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IDENTIFICATION OF ENVIRONMENTAL IMPACT HOT SPOTS IN TRADITIONAL FOOD PRODUCTION LINES

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Identification of environmental impact hot spots in traditional food production lines

Evaluating the environmental impact of agricultural food production systems is a relatively recent research activity and the present methods for assessing the environmental impact associated with production-consumption systems are input-output accounting, ecological footprint analysis, life cycle assessment, financial evaluation of environmental externalities, farm cost and food miles. Complete environmental impact analyses require considerable amounts of data and time and are very likely to be expensive. Preliminary identification of the most-evident environmental hot spots is beneficial in aiding the determination of the analysis scope and goal and in setting the borders of the studied system. In the present study a reconstruction of the production schemes was performed and the identification of evident environmental impact hot spots was performed expert-wise for four selected model food products (hard cooked cheese, dry-cured ham, beer and cauliflower), traditional in Europe. This preliminary hot spot identification was preformed specifically for a conceptual life cycle assessment (LCA) technique in prosecution. In our opinion, these results can also be employed as a basis for many other environmental impact assessment approaches.

Key words: traditional food products / environment / environmental impact / Europe

Kritične točke potencialnega obremenjevanja okolja v proizvodnji tradicionalnih živil

Celostno ocenjevanje vplivov na okolje v kmetijski proizvodnji živil je sorazmerno mlada raziskovalna dejavnost. Trenutne metode, ki omogočajo ocenjevanje vpliva na okolje v sistemih proizvodnje in nadaljnjega ravnanja s proizvodom, so t.i. *input-output* računovodstvo, analize ekoloških sledi, ocenjevanje življenjskega cikla, finančno ocenjevanje zunanjih vplivov na okolje, okoljska bilanca kmetije in obremenjevanje okolja zaradi transporta. Podrobne analize vpliva na okolje so drage, prav tako pa za izvedbo potrebujemo precej časa in specifičnih podatkov. S preliminarno identifikacijo kritičnih točk potencialnega obremenjevanja okolja pridobimo rezultate, ki so nam v pomoč pri določevanju obsega in ciljev analize in pri postavljanju mej preučevanega sistema. V tej študiji smo identificirali postopke v štirih modelnih proizvodnih linijah evropskih tradicionalnih živil (sir, pršut, pivo, cvetača) in na podlagi strokovnega znanja opravili izbiro kritičnih okoljskih točk. Pripravljen pregled smo opravili zaradi nadaljnje uporabe v konceptualni študiji ocenjevanja življenjskega cikla. Menimo, da je opisani postopek mogoče uporabiti tudi za druge pristope presoje vplivov na okolje.

Ključne besede: tradicionalna živila / okolje / vpliv na okolje / Evropa

1 INTRODUCTION

In order to improve the knowledge on environmental impact of current food production systems and to find the solutions to reduce the negative impacts effective multi-approach environmental assessment methodologies are required.

Evaluating the environmental impact of agricultural food production systems is a relatively recent research activity (Foster *et al.*, 2006), nevertheless there are new methodologies arising. Because of the need to evaluate global emissions and the impacts from the whole production line in relation to types and amounts of products consumed (COM (2003) 302), the interest for product-

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oriented and life-cycle assessment is increasing (Hlaberg *et al.*, 2005). The present methods for assessing the environmental impact associated with production-consumption systems are input-output accounting, ecological footprint analysis, life cycle assessment (LCA), financial valuation of environmental externalities, farm cost and food miles (Pretty *et al.*, 2005; Tomassen and De Boer, 2005).

