Training course packages targeting food operators on the adoption and management of the technological innovations

EXTRUSION AND BAKING

Extrusion and baking to produce nutrient enriched food products using locally produced novel ingredients

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1. FoodLAND technical innovation for local food supply chains: concepts and approaches

The FoodLAND project has the ambition to impact on a large number of supply chains and communities, hence the process of food operators' capacity development has to be tailored and as much participative as possible. Accordingly, one of the assumptions of FoodLAND is that sustainable and nutrition-responsive farming systems can be achieved basically by strengthening the capacity development, and specifically by **a)** empowering farmers and processors through the implementation of capacity building processes and concrete opportunities; **b)** creating or consolidating cooperation and shared knowledge to overcome the lack of coordination among food operators; **c)** addressing the inefficient use of resources; **d)** trying to address and build resiliency to the high vulnerability of food systems to climate change; **e)** enhancing the integration of supply chains by creating commercial and stakeholders' networks; **f)** improving the responsiveness of the production sector to the market demand.

To implement these elements of capacity development, FoodLAND proposed the adoption of specific innovations, among which the organizational ones, to create strong and responsive links between producers and encompassing all the intermediate actors along the food value chain, such as researchers, SMEs, NGOs, local and national authorities. In order to ease the creation of those links and guarantee the sustainability over time of the results, 14 Food Hubs will be created in 6 countries as part of the organizational innovations. Food Hubs are conceived as multi-actors centers of innovation where to develop or enhance the organizational and operational conditions enabling local food supply chains (D3.6).

Functional to the implementation of the Food Hubs and of the innovations, the training courses were designed – in form of capacity development activities – as a two-phase process. Firstly, a training session focused on general, preparatory

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topics was provided to farmers as described and reported in D3.5 ("Group Introductory Training", GIT). According to the project GA, GIT broad set of goals were: to enhance the knowledge of consumers' nutritional needs and market opportunities, and to boost the notions about climate change, sustainability, resilience, and food culture. Secondly, a specific training session were organized to provide food operators with practical information on the adoption and management of the innovations tested at lab / small scale level and to contribute to validating them at appropriate scale.

However, as the whole approach has been designed by FoodLAND to ensure the inclusion of the local actors from the first moment, both the training sessions were set up accordingly. Indeed, yet in the inception phase of the project, an assessment on participatory methods has been run and Participatory Learning and Action (PLA) approach has been eventually assessed as the best one to ensure the inclusion of multiple perspectives. The main purpose of PLA is to support people within communities to analyze their own situation, rather than have it analyzed by outsiders, and to ensure that any learning is then translated into action (Gosling and Edwards 2003). In addition, a gender-sensitive approach has been applied to the trainings that have been designed considering gender roles and power relations; they have provided equal opportunities to participate in the process by caring to times, venues and use of local languages.

The GITs have been conceived as the first step towards the innovation validation and aim at involving the producers, yet from the inception phase. They are just the first step in a sequence of 6, summed up in **Table 1**. After the GITs, where farmers and processors meet and share their vision and goals for the Food Hubs and exchange information about specific topics, the Food Hubs were created and the innovation tested (first in pre-test, then in pilot phase). The constant iteration between researchers and local actors is a key feature of the project: specifically, the practical trainings focused the single innovations (step 5) are aimed at validating the innovations at adequate scale and planned to trigger feedback loops of control and improvement involving developers and adopters.

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Table 1. Activities with farmers and food processors (SMEs) and participatory approach

Step	**1**	**2**	**3**	**4**	**5**	**6**
Task	**T3.3**	**T3.3**	**T3.4**	**T4.1¸T4.5**	**T5.1¸T5.5**	**T5.1¸T5.5**
Activity	Group introductory training	Food Hubs creation	Innovation undertaking	Innovation tests	Individual and group practical training	Innovation pilot and validation

2. FoodLAND practical training: aims and scope

According to the project bottom-up and participatory approaches, following the courses on introductory topics GIT organized in the early project phase (T3.3), and as component creating / strengthening the Food Hubs as local innovation centres, FoodLAND has organized a second set of training activities with food operators based on active learning methods and gender equality principle (Task 5.1-5.9). In this regard, specific mechanisms (being aware of the gender roles and power relations; providing equal opportunities to participate in the process by putting attention to the times, venues, use of local languages, etc.) will be lifted to ensure women's participation. These training packages are aimed at providing the local farmers and food processors with operational instructions on the adoption and management of the validated innovations.

