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

BIO-BASED PACKAGING

Wheat straw cellulose nanocrystal-based film material

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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

Bio-based packaging

Wheat straw cellulose nanocrystal-based film material

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Bio-based packaging: wheat straw fibres cellulose nanocrystals-based film

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SELECTION OF LOCAL RAW MATERIALS

Four agricultural wastes/by-products collected from local agricultural companies in the **region of Jendouba (TN)** were investigated:

- pea hulls (**a**)
- **artichoke by-products** (**b**)
- olive tree by-product (**c**)
- **wheat straw fibres** (**d**).

After assessing moisture, cellulose, hemicellulose and lignin contents, **wheat straw fibres (WSFs)** were selected for the extraction of cellulose useful for making **cellulose nanocrystals (CNCs)** by acid hydrolysis: as they are characterised by **the lowest moisture content (~10%)** and **the highest cellulose content (~22.50%)**.

artichoke by-products used to obtain an **antioxidant extract**.

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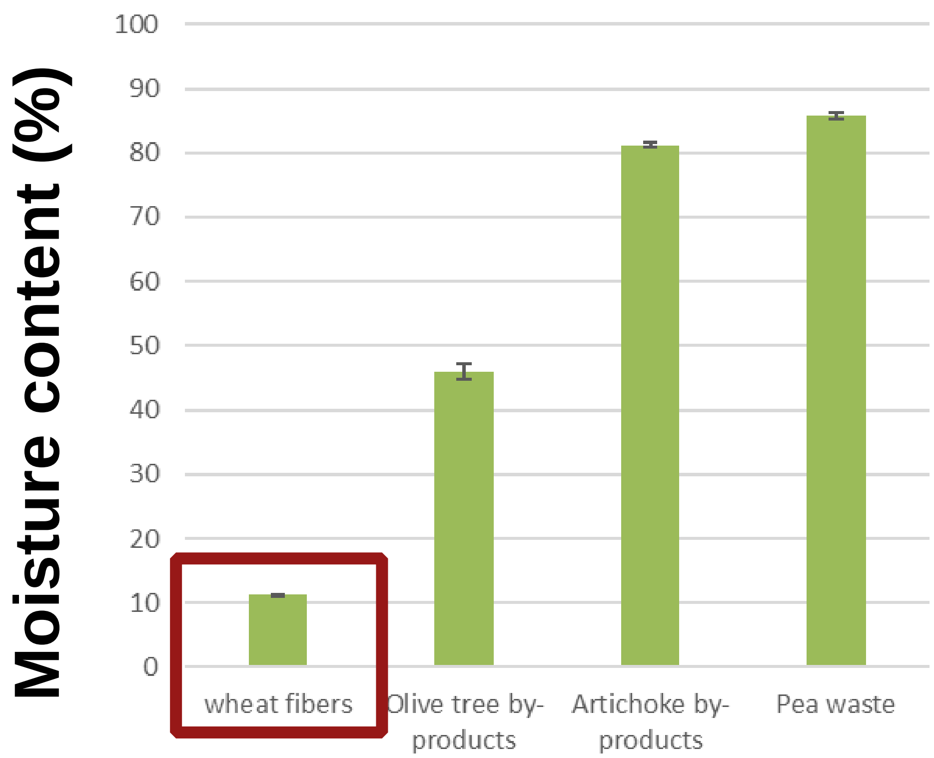
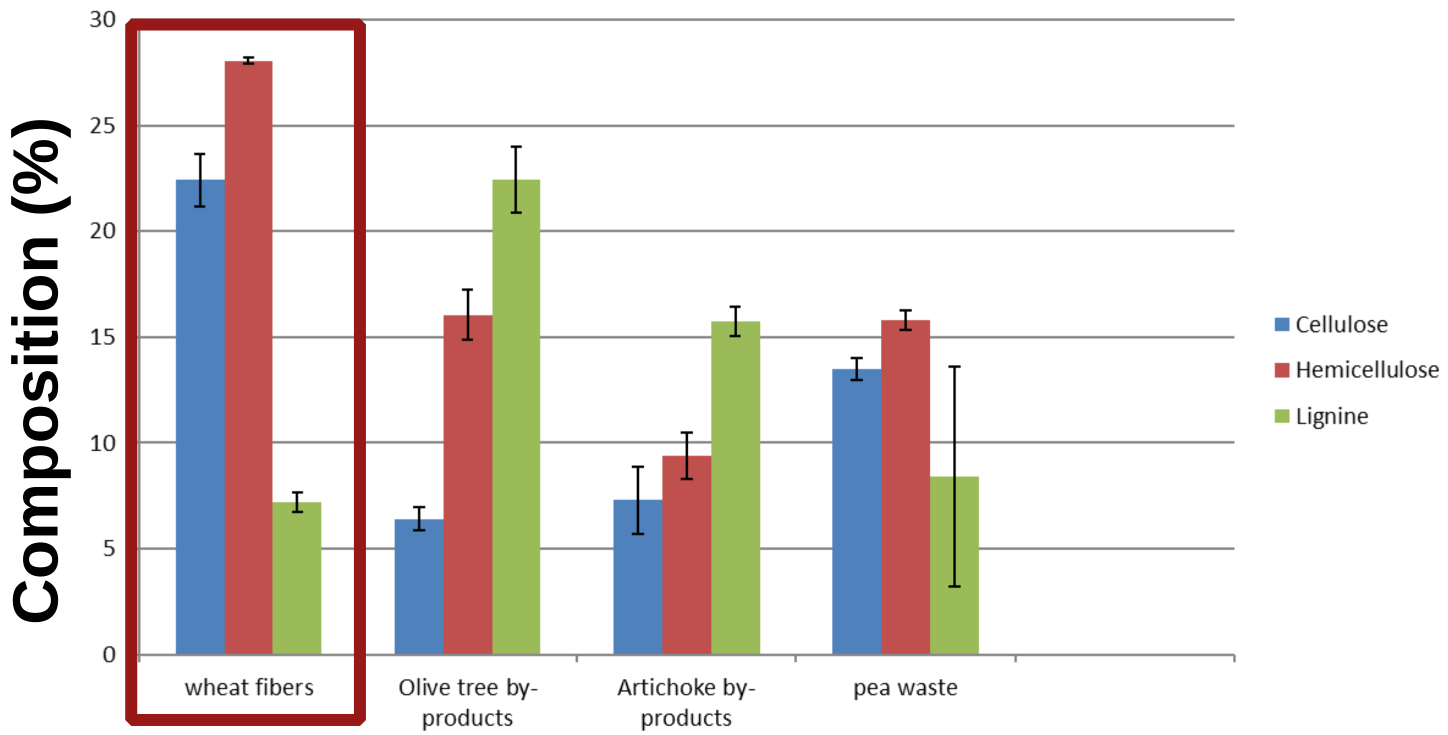
CHARACTERISATION OF WSFs

