Design Parameters of the Factory Buildings for Marmalades and Jams

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Abstract
A preliminary survey in Sicily highlighted thirty suitable companies specialised in making marmalades and jams of which half are within the protected denomination zones of "Ficodindia dell'Etna e di San Cono DOP", "Arancia di Ribera DOP" (Etna and San Cono Prickly Pear PDO, Ribera Orange PDO), "Arancia Rossa di Sicilia IGP" (Blood Orange of Sicily PGI), "Pesca di Leonforte e Limone di Siracusa IGP" (Leonforte Peach and Syracusa Lemon PGI). These companies work with various fruit varieties particularly with citrus fruit and prickly pears. From analyses of the factory buildings, and the environmental and organisational aspects of production phases there are design shortcomings which limit operations and the quality the production systems. Production often takes place in factory buildings built for other purposes and subsequently adapted, and furthermore some are totally off the beaten track. These buildings have spaces and operational flows which do not correspond to the necessities of either production or current norms. Apart from creating operational difficulties and health and hygiene risks, this denigrates the companies' role as driving forces in the re-appraisement of territorial assets based on developing tourist itineraries for gastronomy and local culture. The aim of this study, given the total lack of specific design outlines for rationalizing the production of marmalades and jams, is to propose guidelines for organising work-spaces and health and hygiene requisites.

Keywords: traditional produce, meta-project, building quality, company layouts

1. Introduction

National ISTAT (annual statistics for industrial output) data for 2007 show that average production of citrus conserves and marmalades was 153000 t. The greatest European consumers are Germany, Holland and France with Italy's consumption on the rise over the last 4 – 5 years at breakfast, as an appetiser, in confectionery, and in particular in babies' diets (Stefanoni, 2009).
In Sicily, marmalade production contributes to the local economy and helps maintain rural traditions. Some European studies have shown how the value of local products can help safeguard rural communities. Aside from being agricultural or artisan food products, they are also products of the territory – of its natural and cultural resources.
Analyses of factory buildings, and environmental and organisational aspects of the production phases of 'marmalades and jams in Sicily within the protected denomination zones of Etna and San Cono Prickly Pear PDO (Protected Designation of Origin), Ribera Orange PDO, Blood Orange of Sicily PGI (Protected Geographical Indication), Leonforte Peach and Syracusa Lemon PGI, have highlighted design shortcomings which limit operations and the quality of these production systems.
Production takes place in buildings designed for other uses which have been approximately adapted, and in some cases are quite far from the main routes of communication.

These buildings exhibit spaces and work flows which neither meet production requirements nor the applicable norms. For example, ingredients are often stored alongside empty jars and cardboard. This inconveniences employees who are forced to work in cramped spaces between considerable stacks which limit visibility (D.P.R 327/80 art. 28). Other obvious examples are the absence or adoption of insufficient ventilation to clear the accumulated condensation; the absence of outside spaces for ferrying incoming or outgoing products and the lack of asphalt; wash-water and puddles on the floor making the environment unhygienic and dangerous for employees. Apart from creating production difficulties and health and safety risks, it denigrates the driving force behind the firm as a value-adder to the territory based on developing cultural and gastronomic tourism itineraries.
Making production buildings part of these itineraries with consequent product spread beyond regional borders can only improve current production systems while respecting tradition.
So, since there are no design templates for producing marmalades and jams/conserves, this study proposes design layouts for small, medium and large manufacturers.

2. Material and methods

This research uses the metadesign approach to analyse the production requirements for making marmalades and jams outlining the consequent functional and building requisites for the production facilities. This time-proven method applied to other sectors of the agricultural food industry has been able to define interesting outcomes for designing a variety of building facilities (Strano et al., 2006a).
The study was carried out in the following phases:
a) survey of marmalade and jam/conserve producers in PDO and PGI fruit areas choosing the most innovative ones;
b) analysis of employee activities and machine functions relative to production cycle and operational space;
c) defining the building most appropriate for producing marmalades and conserves.
Initially, the company survey chose samples as per point a). The following data were collected in for each company: production size, production spaces, organisational and building characteristics, health, hygiene and safety characteristics, products, production cycles, plant technology, raw material quantities and product sales, and employee activities and requirements (Strano et al., 2009b and 2009c). The data was collected on tick charts integrated with flow charts (products, employees & vehicles).
Furthermore, the main legislative norms on product hygiene and workplace safety were considered as they influence defining the *building regulations* and design.
Data processing and comparison highlighted production cycle requirements, employee and machine operations, as well as any design, environmental and organisational criticalities to define the building regulations. The methodology in this last phase has been amply developed in other scientific articles (Fichera et al., 1995).