This second set of training activities has been organised – triggering PLA approach – as individual and group practical (demonstration/capacity building) activities to be conducted in parallel to the implementation of the technological research (where relevant) and of the innovation pilots and validation. These technology-centred trainings aim at strengthening the participants' understanding of novel production and post-harvest techniques, innovative tools and systems (e.g., climate smart/precision agriculture, hydroponics, and integrated aquaculture), new technologies for primary and secondary processing, and supply chain management. Thus they aim at fostering knowledge and operational

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capacity to deploy, manage, and maintain the validated technological innovations – documented by the released guidelines D4.1 ÷ D4.11 (e.g., training pamphlets, user manuals, flow diagrams, and operational recommendations) and practice abstracts D6.5 – validated jointly at appropriate scale.

3. Second training packages on the adoption and management of the tested innovations: an overview

The second training course aimed at consolidating the food operators' knowledge and practical skills to adopt, manage and validate the project innovations and complement the related guidelines. Specifically, the realized training materials provide local farmers and food operators with a set of notions and concrete information on a series of innovative tools and systems as per the following **Table 2**. It is clear that both the contents and formats of the learning packages widely differ across technologies as well as Food Hubs (when the same type of innovation must be validated in different contexts). The diversity that emerges from the proposed solutions reflects the different needs highlighted by farmers and stakeholders as well as the conditions and opportunities characterizing the local communities. Nevertheless, in order to take into due account the existing heterogeneity inside the local communities, the developed learning materials have been let available on the project intranet so as to be used for further training initiatives across the network of Food Hubs.

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4. Second training packages on practical information on the adoption and management of the tested innovations

Extrusion and baking

Extrusion and baking to produce nutrient enriched food products using locally produced novel ingredients

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Extrusion and baking to produce nutrient enriched food products using locally produced novel ingredients

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Introduction

- Extrusion and baking are conventionally used to process cereals into precooked products
- Increasingly, the range of raw materials to which extrusion and baking are applied is widening, leading to:
  - More diversity
  - Production of more nutritious products
  - Utilisation of local raw materials
- With increased urbanisation, demand for convenient ready to eat foods has increased, creating more demand for extrusion and baking

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Extrusion

- High temperature short time process that entails application of heat and pressure to food materials resulting in cooking, drying, texturising, mixing, puffing, forming, sterilisation, etc.
- Leads to gelatinisation of starch and denaturing of proteins, resulting in change in functional properties and improved digestibility
- Has been shown to denature antinutritional factors, improving nutrient bioavailability
- Destroys pathogens and mycotoxins
- Inactivates enzymes making the products more stable
- Widely applied to cereals but application to legumes also on the increase
- Products include pasta, ready-to-eat cereals, snacks, pet foods, etc

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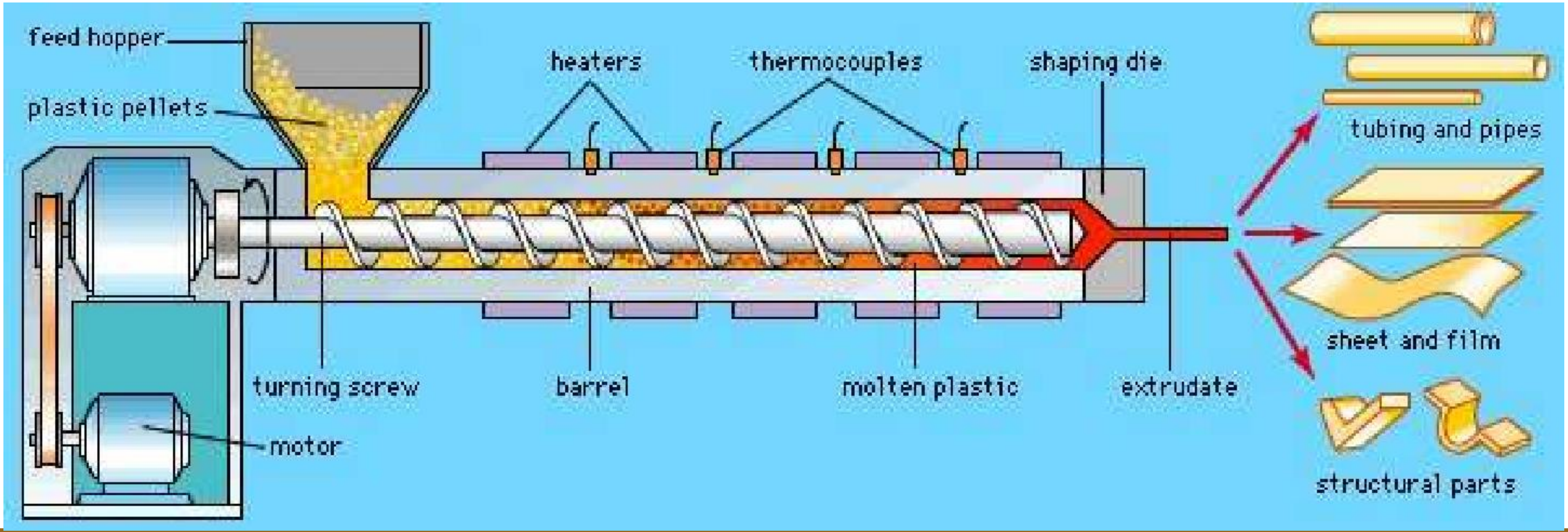
Principles of Extrusion Cooking

