medacornet

Rescuing acorns as a Mediterranean traditional superfood

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INTERNATIONAL CONFERENCE ON SUSTAINABLE FOODS
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المملكة المغربية وزارة التعليم العالي و البحث العلمي و الإبتكار
CDTI Centro para el Desarrollo Tecnológico Industrial

Systematic problem

Long market chains

- High CO_2 footprint
- No food sovereignty in EU
- High costs

Environmental crisis

- Climatic urgency
- 80% deforestation
- Wildfires high frequency

Food emergency

- 16,6% world population undernourished
- ≈37% of human-induced GHG emissions

Mediterranean oak forests

Quercus suber L., Q. rotundifolia L., Q. ilex L., Q. robur L., Q. cerris L., Q. petraea L., Q. pubescens L., Q. ithaburensis L, etc.

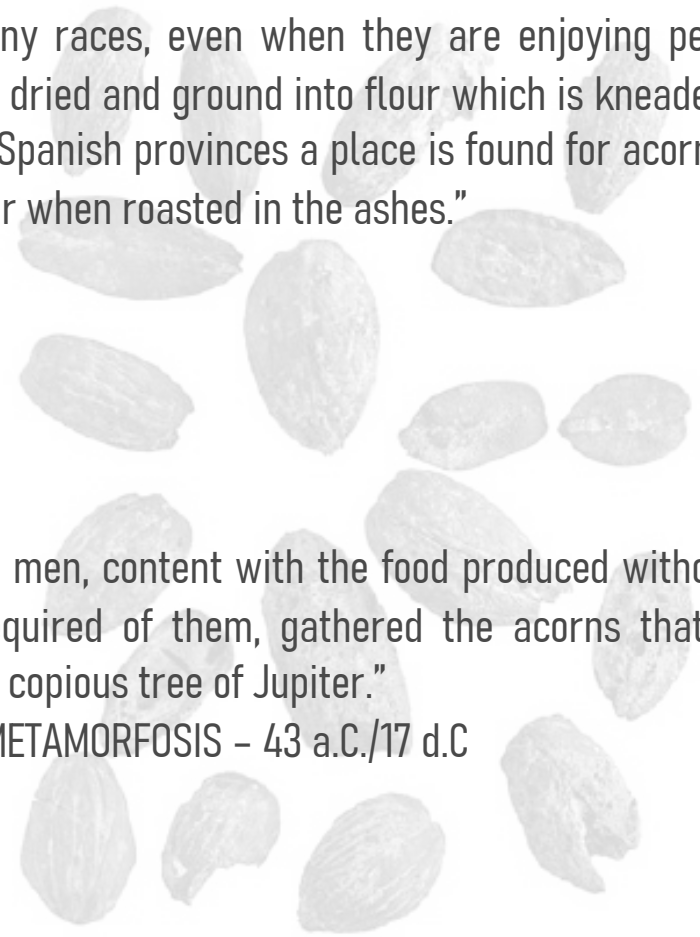
- About 30% of the Mediterranean basin area.
- Responsible for carbon fixation.
- Resilient to climatic changes.
- Produce 250-1600 Kg acorn/ha/year

Acorns - food from forests

"Acorns at this very day constitute the wealth of many races, even when they are enjoying peace. Moreover also when there is a scarcity of corn they are dried and ground into flour which is kneaded to make bread; beside this, at the present day also in the Spanish provinces a place is found for acorns in the second course at table. Acorns have a sweeter flavor when roasted in the ashes."
PLINY THE ELDER, NATURAL HISTORY, 12-37

"For two-thirds of the year the mountaineers feed on the acorn, which they dry, bruise, and afterwards grind and make into a kind of bread, which may be stored up for a long period."
STRABO, GEOGRAPHY, BOOK III, CHAPTER III

"And the men, content with the food produced without anything being required of them, gathered the acorns that had fallen from the copious tree of Jupiter."
OVIDIO, METAMORFOSIS – 43 a.C./17 d.C



Bellorce, et al. 2009 - Bronze age charred acorns

The opportunity

A FOOD FROM THE PAST TO THE FUTURE

... aligned with market demands

Sustainable Production

Without use of watering, fertilizers or phytochemicals.