3. Results

3.1 Analysing the existing buildings and facilities and identifying production requirements

In January 2009 on the website of the National Chamber of Commerce under 'Fruit and vegetable production and conservation' in Sicily, 30 companies specialised in 'marmalades and jams/conserves' were selected and surveyed.
Most of the companies are based in Eastern Sicily and they deal mainly with citrus fruit and prickly pears. About 50% of the companies lie within areas of protected denomination.
Of these, 13 companies from PDO and PGI areas were chosen to help identify the building requirements for production.
The data identified three company types:
- Artisan: the equipment used is simple – cooking is in a saucepan and all the preparation is manual. Pasteurisation is not always carried out. On average 4 employees produce 300 kg/day of marmalade and conserve.
- Semi-industrial: some production phases are technologically advanced but some are manual. The production line is interrupted for pasteurisation and cooling so most employee interventions occur at the beginning or end of the cycle. On average, 5 employees produce 1000 kg/day of product.
- Industrial: the building facilities are similar to the semi-industrial ones except the production line is not interrupted right up to packaging. The production line reduces employee intervention. On average, 12 employees produce 3500 kg/day of product.
Analysis of the production lines (process, equipment, facilities) has helped identify environmental, functional and technological issues relating to the companies' building characteristics within their territorial contexts (Strano et al., 2009b and 2009c).
The company study helped identify some invariants as references in defining the building facility:
- there are three production types: manual, mostly based on employees; semi-mechanized, based on machines which aid the manual work; mechanized, based on entire mechanized production lines;
- for the manual and semi-mechanized cycles, the equipment is similar to that usually used but it needs to be better organised and the spaces managed better;
- for the mechanized cycle, some equipment and plant used for other types of product (ready sauces, tomato extract, fruit juices) can be applied by rationalising the layout and organising internal space;
- it is recommended that production spaces are physically subdivided to differentiate protection levels and thermohygrometric parameters at every production phase. When necessary, these conditions can be evaluated according to company size. In small companies, it may be sufficient to physically separate 'dirty zones' from 'clean zones'.
Furthermore, all those areas dedicated to mechanized product conveying should be clearly marked to guarantee appropriate safety levels and create design solutions to maintain environmental hygiene.

3.2 Production phases
Marmalade production originated in ancient Greece to conserve quinces by slow cooking them to concentrate the sugar they contain. Various documents attest to their name as 'honey apple' (http://en.wikipedia.org/wiki/Marmalade, June 2010)
The procedure for making marmalade is simple: the peeled, cored and chopped fruit is cooked with sugar and hermetically sealed boiling into jars.
The sugar and residual heat in the jars guaranteed long conservation even without refrigeration.

Marmalade is defined as originating exclusively from citrus fruit, whereas jam is made with other fruit like apples, pears, peaches, prickly pears, strawberries etc. (Directive 2001/113/EC). Figure 1 chart the production process which when analysed together with its connected activities helps define the building regulations and then the reference design criteria for this sector.

3.3 Defining the building regulations

Analysing production helps identify size, environmental, safety and access point requirements so as to organise space into sectors or space units.

Sector planimetry derives from the aggregation of workplaces as a result of employee number, vehicular transit, product type and the specifics of production phase (aggregated activities).

By analysing the methods of production and taking into account the 'invariants' above, defining the building regulations makes reference to three categories of production line: manual, semi-mechanized and mechanized. The spaces (Spatial Units and Enviromental Units) shared by these three lines have been defined as have those exclusive to the manual and semi-mechanized lines (lines a & b fig. 2). Figure 3 shows the Enviromental Units specific to each line.

In the design phase, the different Enviromental Units must be arranged so that over time any production line expansion can be made without interference. Analysing the needs and interflow between production spaces helped produce the three organisational layouts in figures 4 & 5. They exemplify how to organise manual, semi-mechanized and mechanized production. Subsequently, there are summarised descriptions of the building characteristics of the production sectors, whereas at this stage the design characteristics of the support departments can be referred to in specialised manuals.