- Raw materials fed into the extruder barrel and the screw(s) convey the food forward
- As the food moves in the barrel, it is compressed in the spaces between the screw flights. The the screw movement also kneads the material into a semi-solid, plasticized mass.
- Food in the barrel is also heated by heat generated by heaters attached to the barrel
- High temperature of operation in presence of water promotes gelatinization of starch components and stretching of expandable components
- At the discharge end of the barrel food is forced through one or more restricted
- openings (dies). The pressure difference as the food emerges from the die leads to expansion and rapid cooling



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Examples of products

Types of product	Examples
Cereal-based products	Expanded snackfoods RTE and puffed breakfast cereals Soup and beverage bases, instant drinks Weaning foods Pre-gelatinised and modified starches, dextrins Crispbread and croutons Pasta products Pre-cooked composite flours
Sugar-based products	Chewing gum Liquorice Toffee, caramel, peanut brittle Fruit gums
Protein-based products	Texturised vegetable protein (TVP) Semi-moist and expanded petfoods and animal feeds and protein supplements Sausage products, frankfurters, hot dogs Surimi Caseinates Processed cheese

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Advantages of extrusion cooking technology

- Highly adaptable
- Can be used to produce products of different shapes, texture, appearances, etc
- Energy efficient
- Relatively inexpensive
- Fast
- Compact
- Relatively easy to operate
- Retains heat sensitive food components
- Doesn't produce effluents
- Extruded products are precooked and therefore convenient

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Baking

- Baking: Dry heat treatment which entails cooking of food materials in an oven.
- Used mainly for production of bread, cakes, cookies, and other products, majorly from **wheat**.
  - Other ingredients commonly used in baking include other flours, fat, eggs, sweetner, salt, leavener
  - Gluten, a protein found in wheat is essential for crumb structure of baked products because of it's ability to stretch
  - Gluten free baked products desired for persons with gluten intolerence (celiac disease)
- Baking is a very old food processing technology

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Advantages of baking

1. Simple technology which can suit different levels of expertise and investment
2. Adaptable to different energy sources
3. Can be applied to diverse raw materials and make diverse food products
4. Products are ready to consume
5. It is relatively easy to produce safe baked products
6. Relatively high demand for baked products

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Trends in Baking

- Gluten free products
- Wholesome products
- Diversity
- Nutrient rich products
- Low glycaemic index
- Better organoleptic properties

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Ingredients used for enrichment of products and their prime nutrients

Ingredient	Orange fleshed sweet potatoes	Biofortified beans	Grain amaranth	Underutilised legumes	Fish powder (bones of tilapia and catfish
Nutrients	– Beta Carotene	– Iron – Zinc – Proteins	– Gluten-free grain – Fiber – Protein – Micronutrients (minerals and vitamins)	– Protein – Fiber – Fat – Minerals (Ca, K, Na, P, Fe, Mg)	– Iron – Calcium