Environmental impact assessment techniques impose evaluation measures based on different environmental condition indicators. Yet, the set of agri-environmental indicators varies little between governmental

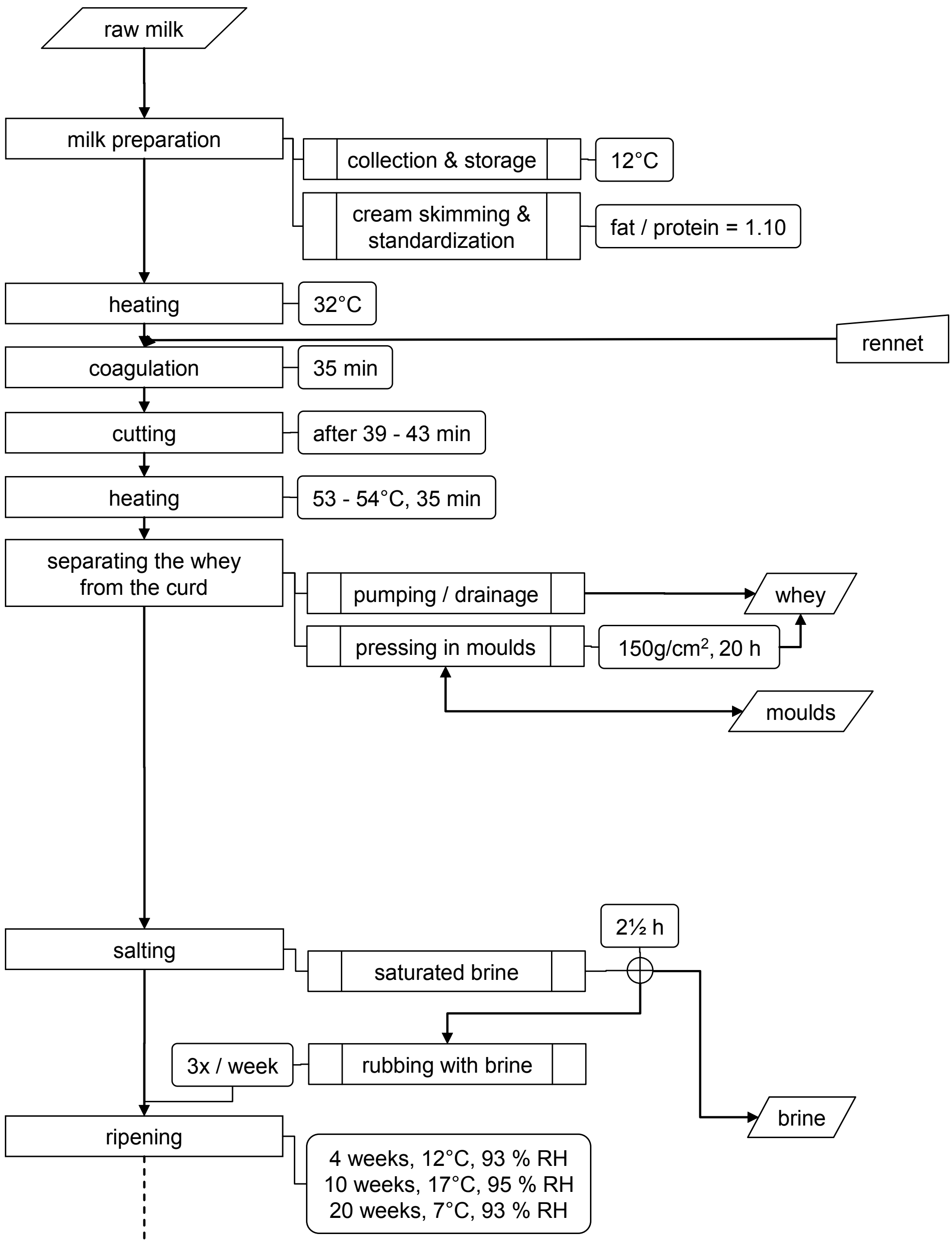

Figure 1: *Process flowchart of studied hard cooked cheese manufacturing line (RH – relative humidity).*
Slika 1: *Procesni diagram preučevane proizvodnje linije trdega sira (RH – relativna vlažnost).*

and international authorities involved in impact assessment (OECD, 2001; EEA, 2006; USDA, 2006; EPA, 2007) which all observe the environmental impact of agriculture from the shared viewpoints of soil, air and water quality, climate change, land consumption, biodiversity, ecosystems and human health.

Amongst the aforementioned methodologies, the "cradle to grave" approach of life cycle assessment offers the most comprehensive incorporation of the environmental indicators. LCA is a process of evaluating the effects that a product has on the environment over the entire period of its life. It can be used to study the environmental impact of either a product or the function the product is designed to perform (EPLC, 2007).