Operative procedure for **WSFs washing and characterization**:

- Clean the raw WSFs under running tap water and soak it in distilled water for 1 h
- Dry the cleaned raw material in an oven at 40 °C to evaporate the distilled water
- Crush and sieve through a 0.280 mm mesh sieve to obtain a fine powder
- Moisture content according to AOAC 1990 (925.10)
- Cellulose, hemicellulose and lignin contents of the powder following the methods of detergents according to Goering and Van Soest (1970).





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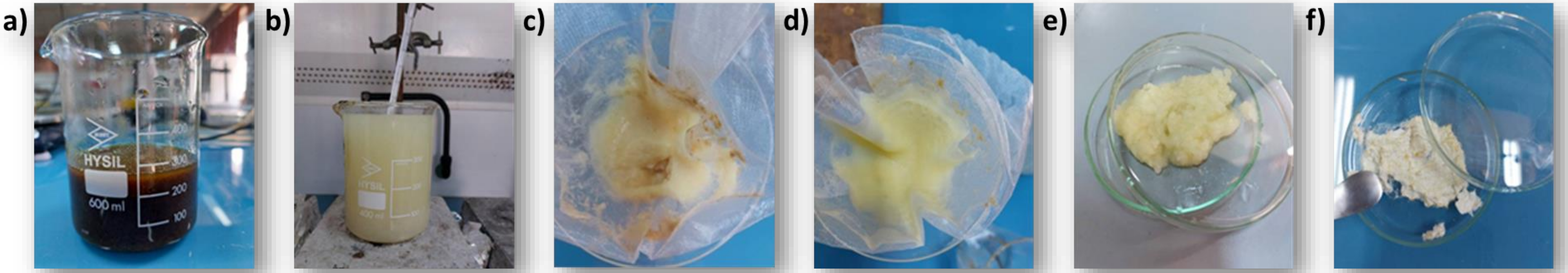
EXTRACTION OF CELLULOSE FROM WSFs

Operative procedure for the **extraction of cellulose from WSFs by chemical method** (El Achaby et al., 2018):

- Treat ground fine powder of WSFs in distilled water for 1 h at 60 °C
- Treat three times with 4% (w/w) of NaOH solution at 80 °C for 2 h under stirring (**a**)
- Treat the resulted alkali WSFs three times by bleaching using a solution made up of equal parts (v/v) of 27 g NaOH and 75 mL glacial acetic acid diluted to 1 L of distilled water and of aqueous $NaClO_2$ (1.7%, w/w, in water) (**b**, **c**, **d**, **e**)
- In all previous treatments the ratio of the WSFs to liquor was 1/20 (g/mL)
- Dry the resulting white cellulose extract in an oven at 40 °C for about 24 h (**f**)
- Calculate cellulose extraction yield (Yield % = (m/M)·100), where m: mass of cellulose extracted and M: mass of raw WSFs used.



