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D 3.6. Process conditions for new food products for incorporation in WP5 (LCA)

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University College Cork

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Contents

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0. Summary

Recipes and processes were developed for high protein foods as part of Work Package 3 (WP3), using protein-rich ingredients that were developed in WP2 as part of PROTEIN2FOOD. The new plant-based protein-rich food prototypes developed include meat replacers, bakery products, pasta, breakfast cereal, beverages and infant food prototypes. This deliverable includes the ingredient composition and processing conditions developed for these products (at lab scale or pilot plant scale). This deliverable provided important data and knowledge on the processing conditions of the prototypes mentioned above, which was necessary for completing the Life Cycle Assessment (LCA) of the prototypes in WP5.

1. Introduction and objectives

The LCA component of WP5 aims to assess the environmental impact of the food product prototypes developed in PROTEIN2FOOD. This includes the whole food supply chain, from crop cultivation to finished food product, also used “from farm to fork”. This will allow the products to be assessed in terms of their sustainability and environmental impact. Furthermore, the innovative products can be compared with each other as well as against pre-existing products. This allows the identification of selection of products/processes with lower environmental impact. In order to carry out the LCA, information is required on the recipe and process conditions for each product prototype, i.e. raw material inputs, energy and water inputs & additives/chemicals. The valuable output were recorded including the nutritional value, along with any by-products/waste streams.

2. Activities for solving the task(s)

Each of the partners involved in WP3 have developed high-protein product prototypes based on the protein rich ingredients resulting from WP2. The processes have been developed to give high quality, stable products with good sensory attributes. All the relevant data regarding the process conditions was recorded and provided to IFEU (based on the IFEU LCA questionnaires[1] and as far as possible disaggregated by the individual processing stages as described in section 3) in order to complete the LCA. Data gathered by this procedure were fed into the prototype LCA models developed by IFEU. Related results are represented by the environmental indicator results for the life cycle step “processing to final product” for each of the prototypes. For an explanation which processing stages are found in which life cycle step of the LCA results, please see section 3.1 in Deliverable D5.3.

[1] For explanations regarding the IFEU LCA questionnaires please see section 2.5.2 in Deliverable D5.2

Individual processing stages as documented in the results section 3 for the prototypes are grouped into the life cycle step as "processing to final product" for the overall LCA result. This type of documentation was necessary in order to show the contribution of the prototype preparation stages, relative to all other life cycle steps, starting from crop cultivation and processing of crops into food ingredients, as well as including for example transports throughout the value chain.

However, some factors such as waste water, were hard to assess in this study. Most assumptions that had to be made regarding the processing conditions, were made in agreement and by consulting the WP5 (IFEU). If no data was available, n.a. for not available was indicated. Those data gaps were subsequently closed by IFEU through use of literature data or best-available proxy data.

One key outcome of the data collection activity for WP5 were the prototype composition tables and their respective nutritional values. Those were directly fed into the LCA models and have already been documented in section 2.4 of Deliverable D5.3.

3. Results

All the optimised conditions listed below for the target food and beverages products developed within the projects are results of several and prelaminar investigations. These have included different food processing step combinations that have been studied with the aim to develop final food prototypes, with techno-functional and sensory attributes matching those characterizing their commercial counterparts (i.e. traditional products in the market). Particular emphasis has been put in developing manufacturing conditions/procedure that are able to preserve the nutritional quality of the raw materials employed in the food prototyping, while, at the same time, ensuring the microbiological stability of the resulting food prototypes.

3.1 Development of quinoa-based milk substitutes (UCC)

For developing quinoa-based milk substitutes, organic quinoa flour and water (1:7) were first mixed in a semi-industrial blender at a maximum speed for 3 minutes. For dextrinization and liquefaction of starch, an alpha-amylase was applied. Further, for protein extraction and flavor improvement a protease was added. The suspension was then stirred and heated to 50 °C for at least 180 min. Subsequently, samples were filtered, homogenised and submitted to a low temperature heat treatment (Figure 1).

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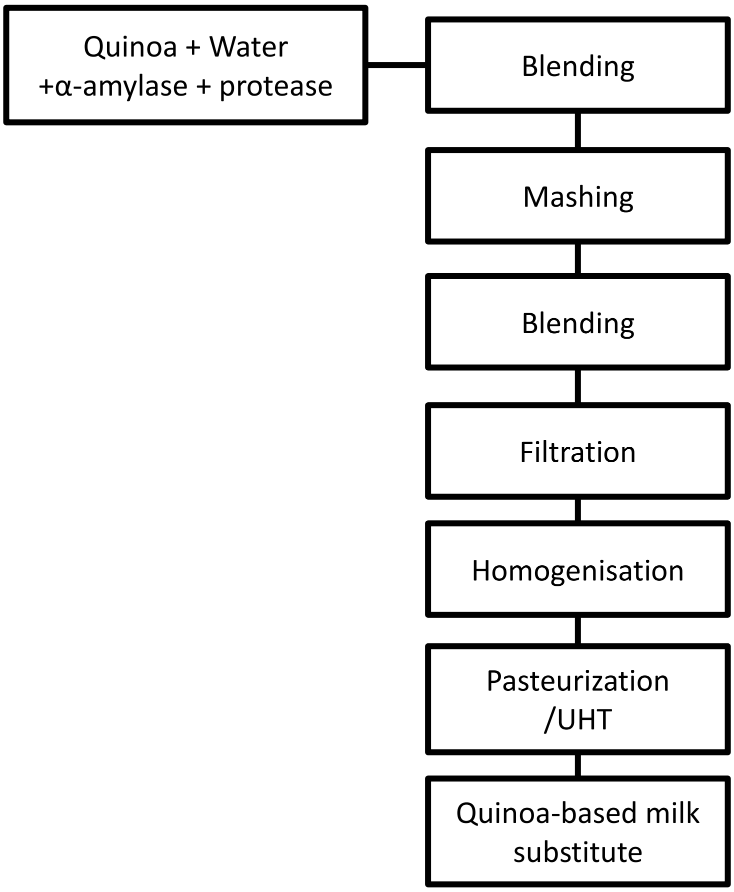