Processes of protocol development

Processes of protocol development

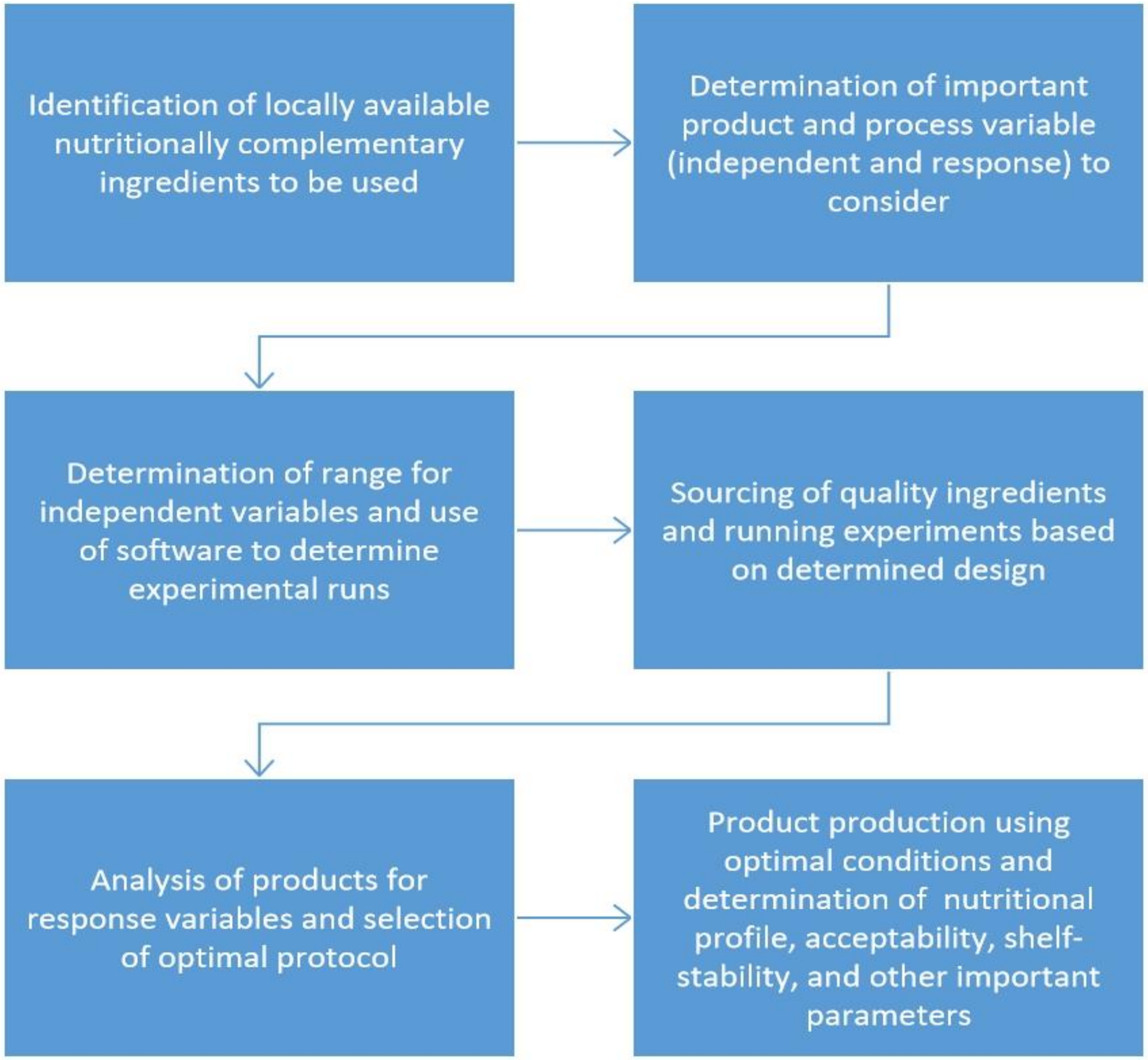


Figure 1. General procedure used in developing protocols for extruded and baked products