Reduced Carbon Footprint

"Forest2Fork" short supply chains, from carbon-fixing forests

Healthy Food

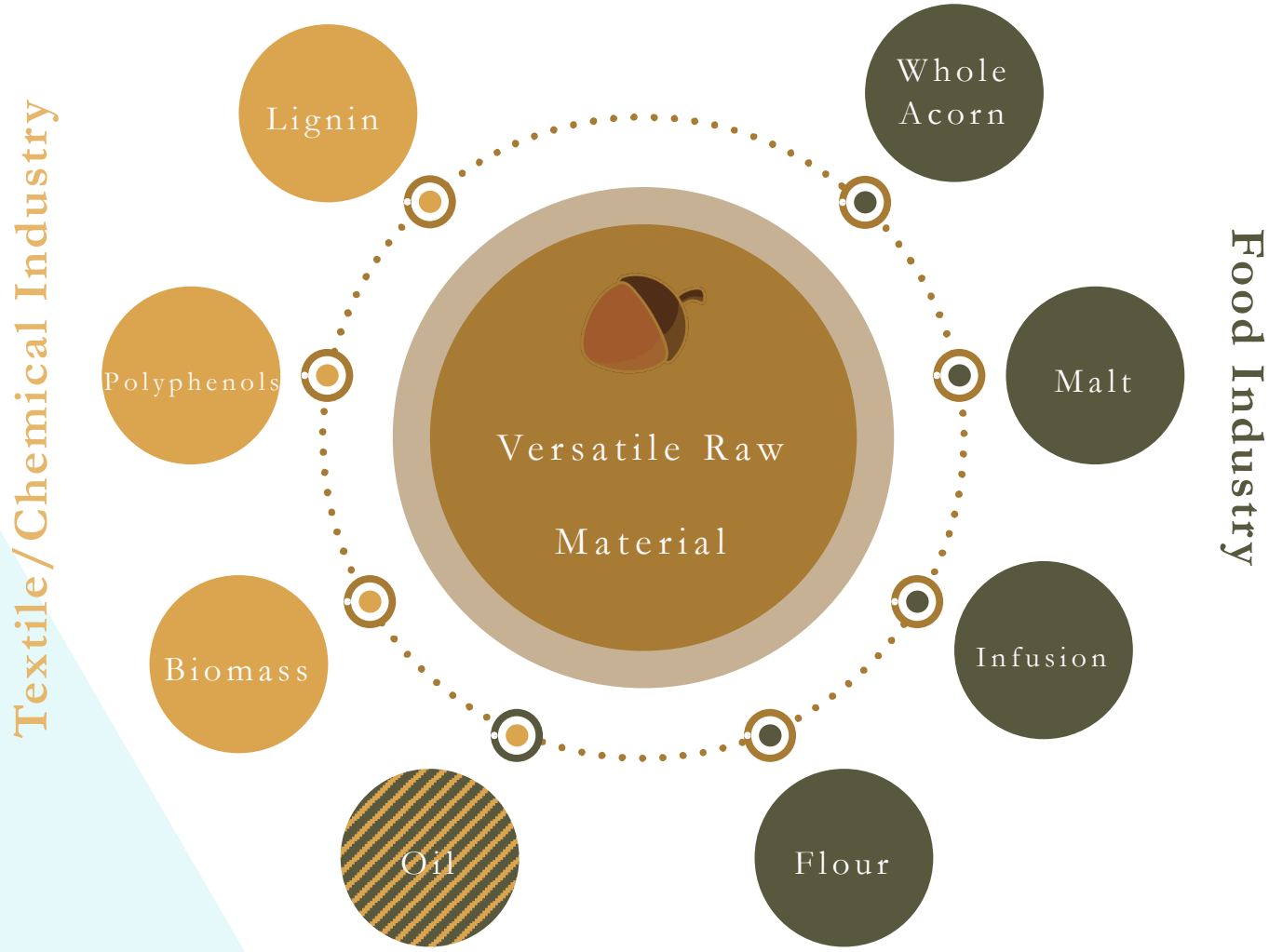
Nutritious food with nutraceutical properties.

Tasty and Versatile Ingredient

87.5% consumers of food and drinks with acorns satisfied.*

*Survey carried out in 2021 to 231 consumers of 8 nationalities spread across 4 countries.

