POULTRYNSECT

Report on LCC Analysis

Deliverable 4.2

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Content

Introduction

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The POULTRYNSECT Work Package 4 "**Integrated sustainability assessment**" aims to evaluate the potential changes in the sustainability of chicken meat achieved through Black Soldier Fly live larvae (BSFL) inclusion in the chicken diet.

Product sustainability lies on three pillars: environmental sustainability, economic sustainability, and social sustainability. The economic sustainability of broiler meat produced through the Poultrynsect system was tackled within task 4.2. Within the task, Life Cycle Costing analysis, the process of compiling all costs incurred throughout a product's life cycle, of broiler meat was conducted. Particular attention was given to BSFL production. Very significant market changes, price volatility and high inflation within the project timespan had a major impact on the market analysis, particularly for larvae production. Therefore, this report focuses predominantly on Life Cycle Costing analysis of the organic broiler meat value chain, while also providing some key information for the insect value chain. The social sustainability, as the remaining pillar, will be tackled within task 4.3.

1. Material and Methods

Goal, scope, system boundaries and functional unit

The main goal of the research was to compare the economic efficiency and economic sustainability of organic chicken meat produced with the inclusion of 10% of Black Soldier Fly larvae (BSFL) in the diet with the organic meats produced conventionally.

This Life Cycle Costing (LCC) study followed the system boundaries established for the Life cycle assessment (LCA), which took a cradle-to-slaughterhouse gate perspective with extensions of waste treatments and considered therefore the whole chain of poultry production. The main systems included are feed production, larvae production, hatchery, poultry production, and slaughterhouse. Within the defined boundaries, special attention was also paid to production costs of insect rearing. Costs of the background processes such as electricity or litter production were included in the system boundaries. Waste streams were treated by relevant waste treatments, and the treatments were paid by market prices. The boundaries of the assessment are shown below schematically (Fig. 1, 2).

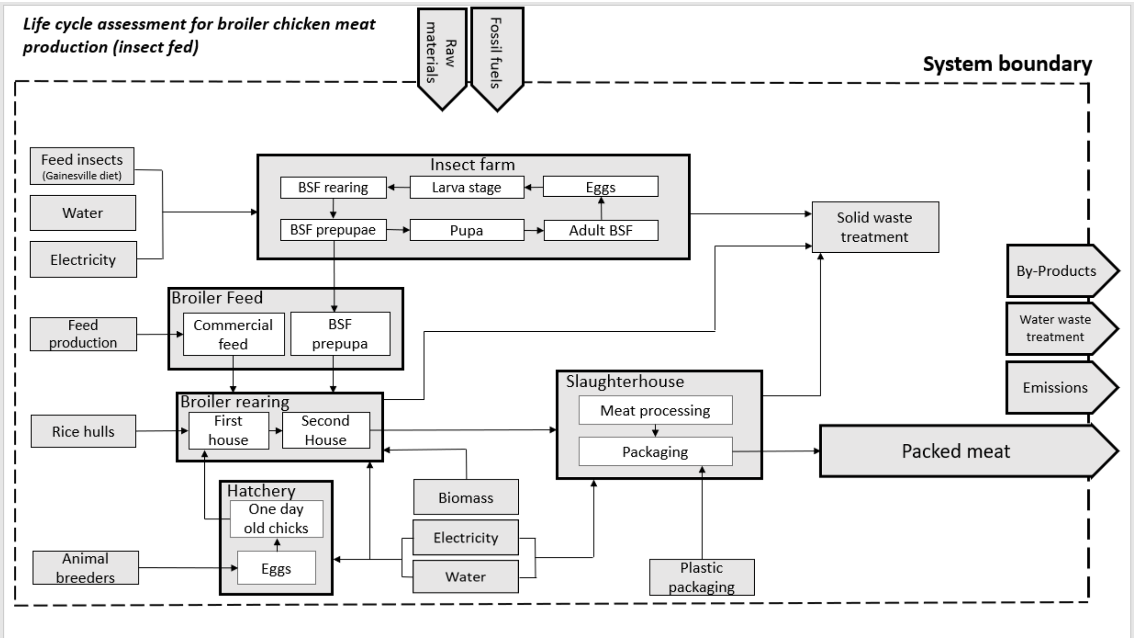


Fig. 1. System boundaries for the LCC analysis of the system with inclusion of insects in the diet of chicken

The assessment was predominantly based on the information collected from the market, and partially from the project partners. The scope of the study included operating expenses of the broiler farm identical to the experimental chicken farm, and the profit of the bird-rearing company was not included in the analysis. The modelled insect farm was also identical to the one used in the project, with its profit also excluded from the analysis. It is worth mentioning that, within the timespan of the project, the volatility of the prices, as well as inflation, were very high, and in some cases extreme. This prolonged and partially undermined the price collection. It might also be argued that it influenced the results of the study, as well as its relevance and repeatability: the prices are still volatile, and it is difficult to reliably predict or even assume their further changes.