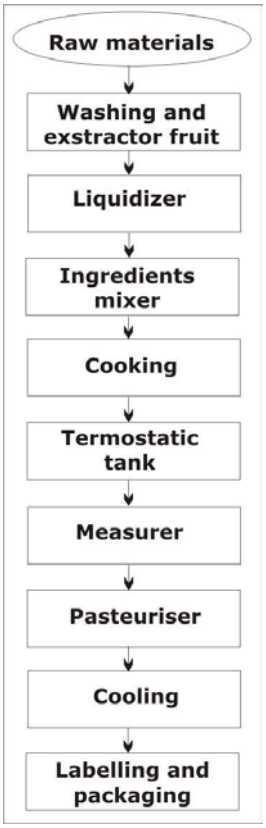

Figure 1. Chart the production process

<u>The Enviromental Units for preparing marmalades and jams</u>

Manual, semi-mechanized and mechanized production lines require the following units as part of the 'production sector': fruit store; ingredients store; jar store; cardboard and packaging store; cold store; equipment wash; fruit wash; transformation; finished product store and waste store. The three production lines are differentiated by the space they occupy, the fact that the manual line converges several enviromental units and by the differing equipment and spaces employed for fruit washing and transformation. Below, the enviromental units are summarised and figures 2 and 3 show the planimetric organisation.

The *fruit store* must be directly accessible from outside. It is characterised by cases of fruit, aisles for the transit of employees and vehicles, durable and easily cleaned floors and air conditioning. So its efficiency depends on ease of transit.

The *ingredients store* must be cool and well-aired. It should be equipped to store sugar, pectin, and juice concentrates and have platforms for bins and tanks. The organisation of space must be such that hygiene may be checked, there is protection against external agents, and there is easy transit of employees and small transport vehicles to and from other spaces. It should be connected to the outside and transformation space.