In the first stage of LCA, the scope and boundaries of the studied system are defined. The second stage, the life cycle inventory (LCI) consists of all information, material and energy flow registration within the chosen limits. Thirdly, life cycle impact assessment (LCIA) is executed by transforming LCI qualitative descriptors into quantitative contributions to specific environmental categories (e.g. acidification, eutrophication, global warming, human and eco toxicity, use of resource etc.), which are put into perspective in the last, interpretation phase (ISO 14040).

A well defined scope of the environmental impact assessment is essential. A highly specific LCA, for example, can be employed to discover the points in the production where the potential for environmental burdening is the highest. On the other hand, conceptual LCA can be set on evaluating the potentials of known environmental impact production hot spots (EEA, 1997).

In traditional food production simplified and conceptual applications of LCA are fit for use in the method development. A procedure for a preliminary-level expert-wise determination of environmental production hot spots is presented in the following article. In all studied model production lines, the environmental hot spots were annotated to processes in the agricultural production. Separately, the models were mostly connected to direct or indirect water and energy consumption.

2 METHODS

2.1 SELECTED MODEL TRADITIONAL FOOD PRODUCTS

Four model production lines were reconstructed to represent European traditional food products in the sectors of dairy, meet, beverages and vegetables.

The dairy model was based on Slovenian hard cooked cheese. In the European Union cheese consumption is prevailing in semi hard and hard type of cheeses. In 2002 cheese accounted for 44% of milk utilization in EU-15 and is an important product in the dairy portfolio (Foster *et al.*, 2006).

The meat model was based on Spanish dry-cured ham production. Pork remains the predominant meat consumed in Europe. In 2002 the EU-15 gross human apparent consumption of pig meat was 16.5 kilotons, equal to the total amount of cattle and poultry meat consumed (EUROSTAT, 2007). The environmental impacts of dry-cured ham production have not yet been assessed and they present a challenge.

The beer model was based on Italian and Czech lager beer production. Environmental impact extents of food production are reported to be higher than those of beverage production, where bottled and canned drinks appear to be most significant in environmental impact contribution (Tukker *et al.*, 2006).

The vegetable model was based on the Mediterranean cauliflower growing. Worldwide, brassicaceous plants are one of the most abundant vegetable families grown in agricultural farming systems. Many crop species of the economically important *Brassica* genus provide edible roots, leaves, stems, buds, flowers and/or seeds, rich in compounds which have shown a beneficial effect on human nutrition and health (Pua and Douglas, 2004; Ayaz *et al.*, 2006; Higdon *et al.*, 2007)

2.2 PRELIMINARY ENVIRONMENTAL HOT SPOTS IDENTIFICATION

The basic sources of information were various commercial, educational and research organizations. From them general production descriptions were obtained in order to formulate process diagrams of the model traditional food production lines. These flowcharts were then sent back to the source and some additional field experts, for approval, correction and to gain feedback on the practical regularities of the reconstructions.

Basing on the conceptual production schemes, the evident points where potential environmental burdening can occur were identified as pollution hot spots.

3 RESULTS AND DISCUSSION

3.1 HARD COOKED CHEESE

There are a number of stages involved in the process of natural cheesemaking. The production involves primary production of raw milk, cheese production (Fig. 1) and post ripening treatments.

The production of cooked hard cheese includes four basic steps: coagulation, draining, salting and ripening. After the raw milk is collected, it is stored at 12 °C. In the dairy, the raw milk is standardized to a certain fat / protein ratio and heated. Rennet is mixed with the milk and after coagulation the curd is cut. Whey is separated from the curd with draining or pumping and with pressing in moulds. The cheese is then exposed to saturated brine and rubbed with brine in successive intervals during ripening (Berlin, 2002; Buchin, 2007).

Evident points of potential environmental impact in the cheese production line are:

- primary production
- whey management
- washing of used hoops and moulds
- brine management
- ripening
- packaging.

The environmental charge of raw milk is, therefore, dependant on milk yield, breeding regime, breed (dairy or combined) and nutrition (year long or with pasture, also application and origin of concentrates), location (lowland or mountains) and manure management (storing of slurry or farmyard manure; spreading times and types).