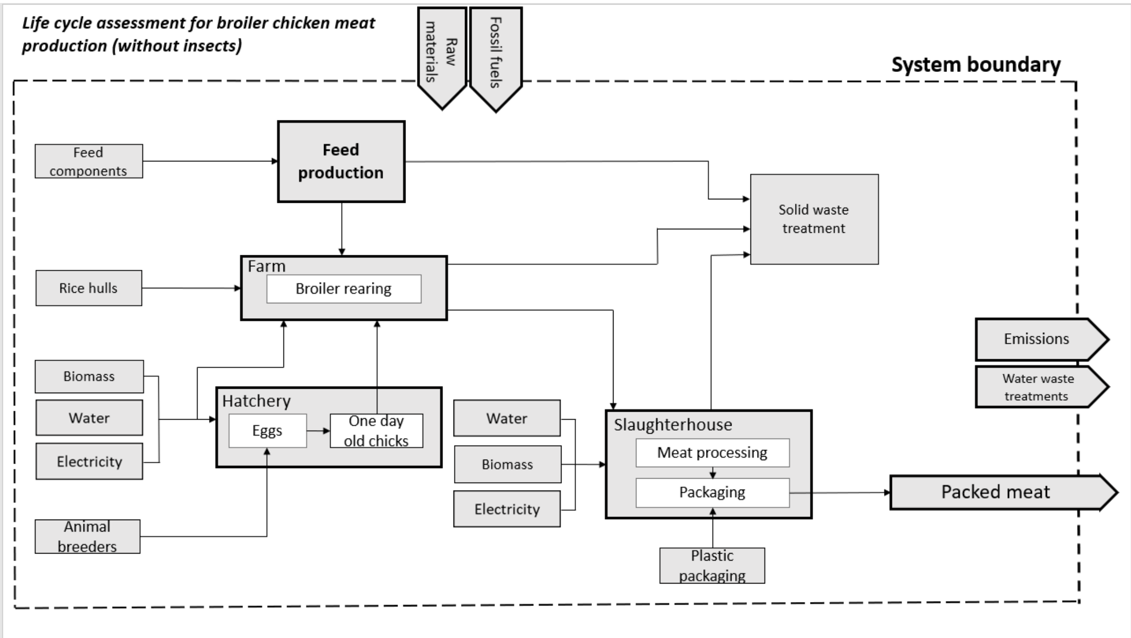


Fig. 2. System boundaries for the LCC analysis of the system without inclusion of insects in the diet of chicken

Two different feeding trials were performed on a local Italian chicken breed *Label Naked Neck*. The first group was reared on 90% commercial organic feed and 10% of insect substitution, which consisted of the *Hermetia illucens* larvae, commonly known as black soldier fly larvae (BSFL). The second group was fully reared on commercial organic feed and was used as the control group. Within each of the groups, the differences between the sexes were closely followed. As the chicken production took place in Italy, the parameters were adapted to Italy, and when possible, specifically to the region of Piedmont. The functional unit was 1 kg of packed ready-to-cook chicken carcass.

Life Cycle Cost Inventory

The assessment started from the 1-day-old hatched chicks, which were assumed to be paid the average price for the organic chicken breeds. In the first rearing facility the chicken spent 20 days during which they were reared under special conditions. After the initial 20 days, the chickens were transferred to the second building. In this building, only natural light was used and there was no heating system.

On the other hand, BSFL were produced in a 4-stage circular process, with the extension for the adult rearing and processing of waste streams. About 30 000 neonates were produced per 1g of BSF eggs, and in the next step, about 48 000 larvae were produced from 1 g of neonates. To grow 48 000 larvae, 300g of dry Gainesville diet feed, corresponding to 1 kg of wet feed, were used. From the larvae, about 99% were used as the chicken feed supplement, while the remaining 1% was used to grow the adult flies and then repeat the circle.