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PRODUCTION OF CELLULOSE NANOCRYSTALS (CNCs)

Operative procedure to obtain **cellulose nanocrystals (CNCs) from WSFs cellulose** by acid hydrolysis (El Achaby et al., 2018):

- Treat WSFs cellulose with 64% (w/w) sulphuric acid (H_2SO_4) (pre-heated) at 45 °C for 45 min under mechanical stirring
- Stop the acid hydrolysis by adding cold distilled water (ice cubes) into hydrolysed solution
- Centrifuge three time at 9500 rpm and 10 °C for 10 min to remove the excess of sulphuric acid resulting in white CNCs suspension
- Subject the white CNCs suspension to a dialysis process against distilled water at 4 °C for 72 h to reach a neutral pH
- Homogenize the CNCs with ultrasonic homogenizer and store the resulting CNCs suspension in the refrigerator until its use.

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EXTRACTION OF ANTIOXIDANTS FROM ARTICHOKE

Operative procedure to obtain **antioxidants-rich extract from artichoke by-products** by methanol maceration:

- Clean the inedible plant parts of artichoke under running tap water and then soak it in distilled water for 1 h and dry at 37 °C
- Crush and sieve through a 0.280 mm mesh sieve to obtain a fine powder
- Plant extracts were obtained by maceration in methanol 80%
- After filtration, the extract was transferred to vials and stored in the dark at 4 °C until use.

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BIO-BASED FILM PREPARATION

<u>Operative procedure</u> for the preparation of **wheat straw cellulose-based film** material:

- Preparation of a “master-batch” (4 kg) in the form of granules consisting of:
  - 5% TPS (thermoplastic starch, consisting of 70% starch and 30% glycerol),
  - 58% PBAT (polybutylene adipate terephthalate),
  - 3% PBAT grafted maleic anhydride,
  - 4% CNCs obtained from wheat straw fibres and 10 mL artichoke extract by a twin-screw extrusion process (**a**).
- Production of a thin film by blown extrusion (**b**) from the «master-batch» using a temperature of 110 °C.

a)

b)

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MATERIAL CHARACTERISATION

- Thickness (µm)
- Moisture (%)
- Water solubility (%)
- Biodegradability (%)
- Elongation (%)
- Tensile strength (MPa)
- Tear resistance (N)
- Coefficient of friction (static and dynamic)
- Water Vapor Transmission Rate - WVTR (g/m^2 x day)
- …..
- …..

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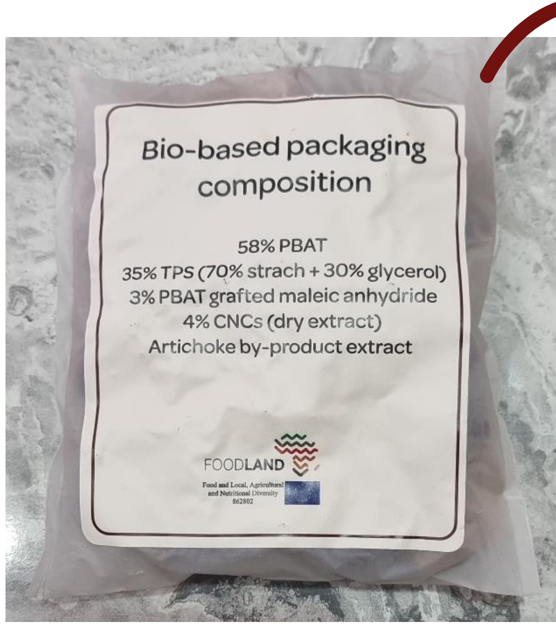
FOOD PACKAGING APPLICATIONS

Examples of foods packaged with the bio-based film that were tested by the INAT team during the shelf life studies:



Dried product

Sealing

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USEFUL REFERENCES

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- **El Achaby M., Kassab Z., Barakat A., Aboulkas A. (2018)**. Alfa fibers as viable sustainable source for cellulose nanocrystals extraction: Application for improving the tensile properties of biopolymer nanocomposite films. Industrial Crops & Products, 112, 499–510.
- **Goering H. K., Van Soest P. J. (1970)**. Forage fiber analysis (apparatus, reagents, procedures and some applications). Agricultural hand book, 379, 1737–41.

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