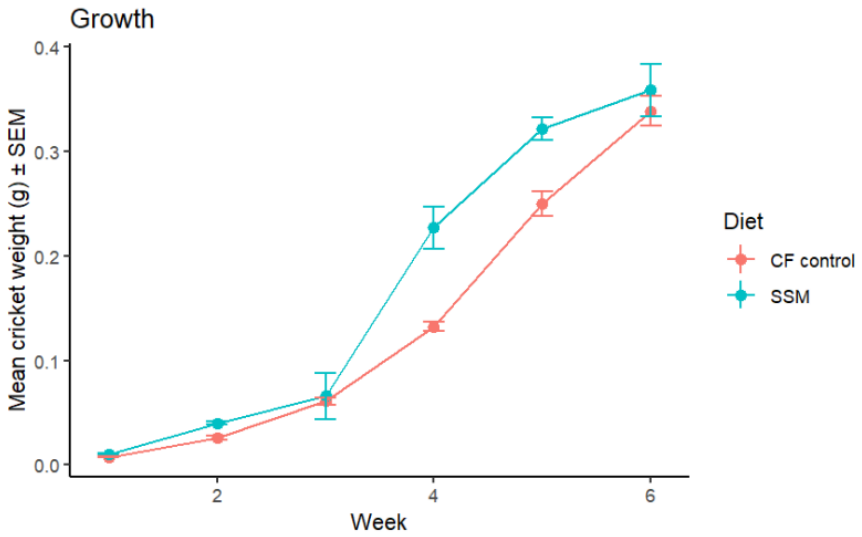


*Figure 1. Development in mean cricket weight (g) ± SEM for commercial chicken feed (CF) and high-fibre sunflower seed meal (SSM) during 6 weeks of treatment (from week 0 to 6). Each point in the graph represents the mean of four replicates and the error bars represent SEM.*

In comparison, several studies show that SSM reduced the growth in growing pigs and poultry as soon as their diets contained 10% or more SSM.
An upper limit to the amount of fibre feasible in cricket feed appears to apply, with studies finding levels above 30% to be detrimental to growth.

**What can be the explanation?**

A high fibre level in the diet naturally leads to correspondingly lower levels of other nutrients in the feed which should in theory lead to lower growth rates. Since the growth rate on high-fibre feed remains high, it is, therefore, possible that crickets can utilize fibre to maintain their growth rather than just tolerate the fibre in the feed.
It is well established that termites can utilize a high amount of fibre material mainly composed of cellulose with the aid of cellulase enzymes that break down cellulose into glucose. No activity of cellulase has been identified in house crickets, but some cellulase activity was detected in another species of crickets, *G. bimaculatus*. Another possibility of utilizing energy from fibre could be by fermentation in the hindgut, similar to what is seen in monogastric animals, in which the microbiota ferment indigestible fibre into short-chain fatty acids (SCFA) that provide an energy source for the host.

# Benefits

At least some species of crickets seem to be able to utilize side-streams that are rich in fibre. This is not the case for monogastric farmed animals such as poultry and growing pigs.
Considering that side-streams often contain a considerable amount of fibre, this allows the use of a broader selection of side-streams as animal feed.
These side-streams would most likely not be utilized efficiently by other monogastric animals (growing pigs and chickens) with reasonable conversion of feed into biomass.
Using high-fibre side-streams as feed for crickets therefore adds to the library of agricultural side-streams that can efficiently be used in the circular economy (see Table 1).


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# Practical recommendations

- Fibre levels in the substrate for crickets should not exceed 20-26%.
- Cricket growth is sensitive to protein level in the feed. Most tested high-fibre substrates contain protein levels between 20% and 35%.
- Sugar and starch (carbohydrates) content in the feed are not rate limiting for crickets in order to grow efficiently.

**Table 1** - Crude fibre and protein levels in weeds, agricultural and food industry side-streams compared to traditional feeds used crickets, broilers and growing pigs:

| Side-stream | Crude fibre (%) | Crude protein (%) | Source |
|---|---|---|---|
| **Standard feed (crickets and broilers)** | 5.5 | 17.5 | |
| **Standard feed (growing pigs)** | 2.7 | 19.7 | |
| **Spent grain** | 16 | 27.1 | Side-stream from beer brewing process |
| **Rice bran** | 23 | 10.2 | Side-stream from rice milling |
| **Wheat bran** | 8.9 | 15.1 | Side-stream from wheat milling |
| **Sunflower seed meal** | 17.4 | 35.5 | Side-stream from sunflower oil production |
| **Cassava plant** | 14.2 | 28.6 | Side-stream from cassava root harvesting |
| ***C. rutidosperma*** | 28.3 | 22.2 | Plant weed |

# Further information

## Further readings

Miech, P., Berggren, Lindberg, J. E., Chhay, T., Khieu, B., & Jansson, A. (2016). Growth and survival of reared Cambodian field crickets (Teleogryllus testaceus) fed weeds, agricultural and food industry by-products. Journal of Insects as Food and Feed, 2(4).

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### About this practice abstract and GIANT LEAPS

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