To produce 1kg of ready-to-cook chicken carcass from the male BSF-fed chickens, roughly 3798 g of feed was required, along with 316.9 g of larvae. To produce 1 kg of chicken meat from the female BSF-fed group the same amount of BSF larvae was used, but coupled with 3089g of feed, a significantly smaller amount. The same pattern was even more pronounced with control, commercially fed chicken. The male commercial-fed chickens consumed 4022.7 g of feed per 1 kg of chicken meat produced, while female commercial-fed chickens consumed 3091.8 g of commercial feed per 1kg of chicken meat produced. Interestingly, female commercial-fed chickens consumed only about 3g of commercial feed more than the BSFL-fed ones, apparently not compensating for the insects they didn't receive. Also, the difference between the feed consumption of the males and females is due to the sex difference and results in the end weight of the males being higher than that of the females.

After 81 days, the chickens were taken to the slaughterhouse and killed. All the carcasses of the birds slaughtered for experimental purposes were thrown to waste after the samplings were made.

The last average live weight was just slightly higher in the supplemented birds compared to the controls (2372.72 g vs 2340.60 g). The slaughter weights for the birds with the BSFL supplementation were 2044 g (female birds) and 2838 g (male), while the chickens reared only on commercial organic feeds achieved 2026 g (female) and 2820 g (male).

2. Results and discussion

For the BSFL production, the combination of an immature market and the mentioned inflation and volatile prices made market analysis very difficult, so we tried to focus on the more robust and repeatable findings. The price of the feed accounted for about 1.2 euro per 1 kg of larvae, however stronger focus on the use of side streams from other industries would decrease this price further. It should be noted that 2 products were assumed from the insect rearing, the larvae and the frass, which somewhat eases the financial pressure from the larvae production. Considering the relatively high amount of wastewater generated during the production, the careful and inexpensive choice of wastewater treatment should be made. On the other hand, the market price of organic insects was found to be almost 8 euro per 1 kg larvae[1], which can be considered rather expensive when compared to organic chicken feed prices.

The production prices of 1 kg of ready-to-cook organic chicken carcass are presented in Fig. 3. The observed differences can be attributed to the difference between the two sexes rather than to the inclusion of insects into the diet.