Figure 1. Flow chart indicating of the development of a quinoa based milk substitute.

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3.2 Development of lentil-based milk substitutes (UCC)

For developing lentil-based milk substitutes, first solutions of legume protein isolates were prepared using a stirring and an ultraturrax device. The solution was heated to 50 °C and pH was adjusted to 7 and then hydrated for 1 hour. The solution was stirred at 70 rpm and utraturraxed. Then, a source of fat was mixed with the protein suspension for 10 min using the stirrer and ultraturrax. To further reduce the particle size, the emulsions were homogenised. Finally, to ensure microbial stability, samples were subjected to pasteurisation (Figure 2).

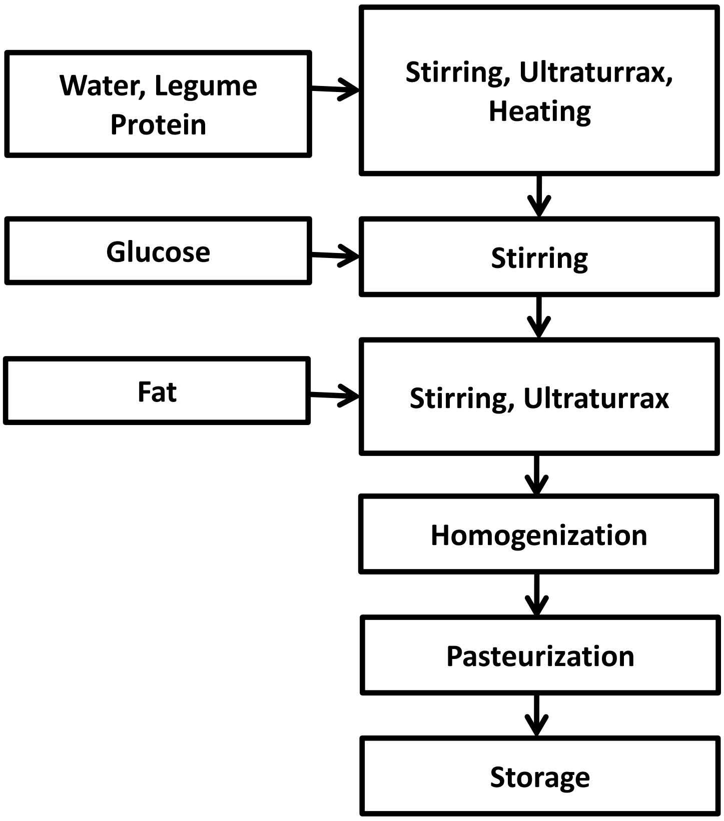

Figure 2. Flow chart indicating of the development of a lentil based milk substitute.

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3.3 Development of protein-rich (PR) wheat-based bread (UCC)

In preparing the protein-rich wheat-based bread, Baker's yeast was first suspended in water for preincubation for 10 minutes. The yeast suspension and vegetable oil were then added to the premixed dry ingredients, including; PR wheat flour blend (baker's flour: PR ingredients with a ratio 85 : 15) and salt. All ingredients were mixed in a kitchen-scale benchtop mixer (Kenwood Chef) at speed 1 for 1 minute, followed by at speed 2 for 7 minutes. The dough was divided and proofed for 75 minutes at 85 % relative humidity and 30 °C. Baking was performed in MIWE deck ovens at 230 °C (top/bottom) for 14 minutes, applying 700 ml of steam and with an open draft. Subsequently, samples were left to cool down before packaging (Figure 3).