Whey management is a persisting environmental problem in the cheesemaking process. Even that several possibilities for whey exploitation have been suggested over the last 50 years (e.g. Gonzalez Siso, 1996), a considerable amount of this lactose and protein rich solution is still left unused. In the European Union, 40% of the liquid whey is applied to further processing (EWPA, 2007).

Washing of moulds and hoops and brine management are contributing to water consumption of the process. Salt content may also influence the duration of ripening. The duration of ripening and the measures for assuring the ripening atmosphere can have a significant impact on the process energy requirements.

The selection of packaging materials is relevant to the onward waste management and recycling procedures.

3.2 DRY-CURED HAM

The manufacturing of dry-cured ham begins with raw meat production followed by the curing process (Fig. 2) and post-ripening treatments.

The fundamental steps of the traditional dry-curing process are salting, stabilization and maturation (Barat *et al.*, 2004). Specifically tailored ham cuts (removal of skin, blood and needless parts) are covered with a mixture of the cure (salt and some other ingredients) and placed in a cold room. Then, the hams are washed, scrubbed and kept at a low temperature, allowing the salt concentration to equalize. In the drying room, the hams mature. The traditional hams can ripen up to 3 years (Arnau *et al.*, 1997; Arnau *et al.*, 2007).

Post-ripening treatments include deboning, cutting, slicing and packaging (laminated packaging material, plastic tray etc.).

Evident points of potential environmental impact in the dry-cured ham production line are:

- aspects in primary production
- waste management
- effluent management
- ripening
- packaging.

The size of the ham cut (depending on genotype, fattening duration, fodder etc.) strongly affects the duration of manufacturing procedures and therefore impacts the environmental load of the whole manufacturing scheme. The duration of ripening has a significant impact on the process energy requirements.

The amount of cuttings depends on the ham cut, subcutaneous fat, skin and is, logically, higher for slices than for pieces and cuts.

The concentration and amount of the salt affects the effluent amount and the ripening time, but also the stability of the product.

3.3 BEER

The production of beer comprises primary production of barley and hops, malting and brewhouse operations (Fig. 3).

Breweries typically purchase malted grain from malting operations. In the malting process, the grain is soaked, softened, germinated and dried. The malt can be grinded in the malting facility or in the brewery. The milled malt is mixed with hot water and heated to convert grain starches to fermentable sugars, a procedure known as mashing. In a mashing process known as decoction, a portion of the mash is boiled and added to the rest to raise the overall temperature. The insoluble grain residues (spent grain / brewers grain) are filtered from the mash to produce wort. The wort and hops are boiled in the brew kettle. After brewing, the hops are strained from the wort and the liquid is cooled to the pitching temperature. Yeasts are added and CO_2 is collected during fermentation. To produce lager beers, bottom-fermenting yeasts are used. After primary fermentation, spent yeast is removed and the beer proceeds to maturation (Hajslova & Kocourek, 2007).