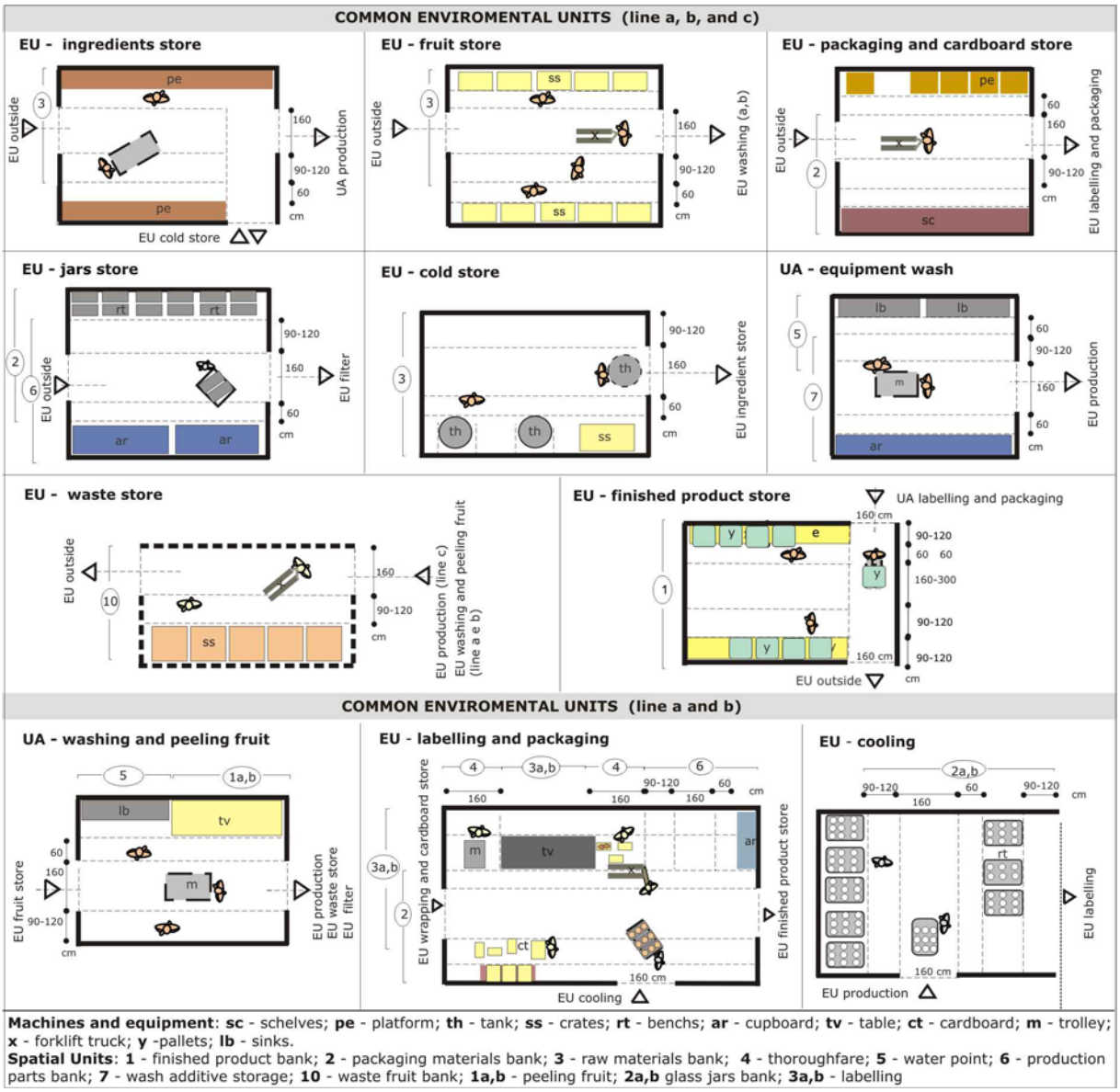

Figure 2. Organisational layouts of Enviromental Units common to all three lines and those just for the manual and semi-mechanized lines (a & b).

The *jar store* must accommodate all the empty jars. Its size depends on the numbers of pallets required. It should be connected to the outside and transformation space as well as enable easy transit of employees and transport.
The *packaging and cardboard store* holds shelving and enables the easy transit of trolleys. It should be connected to the outside and the labelling unit.
The *cold store* holds unfinished product, fruit and flavourings in appropriate containers or tanks. It is ventilated and cooled at -18 °C. Its size depends on production volume and its availability to

employees. It should be located close to the transformation unit. It should also enable easy transit of employees and transport.
Both the *fruit and equipment wash* utilised during production are equipped with sinks which must be kept hygienic and free of stagnating water.
Identified as 'wet and dirty', they must be physically separate from te transformation unit.
In the *fruit wash*, the equipment includes sinks, peeling and coring benches, containers and trolleys for transport to the production unit. In the case of mechanized production, it should have a wash tank, conveyor belts and a sorting bench. This unit may be located outside. Its floor should have drainage channels.