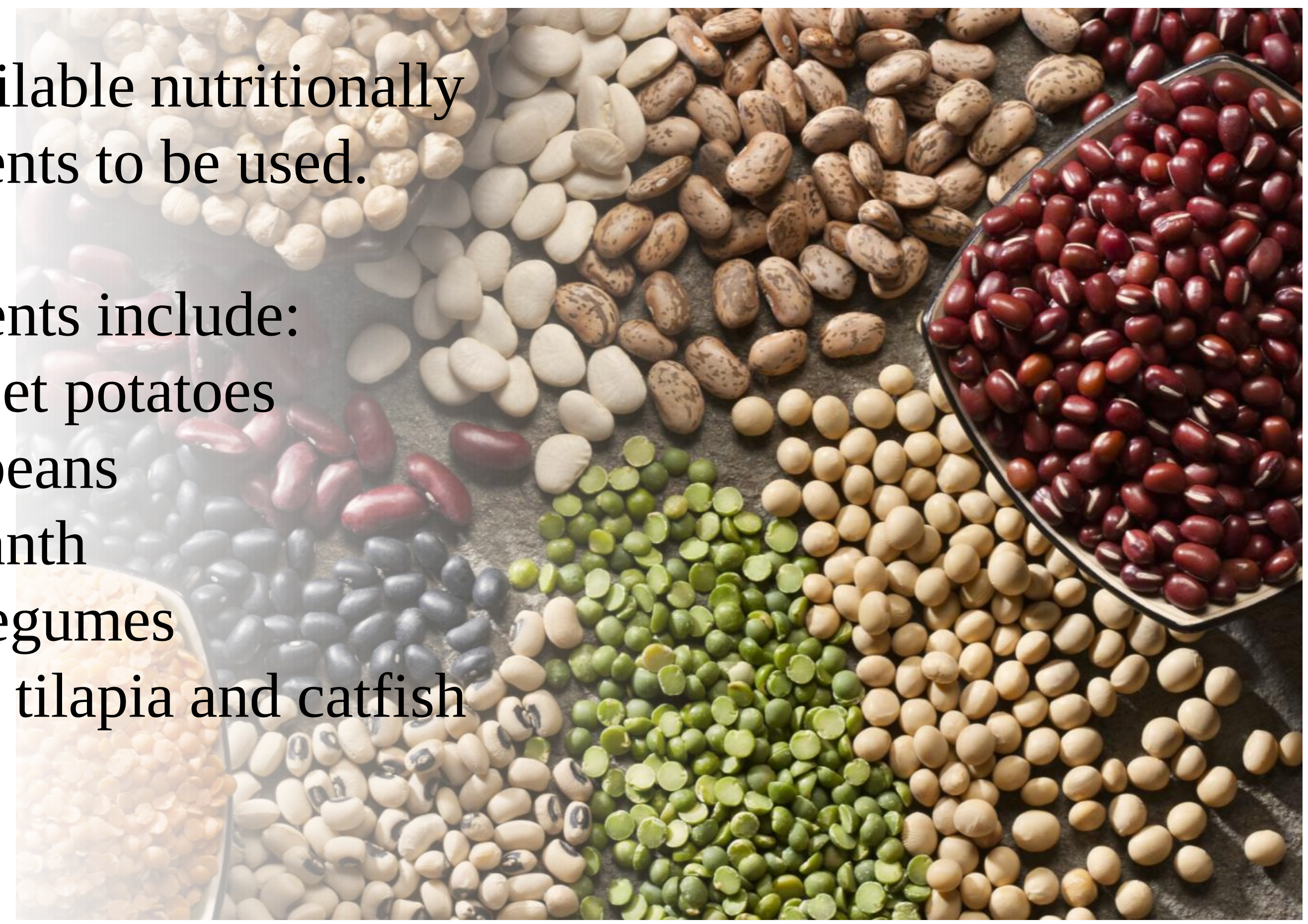
Processes of protocol development

Step 1

Identification of locally available nutritionally complementary ingredients to be used.

E.g. of novel ingredients include:

- Orange fleshed sweet potatoes
- Biofortified beans
- Grain amaranth
- Underutilised legumes
- Fish powder from bones of tilapia and catfish



Processes of protocol development

Step 2

Determination of important product and process variables (independent and response) to consider.

Category	Independent variables	Responses
Selection criteria	- Quality of ingredients - Production process - Equipment used - Personnel and environment - Quality of measurements	- Impact on physico-chemical properties and quality attributes of product
Examples	- % proportion for mixing ingredients - Temperature - Thickness - Processing time	- Nutritional composition - Acceptability - Shelf life

Processes of protocol development

Step 3

Determination of range for independent variables and use of software to determine experimental run

Criteria

- Carry out preliminary trials
- Base on already existing literature
- Use of product formulation software e.g., Design Expert Version 13 Software

Step 4

Sourcing of quality ingredients and running experiments based on determined design