In the packaging line, the beer is filled to bottles

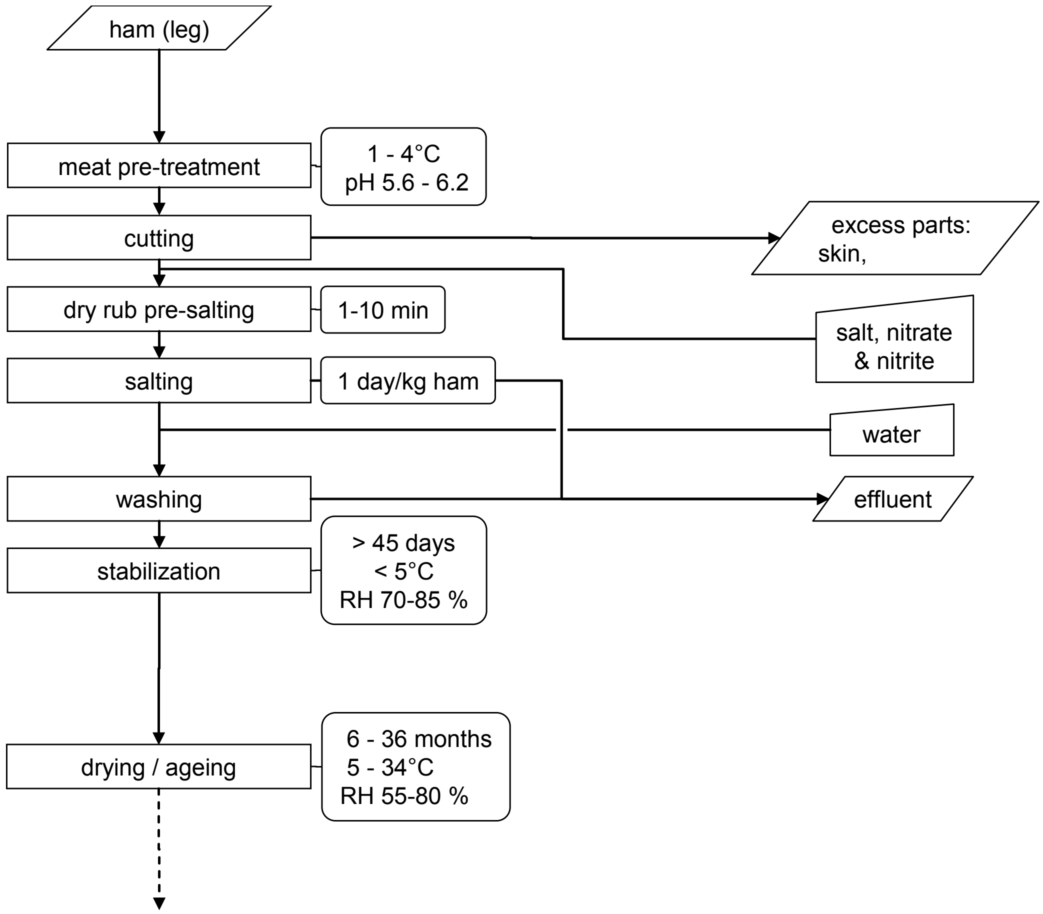

Figure 2: *Process flowchart of studied dry-cured ham production line (RH – relative humidity).*
Slika 2: *Procesni diagram preučevane proizvodnje linije pršuta (RH – relativna vlažnost).*

(glass, plastic or aluminum), cans (steel or aluminum) and kegs of different volume.

Evident points of potential environmental impact in the beer production line are:

- aspects in primary production (barley growing and hop growing)
- spent grain management
- CO_2 management
- yeast management
- energy efficiency
- packaging
- ethanol recovery.

The type of barley purchased, use of fertilizers and pesticides and the distance the material to be transported affect the environmental impact of beer production. Among these categories, transport and pesticides are particularly important in hop growing.

Many different options for the employment of spent grain and spent yeast are possible. The environmental impact of these is to be assessed.

Management of CO_2 directly affects the global warming potential of a production line and has a potential influence on its energy and economic efficiency. Many different packaging possibilities should not be overlooked. The treatment of spoiled series, beer spilled and leaked from damaged packing containers is important towards the eutrophication potential of the facility.

3.4 CAULIFLOWER

The production of cauliflower was simplified to seeding, transplanting, growing and harvesting (Fig. 4).

Seeds are purchased, sown and propagated by transplant producers. Transplanting occurs mostly in the first half of August and can be prolonged up to the end of September.

The crop is irrigated with sprinkler irrigation. Irrigation is given immediately after planting for the first time, a week later the second time and subsequently depending on climatic conditions.