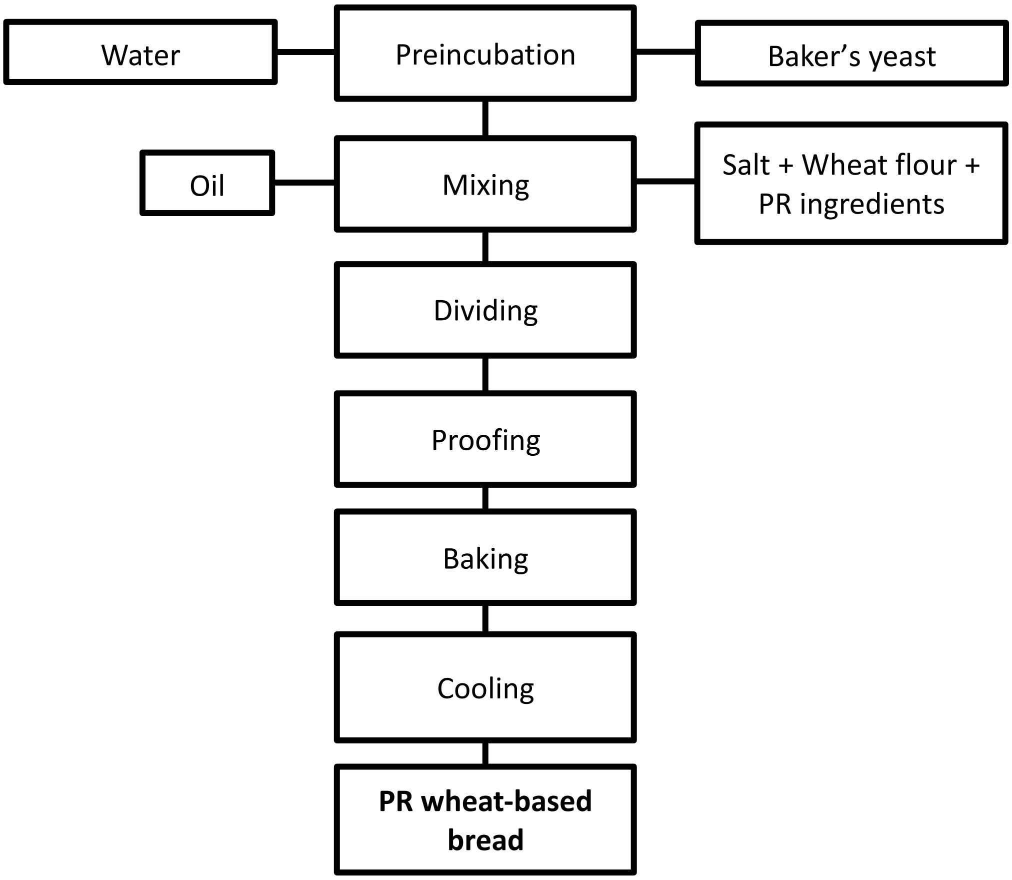

Figure 3. Flow chart indicating of the development of protein- rich (PR) wheat-based bread.

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3.4 Development of protein-rich (PR) wheat-based pasta (UCC)

For developing the protein-rich wheat-based pasta, fresh pasta was produced first by using a benchtop cold extrusion single barrel system (Häussler, Germany), equipped with a spaghetti nozzle (diameter of holes: 2 mm). Dry ingredients (baker' flour, PR ingredients and salt) were premixed in the mixing chamber of the pasta machine, and water (50 °C) was added. Total mixing time was 10 min. Dough was then extruded, and the first 25 cm of spaghetti were discarded (the first extruded parts are not suitable for quality evaluations/comparisons). For preparation of cooked pasta, optimum cooking time was determined and applied (Figure 4).

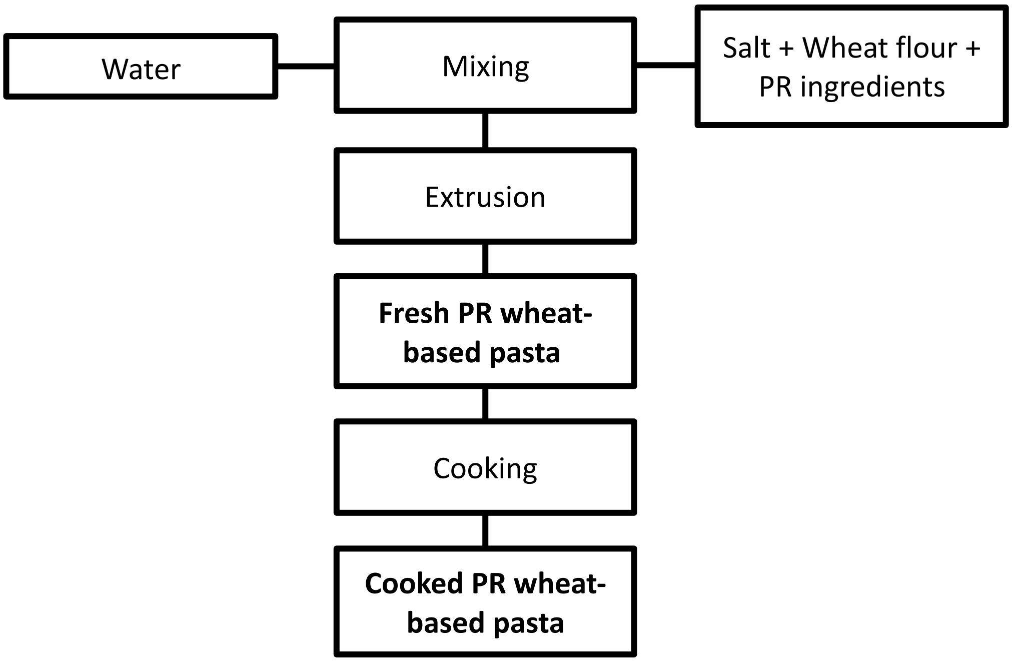

Figure 4. Flow chart indicating of the development of PR wheat-based pasta.

