Valorisation of by-products
A Case Study:
Brussels Sprouts

Brussels sprouts (*Brassica oleracea* L. *gemminifera*)

Interreg2Seas; BIOBOOST

Executive Summary

A growing demand for new and sustainable resources useful for future bio- and circular economies, in combination with stricter regulations, provides an incentive to valorise by-products and waste fractions from the agri-food sector. Thanks to R&D funding from the EU Interreg2Seas fund, the BioBoost Partnership has searched for appropriate harvesting techniques and potential for valorisation of different waste and crop co-products in Belgium, The Netherlands and UK. Brussels sprouts are presented in this case study. Food and farming companies are keen to see improved valorisation of under-utilised biomass fractions and will therefore benefit from these research activities.

Situation

Europe has a total area of approximately 12,250 ha (1) of Brussels sprouts production, with main production (~95%) in the European countries covered by the EU interreg2Seas BioBoost project partners (UK, The Netherlands and Belgium).

The edible part of the Brussels sprout plants (the sprouts themselves) only account for 25-40% weight of the total above-ground biomass, with typical yields of 12 to 18 ton/ha. The following 'inedible' parts are described as a by-product, which is often wasted:

- **Leaves,** left on the main stem
- **Stems,** with a production of approximately 15 ton/ha/year, with 20% DM. On average, 230,000 tons of stems are produced per annum in the EU
- **Under and oversized sprouts,** which are not acceptable to retail outlets (fresh or frozen)

In horticultural value chains, there are often several steps from cultivation to consumption. Agrifood by-products and waste fractions are usually produced throughout the value chain, from cultivation through to harvesting, processing, retail (food loss) and finally consumption (food waste). Improved valorisation of these by-products requires engagement from different actors in the value chain.

Challenges and opportunities

One important challenge early in the Brussels sprout value chain relates to harvesting of residual biomass. Waste leaves are difficult to collect because most will have detached from the plant before the Brussels sprout harvesting period. Furthermore, their dry matter content is low and degrades quickly. Currently, these are usually stripped and left on the field by a defoliator.

Conversely, the stems are produced in large quantities and have greater potential for use in different valorisation paths. Some harvesters have already been adapted, so that this by-product can be collected by growers at the same time as the main crop.

Figure 1 (A) and (B) shows adapted harvesters augmented with an additional collection belt for the stems. When sprouts are harvested, stems are cut and collected separately from the Brussel sprout plants.

These modifications to the harvest regime result in additional harvesting costs of circa €23-34 /ton or €520-740 /ha, accounting for an increase in labour costs (+ 1 h work/ha), fuel costs (+ 1.5 L/ha) and investment costs (~ €30 000, depreciated over 5 years).

Figure 1. Adapted harvester

(A) Adapted harvester for small scale cultivation (1 row)

(B) Adapted harvester for bigger production areas (4 rows)

Stems and sprouts are separated after harvest, by using different collection belts.

The development of a novel value chain forms a second challenge. Brussels sprouts are only harvested between September and March, which means that the co-product biomass is not available throughout the year, unless economically viable storage solutions are found. Ensiling has already been considered, but further experiments are needed to confirm its utility (2).

Currently, the collection of stems as by-product is limited to a few farms; upscaling to more farms is vital to ensure feedstock availability can be ensured, so that supply will be able to fulfil demand. Further efforts from the stakeholders interested in valorisation of Brussels sprout stems into valuable products is therefore needed.

Potential valorisation applications

Paper and cardboard - The stems have a good high fibre content, and they therefore have potential for use as an alternative feedstock in the paper industry. Initial lab tests and pilot production tests were promising and resulted in good quality paper with an aesthetically pleasing range of natural off-white colours (Figure 2).

The next step that is now required is a breakdown of costs to determine whether the price asked by growers for these residues will make their use economically feasible. The logistics required form an important component of this and must be addressed.