Fertilizers are usually applied in all inorganic form,

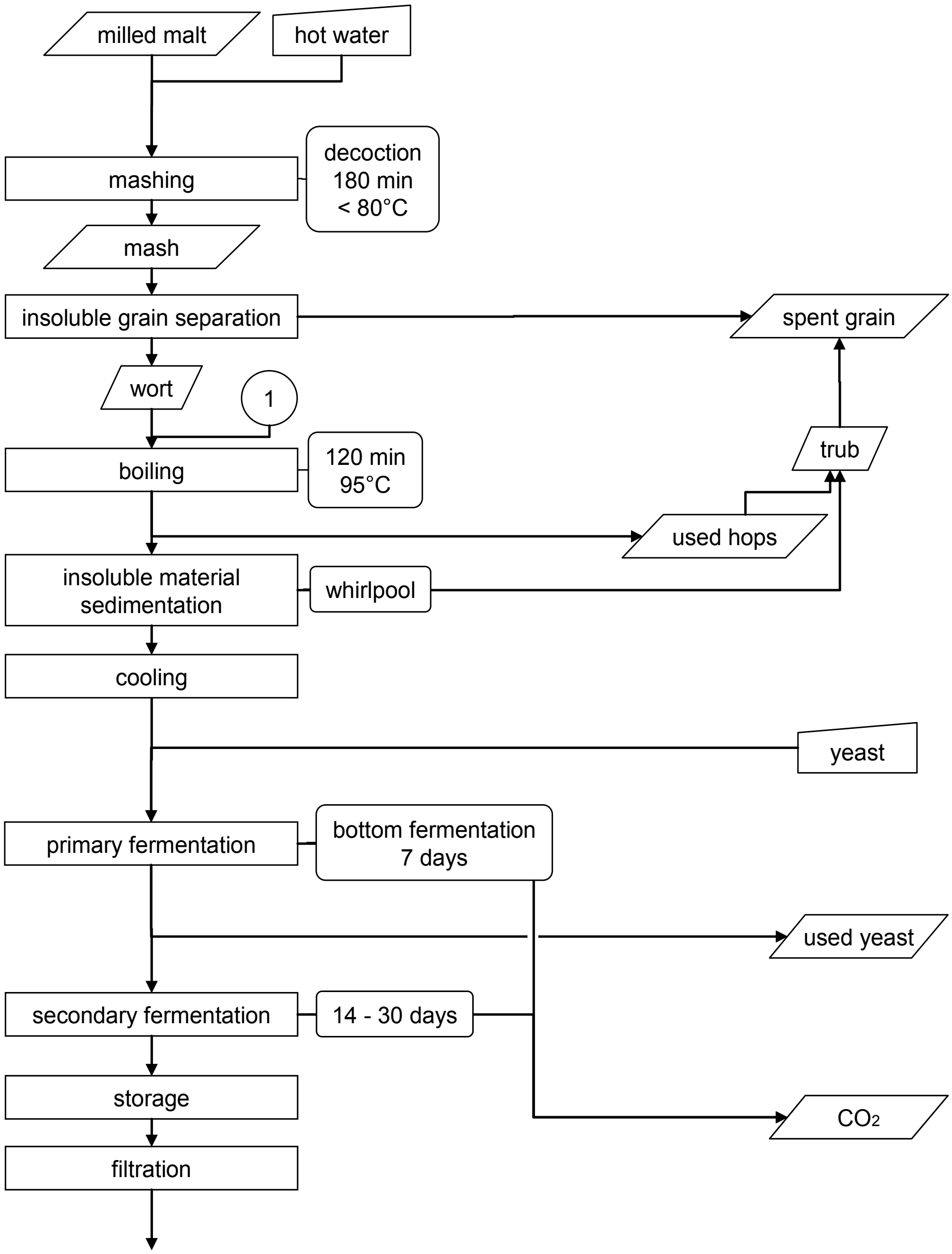

Figure 3: *Process flowchart of lager beer manufacturing line.*
Slika 3: *Procesni diagram preučevane proizvodne linije lager piva.*

yet the combination with locally accessible manure is not uncommon. Inorganic treatment is supplied in single dose for short-duration varieties and twice for long-duration varieties (2/3 at planting and 1/3 30–60 days later).

Short-duration varieties are harvested before 100 growing days, long-growing varieties from 100 to 150 growing days. Therefore, time of harvest is generally from the end of October to the end of March (Munoz, 2007).

Cauliflower heads are picked manually and packed together in plastic or cardboard boxes. For the time being, vegetables are being packaged mostly for the need of transport. Due to higher demand and shelf life prolongation, individual packing (to polypropylene films and such) of plants is arising.