Versatile resource

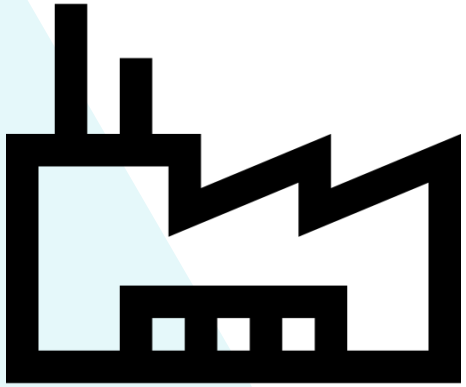


Acorn value chain

HARVESTING

INSIGNIFICANT; MOSTLY MANUAL

PROCESSING



ARTISIANAL PRODUCTION

DISTRIBUTION

LACK OF MARKET CHANELS

FINAL CONSUMER

UNAWARE OF ACORN'S POTENTIAL

Regulatory issues

Quercus rotundifolia Lam. Clear

Common Names

Bolota de Azinheira (PT), Sweet acorn (EN)

Description

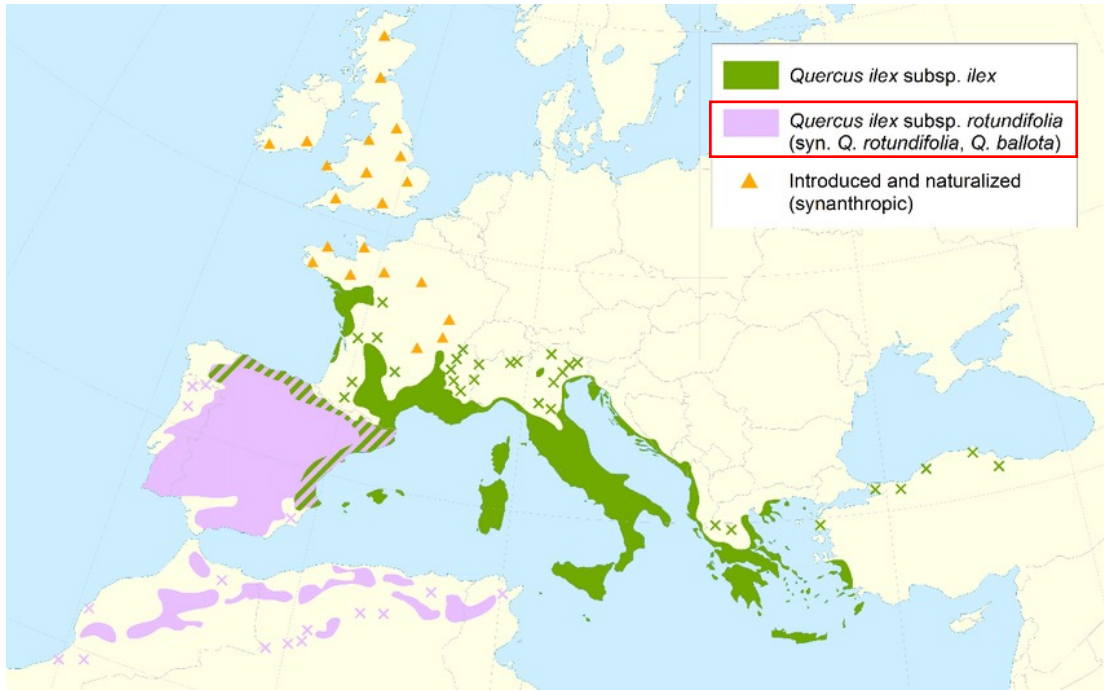
The entry concerns the use of the fruit (acorn) of *Quercus rotundifolia* Lam. It belongs to the plant family *Fagaceae*.

STATUS

- **Fruit (acorn)**

NOT NOVEL IN FOOD - According to the information available to the Member States' competent authorities, this product was used for human consumption to a significant degree within the Union before 15 May 1997. Thus, it is not considered to be 'novel' according to the provisions of the Novel Food Regulation (EU) 2015/2283 and its access to the market is not subject to the pre-market authorisation in accordance with Regulation (EU) 2015/2283.

However, other legislation may restrict the placing on the market of this product as a food in the EU or in some Member States. Therefore, it is recommended to check with the competent authority(ies) of the Member State(s).