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3.5 Development of a plant-based protein infant formula (UCC)

For the preparation of the plant-based infant formula, a legume protein isolate, amino acids, minerals, maltodextrins and sunflower oil were applied. The legume protein, amino acids and maltodextrins were first mixed in water. Afterwards, a high temperature/short time treatment (HTST) was applied to the suspension. Sunflower oil was mixed with the rest of constituents with an ultra-turrax and passed through a homogenizer to obtain the emulsion. Minerals were added to the model formula concentrate and a spray drying process was carried out in order to obtain the infant formula powder (Figure 5).

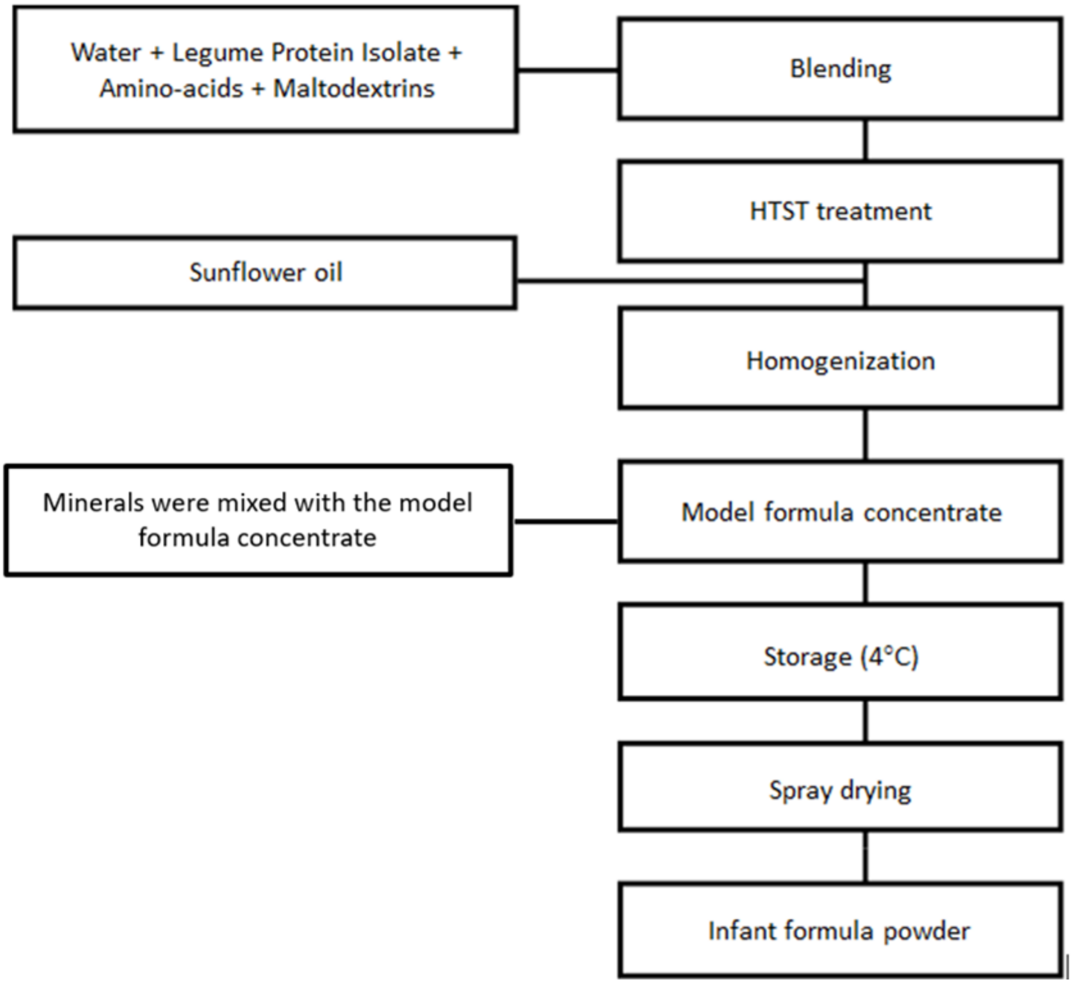

Figure 5. Flow chart of the development of a legume based infant formula

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3.6 Development of gluten free bread with quinoa and potato starch (UNALM)

For developing gluten free bread, red quinoa flour and potato starch (1:1) were mixed in a beater with water, vegetable oil, yeast, salt, sugar and a mixture of hydrocolloids (xanthan gum and tara gum) at a high speed for 3 minutes. The dough formed was then fermented for 30 minutes at 30 °C and 85% RH and as a final step, the bread was baked for 60 minutes at 200 °C (Figure 6).