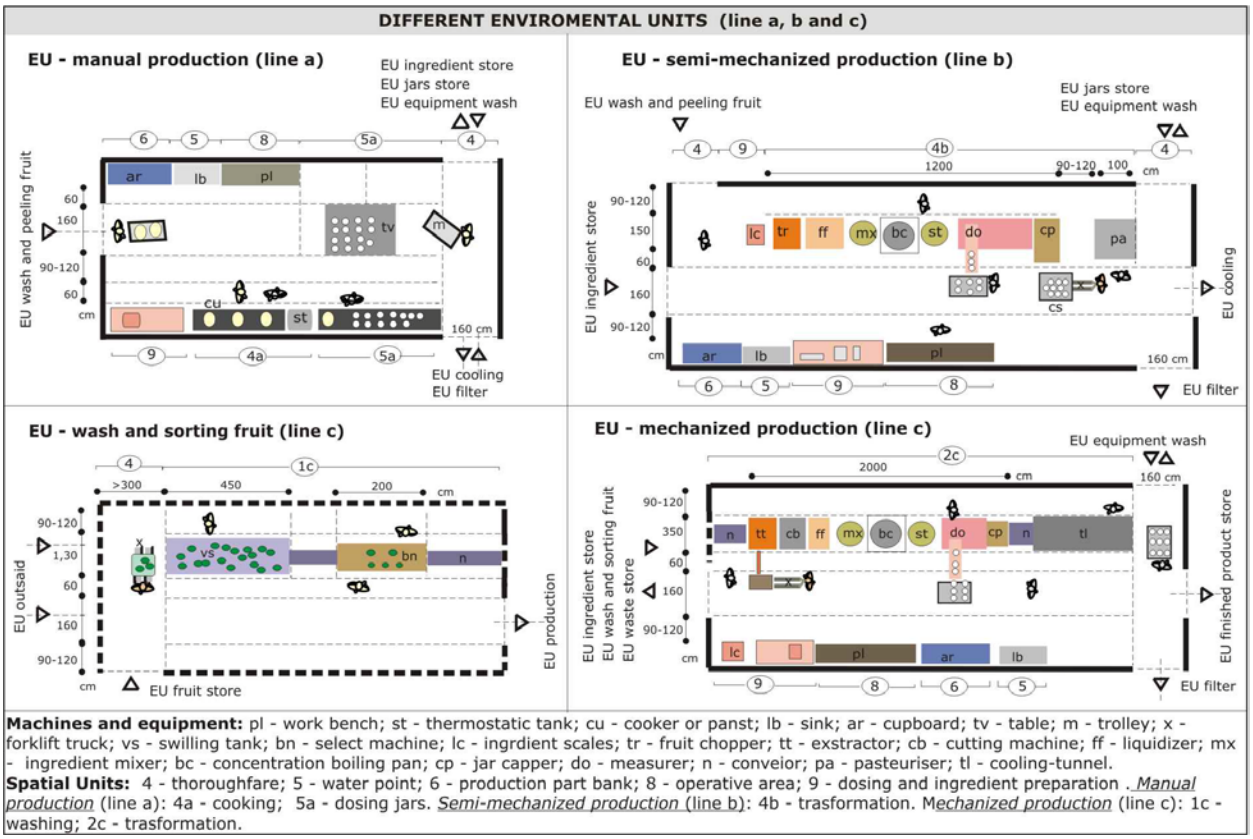

Figure 3. Enviromental Units layouts for the manual, semi-mechanized and mechanized lines.

The *production section* depends on the production type (manual, semi-mechanized, mechanized). Manual production requires: cooker or pans, thermostatic tank, work benches for measuring the ingredients of marmalade, work benches for product testing, and space for employee and vehicle transit.
For the mechanized and semi-mechanized lines the size of the unit must be such to accommodate a longitudinal production line. They differ in the technology used in certain phases. The semi-mechanized line requires the production line be interrupted to add the fruit and sugar, for pasteurisation and cooling. During these phases, the employees intervene so there must be sufficient space for them and their equipment. The line may have a 300 kg/h (150 kg/cycle) capacity and is made up of: ingredient scales, fruit chopper, liquidizer, ingredient mixer,

concentration boiling pan, thermostatic tank, measurer, jar capper and a pasteuriser. So, the fruit is chopped, strained of seeds and concentrated in a boiling pan of 800 mm diameter. After jarring, the jars are taken manually to the pasteurisation and cooling areas.
The continuity of the mechanized line requires employee intervention only during jarring and for adding the sugar. The line would have a 1500 kg/h (750 kg/cycle) capacity with a boiling pan of 1300 mm diameter. The washed fruit is conveyored directly from the liquidizer to the ingredient mixer to the concentration boiler, the measurer and the jarrer as far as the pasteurisation tunnel and cooling. Labelling and packaging are the final sectors of the line.
Both lines (semi-mechanized and mechanized) require employee transit aisles to manage them as well as space for taking waste away. Space unit inter-connection and system type diversification (fig. 4 & 5) depends on production type.