Beck PSA, et al. 2020

Our solution

MEDiterranean

ACORn

NETwork

medacornet

Rescuing acorns as a Mediterranean traditional superfood

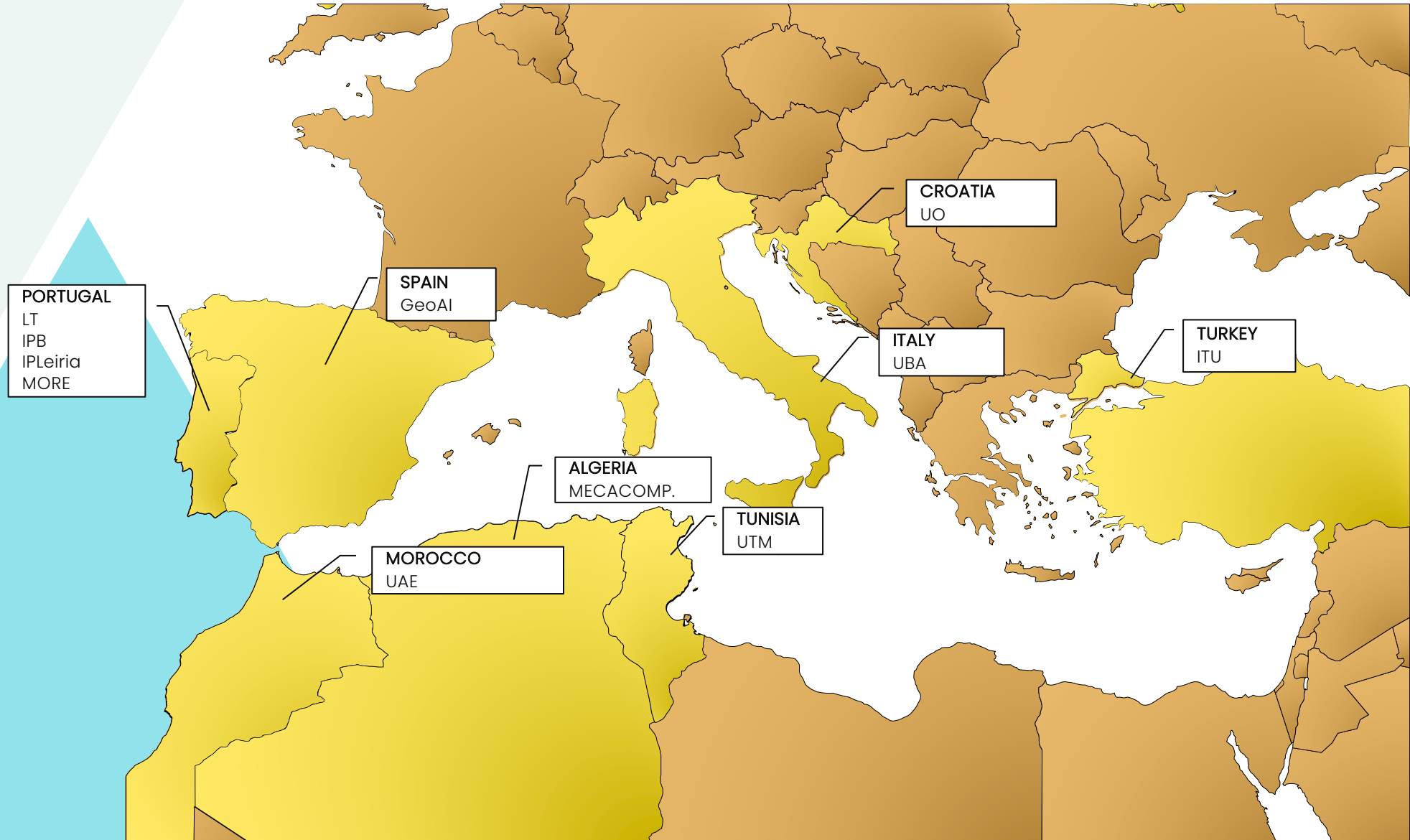
Our solution

The MEDACORNET project aims to ***enhance the adherence to the Mediterranean diet****, through the development of* ***new products based on acorn****, as a Mediterranean historical superfood, while* ***promoting the actors*** *involved in its production and transformation.*

Who are we?

11 Partners

8 Countries



What do we aim for?

- **SO1** Assessment of oak forest distribution in the Mediterranean basin, as well as value chain and stakeholder mapping
- **SO2** Rescue of traditional/historical uses of acorns for human consumption
- **SO3** Characterization of the nutritional profile of acorns from the most relevant Mediterranean-native Quercus spp.
- **SO4** Design of a pilot line capable of producing edible flour from acorns of different species

What do we aim for?