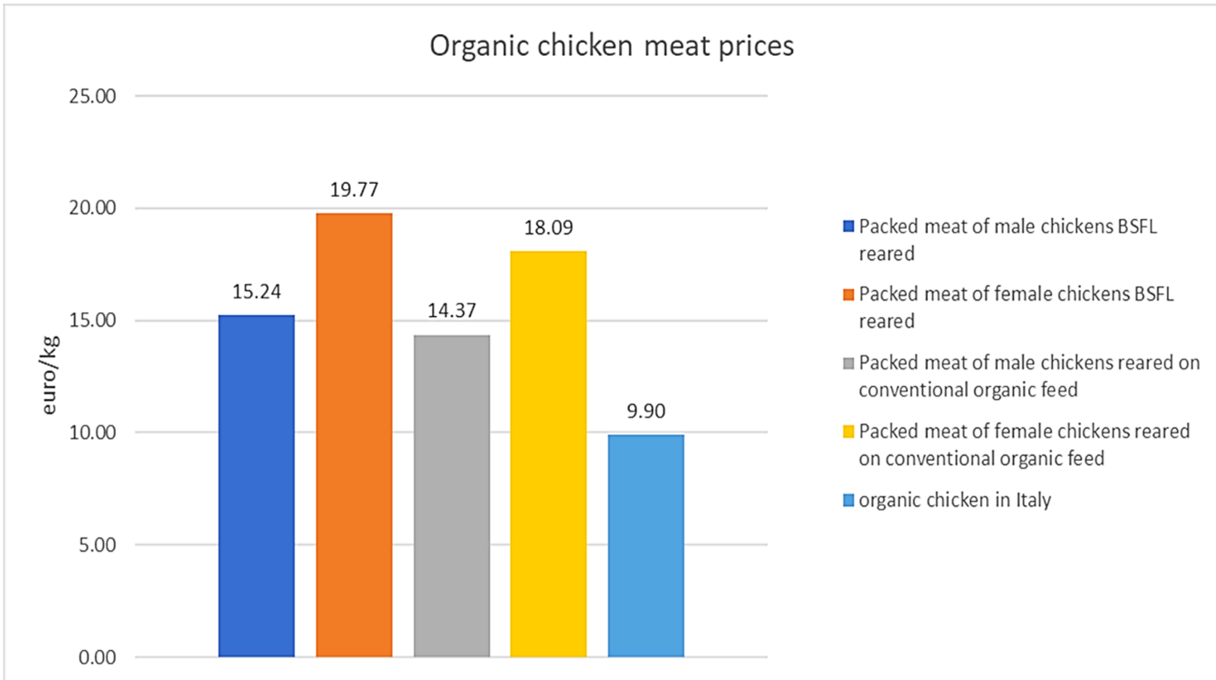


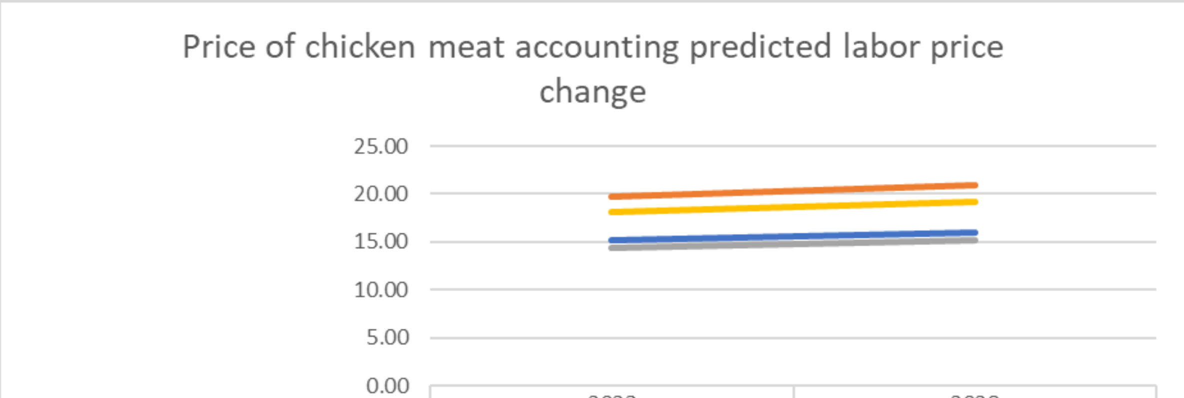
Fig. 3. The prices of 1kg of ready-to-cook organic chicken carcass produced during the project trials

As the price is calculated per 1 kg of the product, the difference in economic performance between the two sexes can be attributed to the meat mass produced. Thus, even though male chickens required more feed, the higher amount of meat produced provided 20% lower production costs.

Insects had a lower influence on the production price. The introduction of insects increased the production costs of 1 kg of ready-to-cook organic chicken carcass by almost 10%, which could be expected, given the relatively high price of insects.

By far and away the highest contribution to the production costs came from labor costs, accounting for over 50% of all production costs. The second highest contribution was from feed. It is to be noted from Figure 1 that all the modeled scenarios had significantly higher production costs when compared with the organic chicken meat currently present on the Italian market[2].

As labor proved to be the decisive factor for the meat price, the predictions of the labor price changes were accounted for in the sensitivity analysis. As it is predicted that the farm workers' salary will increase 11% in the next 5 years[3], the increase in prices of chicken meat produced through the Poultrynsect system can also be expected. The predictions of the increase can be seen on Figure 4.



	2023	2028
Packed meat of male chickens BSFL reared	15.24	16.05
Packed meat of female chickens BSFL reared	19.77	20.89
Packed meat of male chickens reared on conventional organic feed	14.37	15.18
Packed meat of female chickens reared on conventional organic feed	18.09	19.23

Fig. 4. Changes in prices of 1kg of ready-to-cook organic chicken carcass produced by the Poultrynsect system, accounting for the predicted increase in labor costs

3. Conclusions

Based on the Life Cycle Costing assessment of BSFL production, it was shown that not only the production costs, but also emission costs, must be considered. Considering the amount of wastewater generated within the process, its treatment would need to be inexpensive. With the current prices, and with the right wastewater treatment and expected reduction in feed price, the price of organic insects, along with price of organic fertilizer which would be replaced with frass, provides some space for a profitable BSFL production. The wastewater volumes, along with labour costs, could be reduced by increasing the larvae production scale.

Based on the Life Cycle Costing assessment of broiler meat production, it is concluded that the modelled scenarios led to higher production costs when compared with the price of organic chicken already present in the Italian market. The highest contribution comes from the labour costs. What is more, it is estimated that the labor costs will increase in the coming years, leading to even higher price of the chicken meat. The inclusion of 10% of BSFL into chicken feed increased the production costs by almost 10%. A difference of 20% was observed between the sexes.

Better results might be expected on a higher production scale, as that would increase labor efficiency. Secondly, along with the general stabilization of inflation and with maturation of insect market, lower prices of organic larvae could be expected, which would be good news for organic chicken farmers. Finally, a specific high-end niche market would need to be found for the product.

References

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