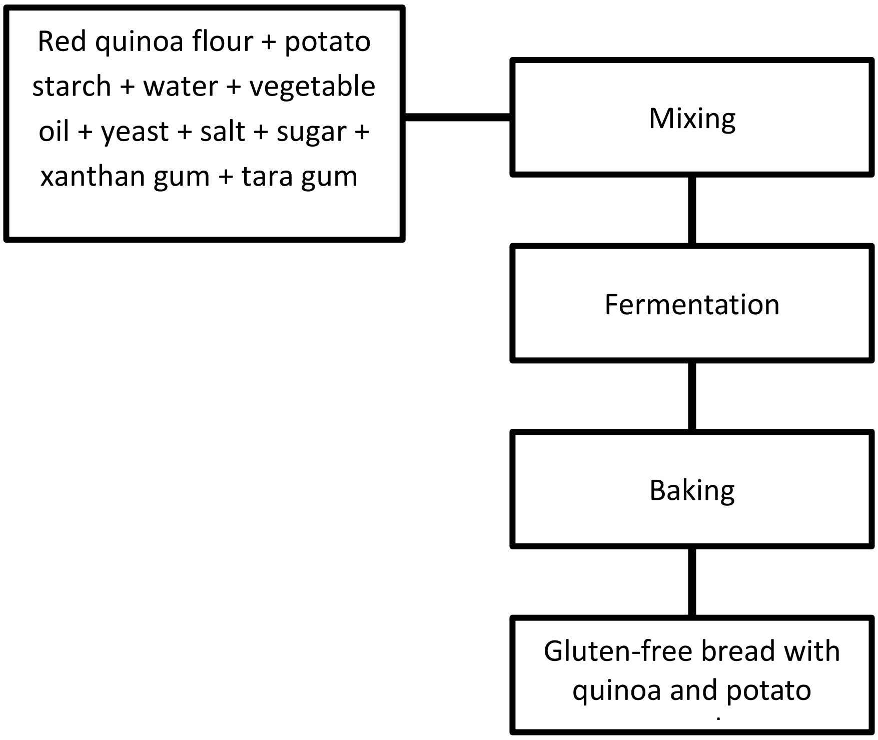

Figure 6. Flow chart indicating of the development of gluten-free bread with quinoa flour and potato starch.

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3.7 Development of meat substitutes (FRAUNHOFER)

In preparation of the meat substitutes, lentil protein (IEP) and amaranth flour were first mixed in a kitchen blender (Thermomix) for 30 seconds at a setting 5. Extrusion experiments in laboratory scale, with a mass flow rate of 1 kg/h, were performed. This was done using a laboratory, co-rotating, and intermeshing twin screw extruder (Haake Rheocord, Thermo Fisher Scientific, Inc., UK) with a screw diameter of 16 mm, a smooth barrel, and a length-diameter ratio of 25:1. The extruder is divided into a five heating zones (TS1 –4 and D1) and one cooling zone. Each zone can be controlled and heated separately and consists of different screw and conveying elements The temperature profile was set at 0 (TS1) -80 (TS2) -100 (TS3) -140 (TS4) -140 (D1) /80°C (cooling zone) and screw speed was 250 rpm. After extrusion, the samples were cut in small pieces, flavored with a gyros-style herb mixture and fried in a pan. For storing the ready-to-eat-product were then frozen and stored at –20°C (Figure 7).

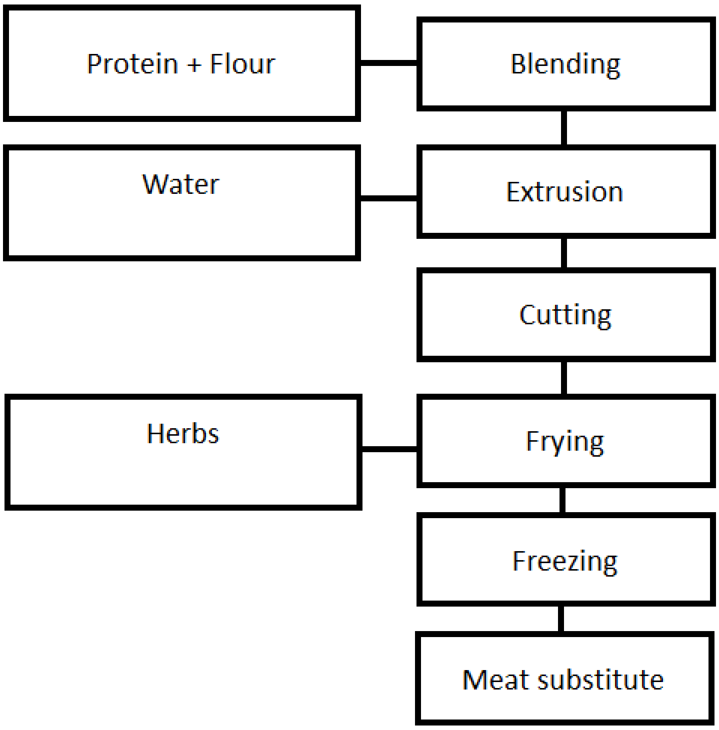

Figure 7. Flow chart indicating of the development of meat substitutes.

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3.8 Development of protein cereals (FRAUNHOFER)

In preparing of the protein cereals, white lupin protein, buckwheat flour and salt were mixed in a spiral kneader at maximum speed for 60 seconds. Extrusion experiments on pilot scale with a mass flow rate of 10 kg/h were performed using a pilot scale co-rotating, intermeshing twin screw extruder (ZSK 26, Coperion GmbH, Stuttgart). This had a screw diameter of 26 mm, a smooth barrel, and a length-diameter ratio of 25:1.

The extrusion temperature was set at 40-60-80-120-140°C and rotation speed of the screw was 800 rpm. Upon exiting the die, extrudates were cut using a die face cutter at 300rpm. The cereals were then dried in a drying chamber until a they reached a moisture content of 4.5% (Figure 8).