Evident points of potential environmental impact in the cauliflower growing are:

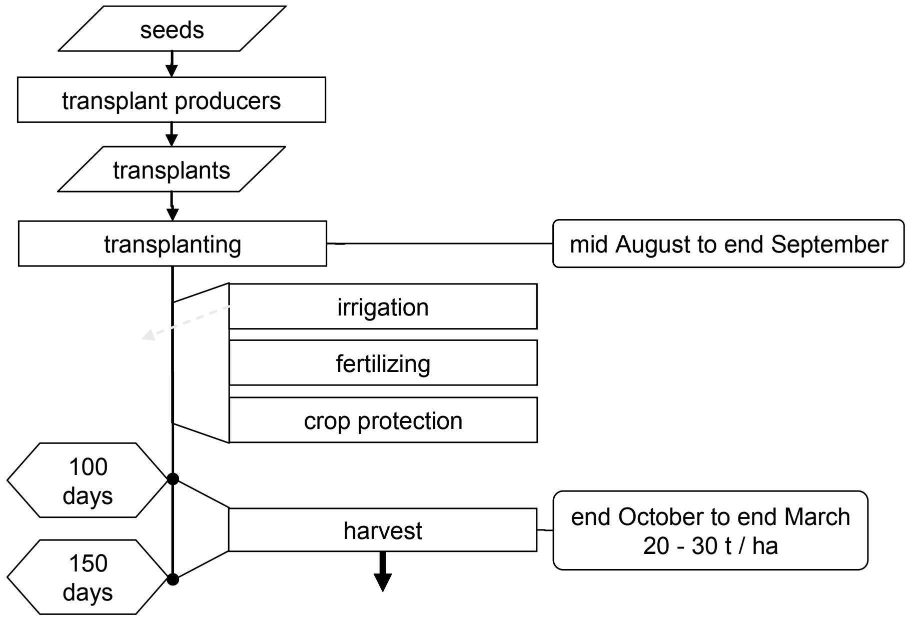

Figure 4: *Process flowchart of cauliflower growing.*
Slika 4: *Procesni diagram v preučevani tehnologiji gojenja cvetače.*

- agronomic practices
  - crop protection
  - irrigation
  - fertilizer management
- packaging.

4 CONCLUSIONS

Approaching environmental impact assessment expert-wise prior to conducting wholesome assessments in detail has successfully challenged the identification of environmental hot spots in traditional food production systems. The described procedure was found to be a useful semi-scientific tool in overviewing the available specificity of the field data, evident environmental hot spots and the existent alternative production steps in the extended production system.

A preliminary approach saves time, and has a strong interpretative power, since it pays regard to theoretical principles and provides valuable practical feedback from the production site. Although some indications toward the environmental impact extent arise in this early stage, one should restrain oneself from premature judging the structure of the final production line's environmental burdening potential.

5 POVZETEK

Podrobne analize vpliva na okolje so drage, prav tako pa za izvedbo potrebujemo precej časa in specifičnih podatkov. S preliminarno identifikacijo kritičnih točk potencialnega obremenjevanja okolja pridobimo rezultate, ki so nam v pomoč pri določanju obsega in ciljev analize in pri postavljanju mej preučevanega sistema.

Identificirali smo postopke v štirih modelnih proizvodnih linijah evropskih tradicionalnih živil (sir, pršut, pivo, cvetača) in na podlagi sodelovanja s raziskovalnimi, izobraževalnimi in tržno naravnanimi inštitucijami opravili strokovno izbiro kritičnih okoljskih točk.

Okoljski vidiki kmetijskih dejavnosti so relevantni za vse štiri modelne proizvodnje. V posameznih modelih smo izpostavili še vidike, ki so posredno ali neposredno povezani s porabo vode in energije. Modelom smo dodali tudi okoljske točke, ki so značilne za posamezno proizvodnjo. Nadaljnje nameravamo pri vseh proizvodnjah preučiti še doprinos embalaže k okoljskemu bremenu celotne proizvodnje.

Pridobili smo primeren okvir za ocenjevanje vpliva na okolje bodisi na konceptualnem bodisi na poglobljenem nivoju, na podlagi katerega šele lahko podamo končno oceno možnega obremenjevanja okolja s preučevano proizvodno linijo.

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