Criteria

- Selection of high-quality ingredients
- Set up and carry out the experiment

Flow chart _Processing of quality ingredients into products

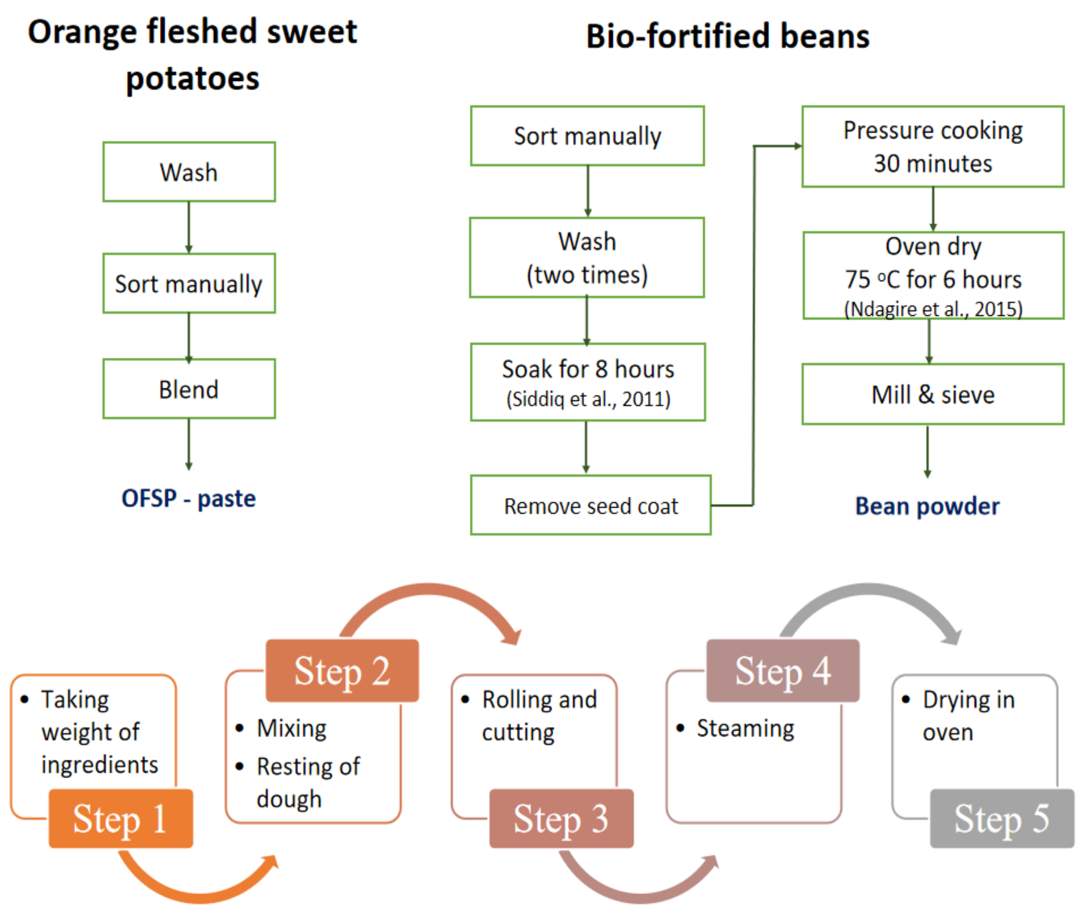


Figure 2: Procedure followed in production of noodles from orange fleshed sweet potatoes and other ingredients

Figure 3. Preparation of extruded fish bone-maize snack

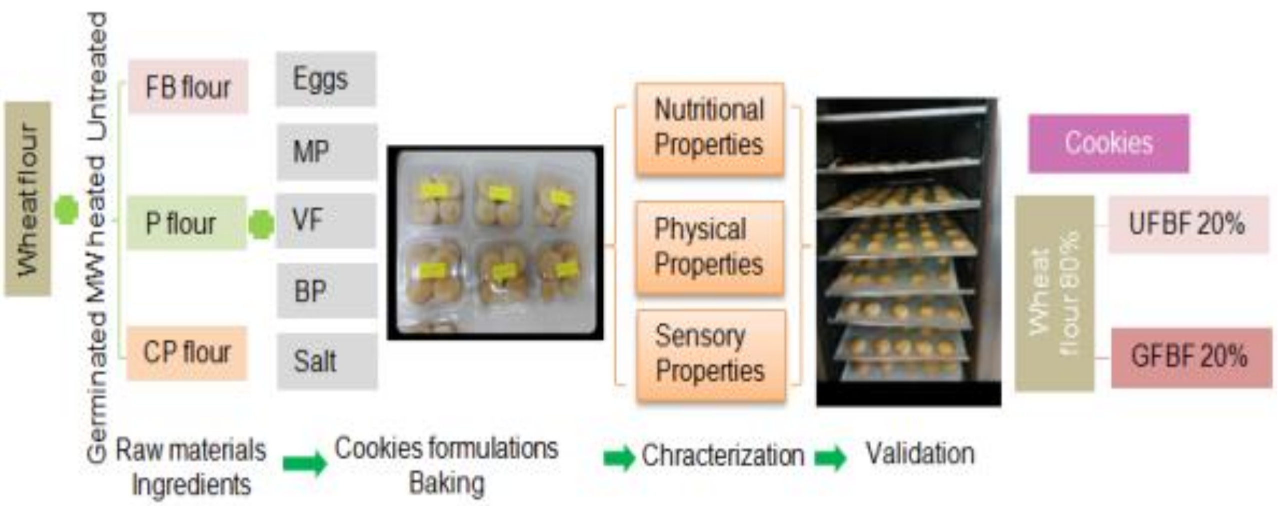


Figure 4. Process for making and evaluation of cookies based on wheat legumes composite flour (FB: faba bean; P: Pea; CP: chickpea; MP: milk powder; VF: vegetable fat; BP: baking powder; UFBF: untreated faba bean flour and GFBF: germinated faba bean flour)