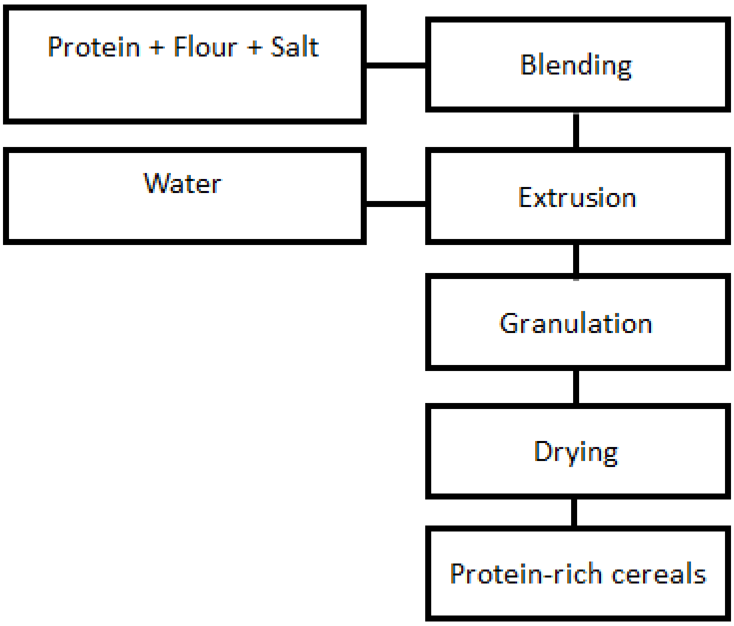

Figure 8. Flow chart indicating of the development of protein cereals.

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3.9 Development of spread like meat alternatives (FRAUNHOFER)

For developing the meat alternatives, protein (Lupin or Faba bean) and flour (Buckwheat or Quinoa) were mixed in a Thermomix at speed 3 for 10 seconds. The dry-mixture and water were mixed in a laboratory mill for 40 seconds by 2000 rpm (mixing process I). In the next step, melted fat was added and mixing process II was applied for 40 seconds at 2000 rpm. Next, spices and all residuary ingredients were added and mixed for 40 seconds at 3000 rpm. Final mixing was completed for 40 seconds at 5000 rpm. As a final step, the suspension was filled in sterile glasses, pasteurised and then stored at 4°C (Figure 9).

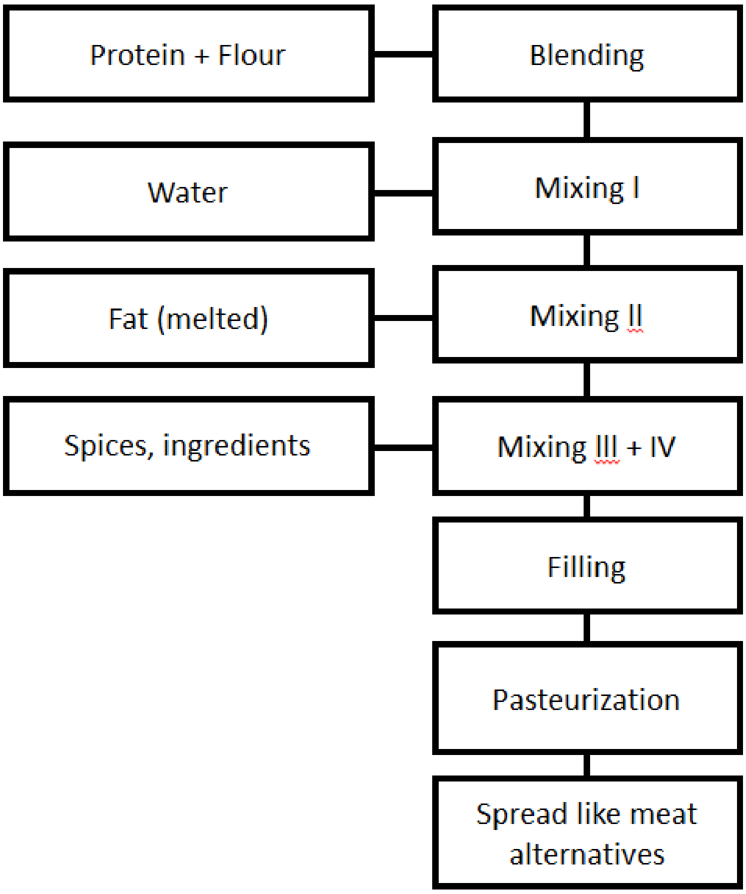

Figure 9. Flow chart indicating of the development of spread like meat substitutes.

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3.10 Development of instant porridge flour (MAK)

The instant porridge flour includes the following ingredients; millet, maize, soy, beans and grain amaranth. These were sorted, cleaned and then milled into flours. The flours were then weighed, mixed, extruded and the extrudate pellets were milled into instant flour. The process was similar to the cooking composite porridge flour, excluding the extrusion process (Figure 10).