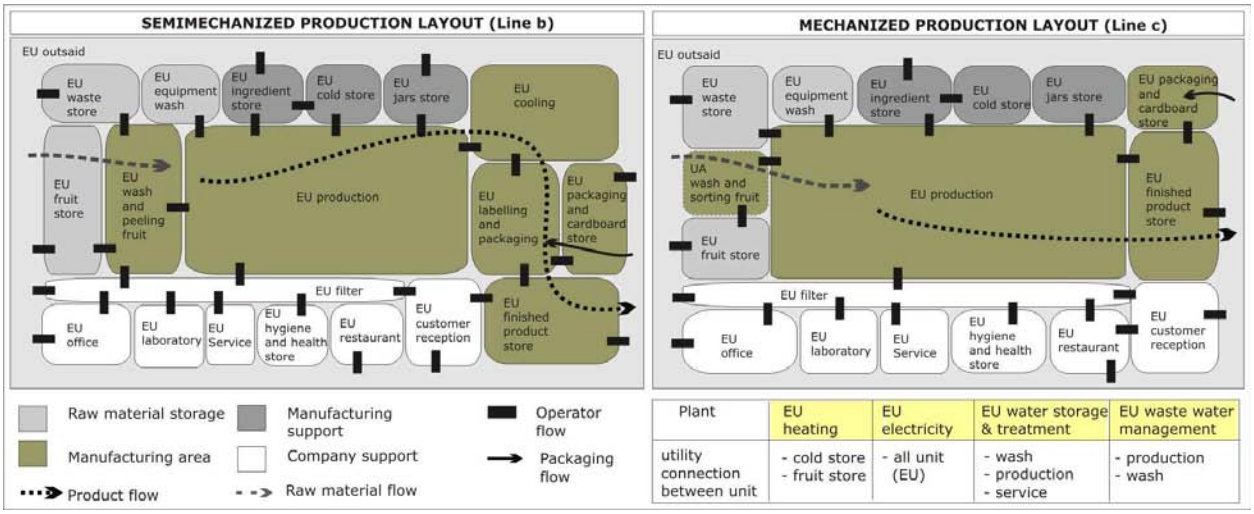

Figure 4. Aggregated Enviromental Units for semi-mechanized and mechanized production of marmalades and jams

The *waste store* can be located outside when immediate removal of organic waste is required or in a space unit with direct access to outside in which the waste remains in bins for brief periods. This space is subject to spills due to the fermentation of peel, so drainage channels and ventilation is required.
The *finished product store* should be such as to accommodate the product packs on shelving with access aisles.

<u>Enviromental Units for preparing marmalade and jams (semi-mechanized)</u>
The semi-mechanized preparation of jams requires a cooling unit and one for labelling and packaging.
The *cooling unit* should have transit aisles and space to park the jar packs. Its organisation depends particularly on the rotation of products. Its indispensible that space is oriented to sequential operation avoiding any employee cross-traffic. It is preferable that this unit is connected to the production and labelling units.

The *labelling and packaging* unit should have enough space for making up the boxes and filling them as well as a table for jar-labelling and aisles for parking and trolleying the product to the store.

The aggregation of Enviromental Units for manual production Given that in traditional production only a few hundreds of kilos of fruit are used per cycle, it is preferable to unite different units especially regarding functional, health and hygiene, thermal hygrometric and luminosity requisites. So, considering that the dirty and clean areas must remain separate, the fruit store and equipment wash could be united to the fruit wash and peeling fruit. The cooling remains separate. Labelling and packaging for small quantities which are immediately marketable requires simple shelving and boxing which may be located in the finished product store (fig. 5).

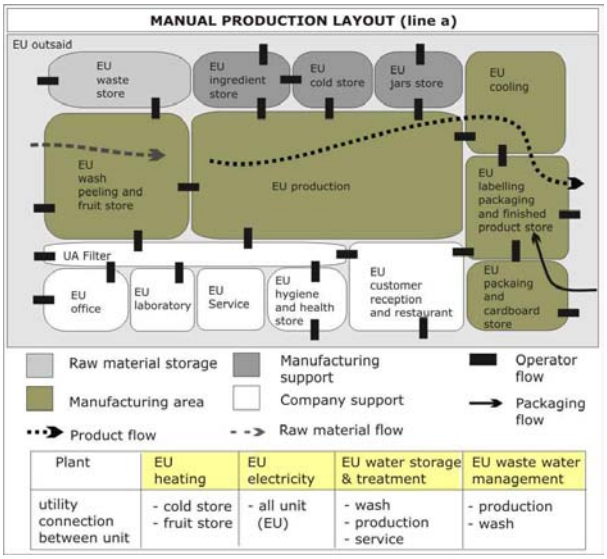

Figure 5. Aggregated Enviromental Units for manual production of marmalades and jams

Conclusion

The research results could provide useful design references for small to medium countryside businesses without specialised buildings.
It proposes specific building regulations for the production of marmalades and jams by defining the environmental and typological characteristics of the production complex whose organisation can vary according to production and equipment type. In particular, space attributes were defined to assure the optimum benefits of the process (manual, semi-mechanized, mechanized) and associated activities. Particular attention was paid to the planimetry of each single Enviromental Unit and their inter-correlation. Thus it was possible to define several layouts, one for each production line which schematizes the organisation of factory space. They show how production spaces correlate which is determined by the type of flow. The proposed layouts and inter-connections are the result of the research and analyses carried out and summarised graphically and represent the principles for correct planimetric organisation.

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The authors' contributions towards the present work are to be considered equal in every way