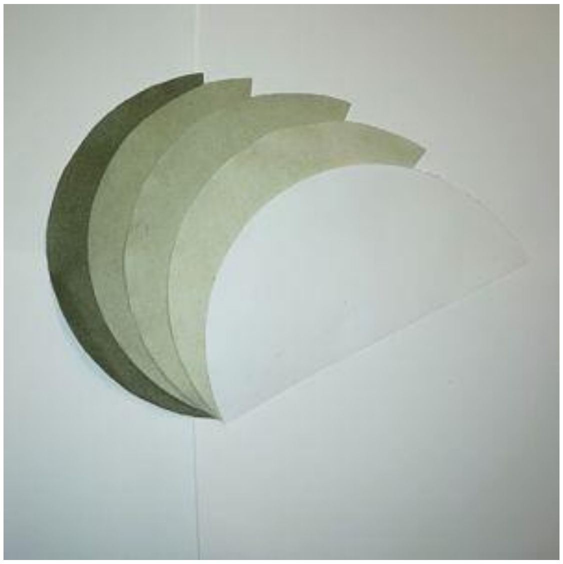

Figure 2 – First experimental results of Brussels sprout paper obtained by Millvision in the Interreg project 'Growing a Green Future'

Additional Valorisation options for Brussels Sprout waste and residual biomass

Animal feed – There are currently seven Brussels sprout farmers in NL and BE using the stems as a component of cattle-feed. It provides their livestock with fresh feed during the winter months, (September to March). Feed values provide between 124.1 kVEM/ton or 10 kg DVE / ton, giving the stems a value of between €25 and €30 per ton. VEM and DVE are standard Dutch feed measurements; VME is a defined as the net energy content of a product for milking cows and is related to the energy content of 1 kg standardised barley (= 1000 VEM); DVE is defined as unit for the amount of proteins available and digestible in the small intestine.

Before using as a feed, the stems were mixed with pressed pulp and then ensiled. This strategy was developed recently in the VEGCAT project; scientists discovered that cattle do not like the hard outer tissues of the stems. Some chopping of the stems is therefore required. This provides good mixed silage feed for all but high output dairy cattle.

A

B

Figure 3 – (A) Ensiled Brussels sprouts stems and (B) parts of Brussel sprouts stems that are not eaten by the cattle

Soil improver - Valorisation of the residuals can also be achieved within the farm. Many growers have highlighted the importance of these residuals as soil improvers. They have found that crop productivity increases if residues are returned to the field (3). Although this also depends on climatic factors and soil characterisation, Brussels sprouts residues are characterised by a high N-content and are become available in wet and cold periods of the year (autumn / winter).

Research has shown that the soil mineral N-contents were not significantly improved in fields in which resides from cauliflower, celery, leek or white cabbage were left, compared to fields were residues were removed (4). Gaseous loss of nitrogen by volatilisation and leaching of soluble NO_3 may explain why only a small fraction of the N is available for following crops. For Brussels sprouts residues, total N_2O emissions ranged between 0.13 and 14.6% of the amount of N added as residue (4).

Leaving the residues on the field can therefore be considered as a potential thread to the Nitrates Directive. Another potential use for these co-products could be in production of compost, although their low dry matter content necessitates the addition of other residues to optimise composting efficiency.

Insect feed - The stems and out-of-spec sprouts also have potential as insect feed (see Bioboost Case Study 1 on Black Soldier Flies and Mealworms). Research in the Bioboost project indicates that if up to 80% of insect feed is replaced by Brussel sprouts residuals, a food conversion ratio (FCR) of 1.7 could be obtained. The FCR indicates the required amount of feed to increase animal weight by one kg. The FCR obtained is approximately the same as the control insect feed (chicken meal, with FCR = 1.6).

This is promising information, because the use of waste/residuals as feed is more sustainable compared to the use of chicken meal that is produced using combinations of wheat and other high value food products. Finally, using these residues as a feedstock valorisation through insect production could be an additional source of income from these products.

Energy - Tests to determine Potential for use in an Anaerobic Digester (AD plant). Digestibility tests were performed on Brussels sprout residues (stems, leaves and remaining sprouts). They were found to have a biogas potential of 104 Nm^3/ton, comparable to the potential of leek (5). However, non-continuous feeding of the digester, and higher (mineral) soil contents, hamper this processing method. The digestate resulting from the digestion can be reapplied to the field and is considered to be a useful soil improver.

References

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