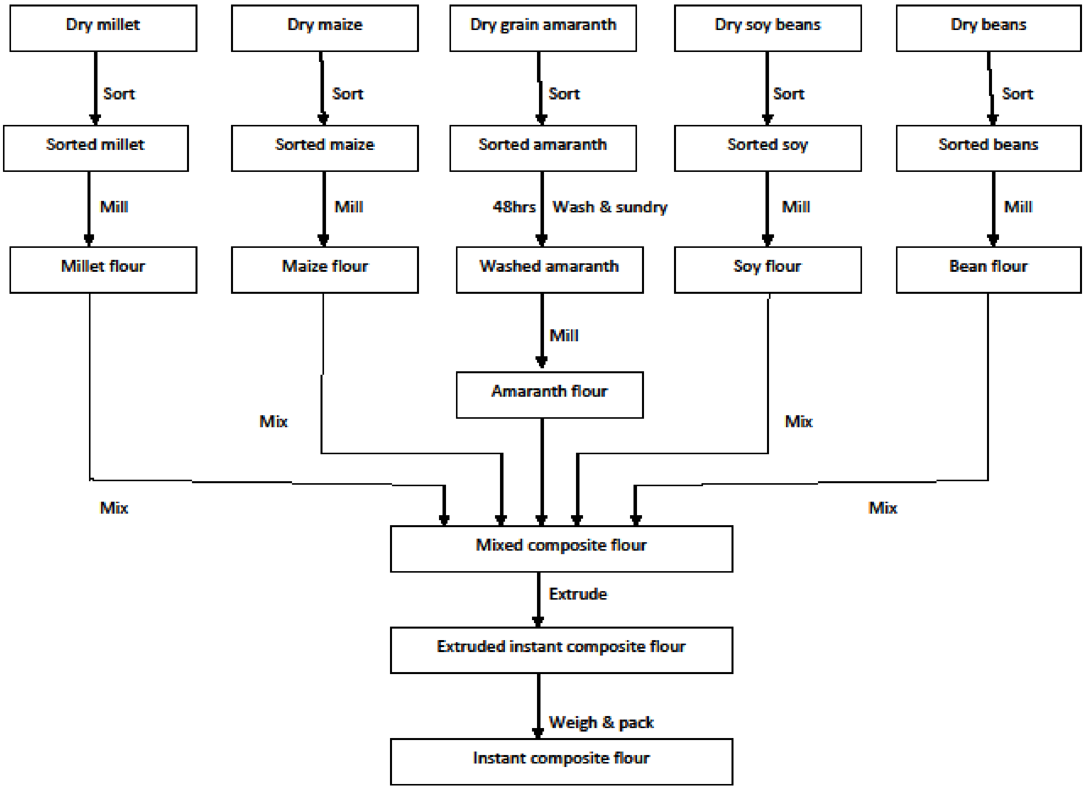

Figure 10. Flow chart indicating of the development of instant porridge flour.

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3.11 Development of protein source cookies (MAK)

To Process the cookies, the peanuts were first sorted, then roasted at 180 °C for 45 minutes and milled. Sugar, fat, milk powder, water and the roasted broken peanuts were then mixed for 15 minutes. Wheat, instant flour and baking powder were added to the uniform mixture, mixed into dough, and then shaped using cookie cutters. The cookies were loaded onto greased trays and baked at 180 °C for 45 minutes. Finally, the cookies were cooled, then packed and stored at ambient temperature (Figure 11).

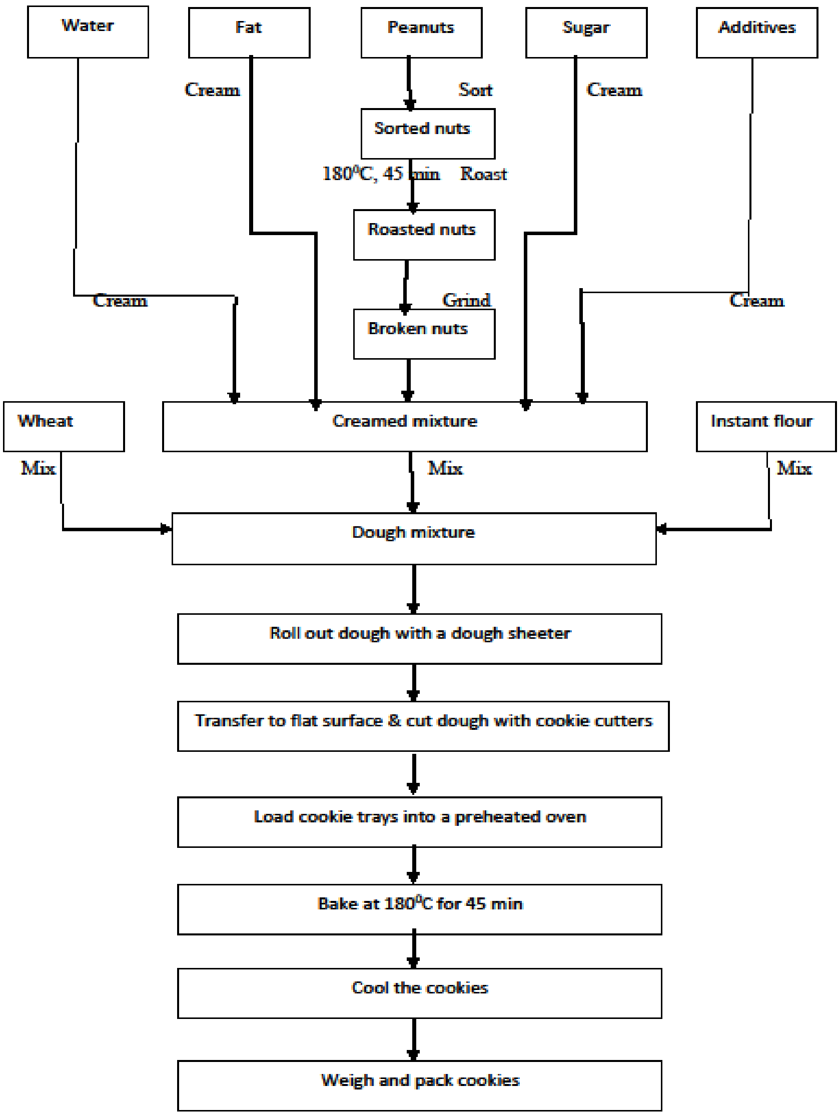

Figure 11. Flow chart indicating of the development of protein source cookies.