Final products

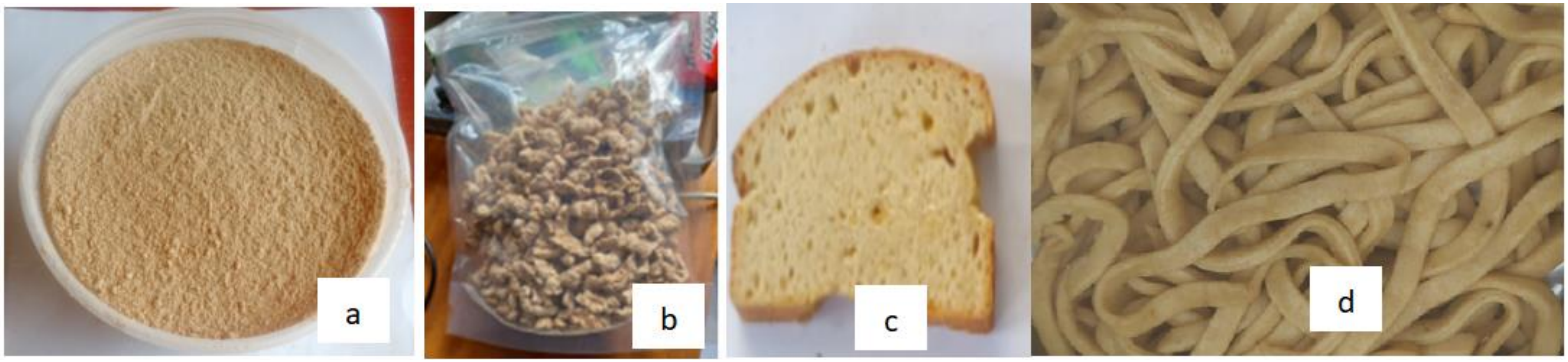


Figure 4: Photos of products produced using extrusion or baking of composites - a: OFSP-based extruded composite flour; b: Fish bone - maize extruded snack; c: Composite bread; d: Composite noodles

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Processes of protocol development

Step 5

Analysis of products for response variables and selection of optimal protocol

Criteria

- Based on official methods of analysis in literature
- Optimisation using response surface methodology in Design Expert software

Step 6

Product production using optimal conditions and determination of nutritional profile, acceptability, shelf stability, and other important parameters

Criteria

- Based on official methods of analysis in literature

Examples of nutrient enriched food products produced using extrusion and baking

Nutrient enriched food products developed

1. Extruded composite flour

Ingredients: Cereals (maize and millet), legumes (biofortified common beans and soya beans) and oil seeds (sesame seeds)

Processing method: Extrusion using a Twin screw extruder

Processing conditions: Barrel temperature for zone 1 (94 – 97 °C) and zone 2 (102 – 110 °C); screw speed (300 rpm) and feed moisture content (13 – 15 % wb)

2. Enriched noodles

Ingredients: Orange fleshed sweet potatoes, biofortified beans and wheat flour and other ingredients

Design of experiment: Mixture design of Design Expert software version 13

Processing conditions: Thickness, drying temperature and time

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Nutrient enriched food products developed

3. **Extruded fish bone-maize snack**

Ingredients: Bones of tilapia and catfish; maize grits and other ingredients
Processing method: Extrusion using a single screw extruder
Processing conditions:
50 - 160 °C, screw speed - 1450 rpm and cutting speed 350 rpm.

4. **Extruded biofortified beans**

Biofortified beans extruded at frequency of 30 Hz, cutting frequency of 50 Hz, and barrel temperatures of 60° C, 130° C, and 150° C in first, second, and third zones, respectively and milled into precooked flour suitable for making sauce

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Nutrient enriched food products developed

5. Baked products (bread and buns)

Ingredients: Wheat flour, orange fleshed sweet potatoes, biofortified beans, grain amaranth and other ingredients

Design of experiment: Mixture design of Design Expert software version 13

Processing conditions: Ingredients, baking temperature and time

6. Nutrient-enhanced cookies

Composite flour formulations using wheat (90, 85 and 80%) and untreated microwave heated and germinated legumes (faba bean, pea and chickpea) added at mixture levels of 10, 15 and 20%. The supplemented ingredients were eggs, vegetable fat, sugar, milk powder, salt and baking powder.

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Products analysis and results

Products analysis and results

Product	Parameter and analysis
Composite flour based on orange fleshed sweet potatoes	– Protein content, Beta carotene, Zinc and Iron – Paste final viscosity (RVA 4500, Perten Instruments, Hägersten, Sweden)
Composite flours based on cereals	– Proximate analysis (moisture, crude protein, crude fibers, ash, and carbohydrates) and Total phenols – Physical properties: bulk density (BD), water absorption index (WAI), water solubility index (WSI), oil absorption and angle of repose
Noodles	– Moisture, protein, dietary fibre, Carotenoids, Iron and Zinc content and Hardness
Extruded fish bone-maize snack	– Sensory evaluation and product acceptability

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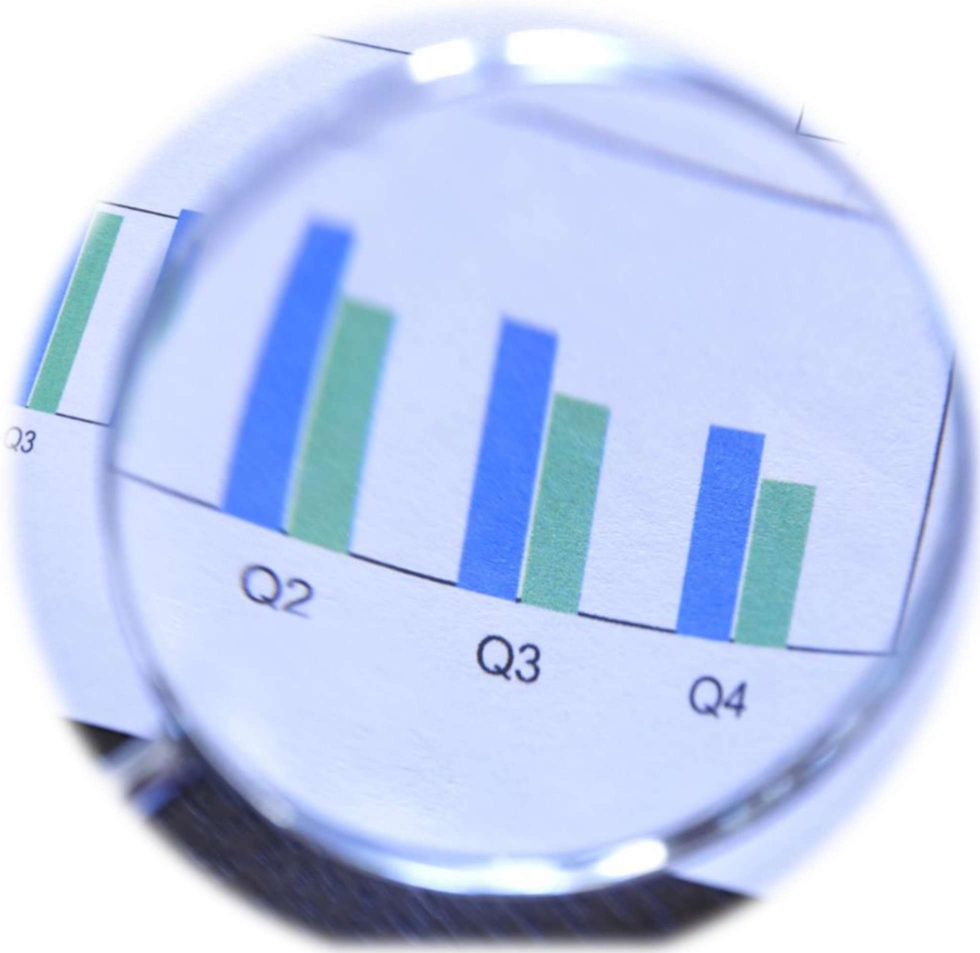
Products analysis and results

Results

❖Analysis of the products developed show that they are rich in proteins, iron, zinc, phytochemicals.

❖The products are generally acceptable by consumers.



Properties of supplemented extruded and baked

- Supplemented extruded and baked products are markedly higher in:
  - Proteins
  - Fibre
  - Phytochemicals
  - Micronutrients
- Products generally acceptable by sensory panelists
- Porridges made from extruded flours exhibit lower viscosity that raw ones and therefore make nutrient-dense gruels

Thank you !

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