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3.12 Development of extruded snacks (UMAK)

Extruded savory snacks were developed using maize and beans as raw materials and forming type of extruded pellets. The grains were first sorted, cleaned and milled. The milled flours were further mixed with 2% salt and then extruded. The discovered optimal extrusion conditions applied were the first, second and third heater temperatures of 60, 130 and 150 °C. Furthermore, the discovered ideal main extruder and cutter speeds were recorded at 30, 35 and 30 HZ, with a cutter diameter of 4 cm. As a final step of development, the extrudates were sprayed with 5% hot soy oil and left to dry before packing (Figure 12).

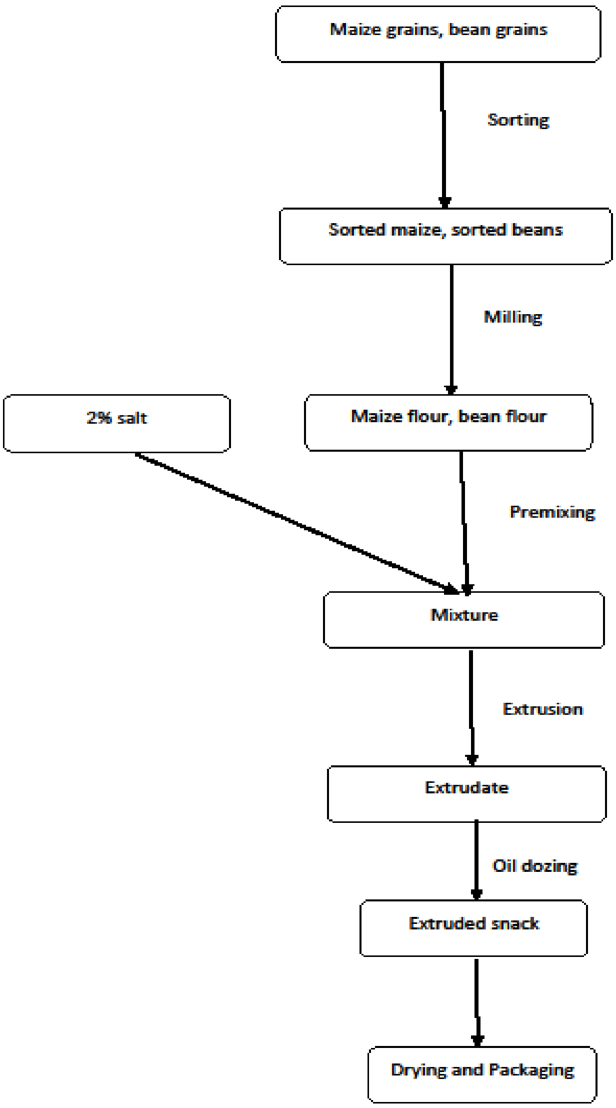

Figure 12. Flow chart indicating of the development of extruded snacks.

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4. Conclusion and next steps

The recipes and process conditions given here on the food prototypes will be used for assessing the life cycle of the products. Recipes and prototype product processes generate the basic mass flow information for ingredients to be fed into the LCA models. Both the mass flow information as well as information on process energy demand are combined in the LCA models and connected with environmental impact profiles for ingredient production and e.g. provision of process energy. Consequently, a full LCA model of the prototypes can be developed, thus environmental impact profiles of the food prototypes can be generated that cover the complete life cycle, starting from crop cultivation up to the finished innovative food prototype. This will give valuable information about the products and the production. This will furthermore allow the products to be further assessed in terms of their sustainability and environmental impact. Furthermore, environmental impact profiles of the new innovative products can be compared with each other, as well as against pre-existing traditional products, which can allow a selection of products/processes with lower environmental impact. Related full environmental impact profiles of food prototypes are documented in section 3 of Deliverable D5.3.

5. Delays and difficulties

Since the tasks on some of the prototypes are still ongoing, some recipes might not yet be in their most optimized version. It is, therefore, likely that further improvement of the recipes and processing conditions could take place and continue to be discovered throughout the project. However, the results given in this study are expected to give further input, if necessary, on how and what to improve in the prototypes.

6. Impact and outreach

The data on recipes and processing conditions discovered in this study are vital for the LCA to be carried out in the WP5. The data collected here form a high quality basis for environmental sustainability assessment. Based on those grounds, robust and realistic environmental impact profiles can be generated for the prototype products. Those in turn also enable comparative assessments on environmental sustainability for innovative food prototypes versus traditional, especially animal-based, food products. The results on sustainability and environmental impact will, therefore, add value to the innovative food prototypes and is increasing the understanding of their impact and importance, especially when compared to the pre-existing animal-based products.

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