- **SO5** Development of novel acorn-based gluten-free, healthy food products
- **SO6** Evaluation of health benefits such as prebiotic and antioxidant effects of acorns of low carbon footprint
- **SO7** Exploration of the residues of acorn processing to improve the sustainability of the transformation process
- **SO8** Development of a targeted and efficient communication strategy to raise stakeholders' awareness on acorn potential as superfood

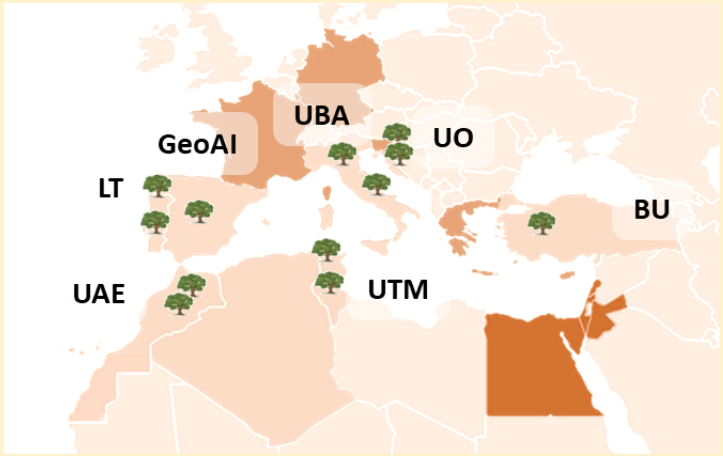
What do we aim for?

- SO9 Reduction of acorn value chain fragmentation by creating a digital marketplace
- SO10 Assessment of the socioeconomic and environmental impacts of revamping the Mediterranean acorn value chain
- SO11 Development of dietary guidelines and promotion strategies to foster the adoption of acorns as sustainable and healthy ingredient for the Mediterranean diet

How will we achieve?

Stage 1

Survey of acorn production and value chain from the Mediterranean region



Mapped value chain

Stage 2

Optimizing the acorn transformation process to produce, pack, store and preserve edible acorn granulate/flour

Acorns

LT, IPB, UBA, IPLeiria, MECACOMP

High quality raw materials

Flour/ granulate

Stage 3

Biochemical, nutritional, morphological and functional characterization of acorn and derived flour/granulate

Acorn	Partner
Nutritional	IPLeiria, IPB, UBA, UO, UTM
Morphological	UO, UTM

Flour/ granulate	Partner
Nutritional	IPLeiria, IPB, UBA, UO, UTM
Morphological	UO
Techno-funciontal	UBA, UO
Safety	LT, IPB, UTM

Flour/ granulate By-products

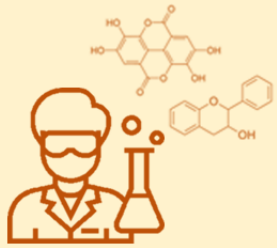
Nutricional/ nutraceutic value

Stage 4

Production of novel acorn-based food products and valorization of processing by-products

Prototypes

IPLeiria, UBA, UO



IPB, UTM

Stage 5

Designing and implementing efficient communication and dissemination strategies to foster the adoption of acorns as a sustainable and healthy Mediterranean food, including an exploitation plan

MORE, GeoAI, BU

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KICK-OFF MEETING

Work Package 1

Survey and collection of acorns from the Mediterranean region

Review of practices associated with the acorn cycle for human consumption in Mediterranean basin

Online survey - 165 responses have been gathered:

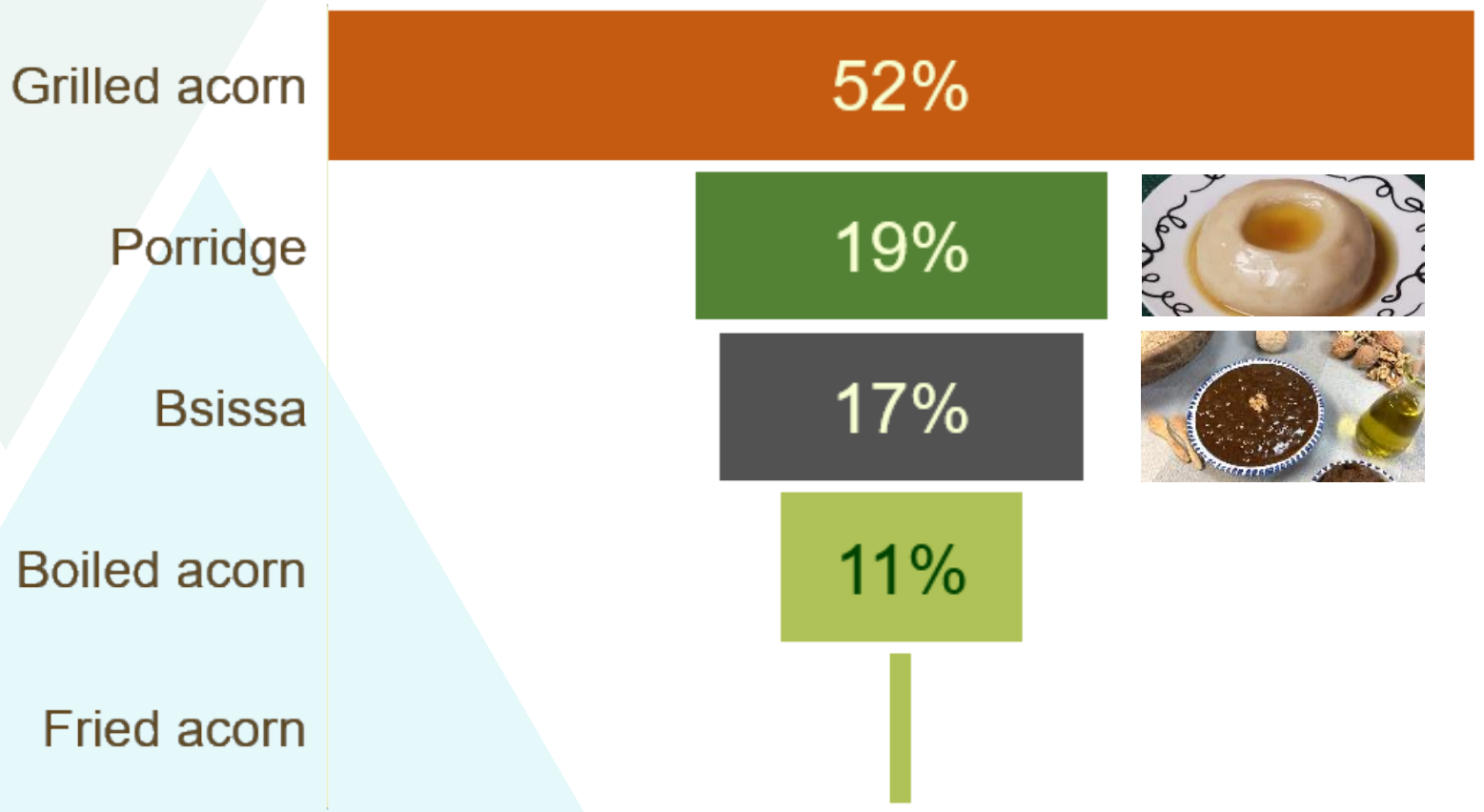
121 (Morocco)
29 (Italy)
9 (Spain)
1 (Portugal)
4 (other)

Face-to-face inquiries

Evidence of use (pre-1990's) as flour, bread and coffee substitute.

Photo credits:
Eleonora Matarrese

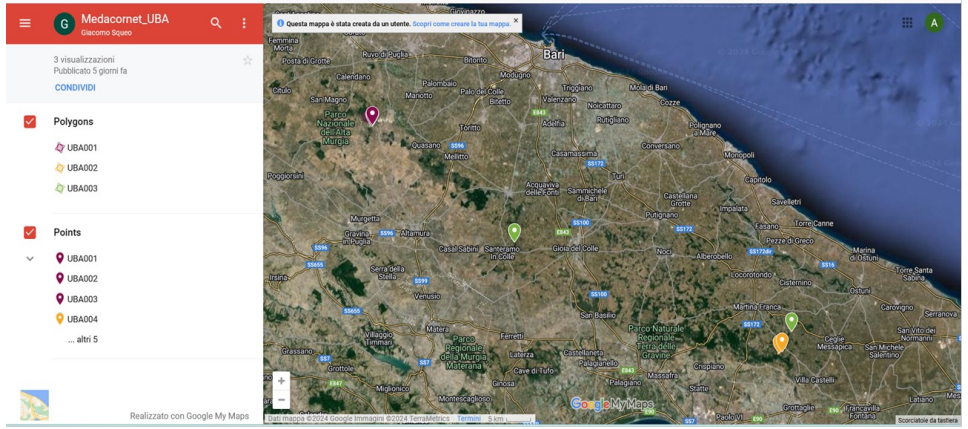
Acorn-based dishes in tunisia



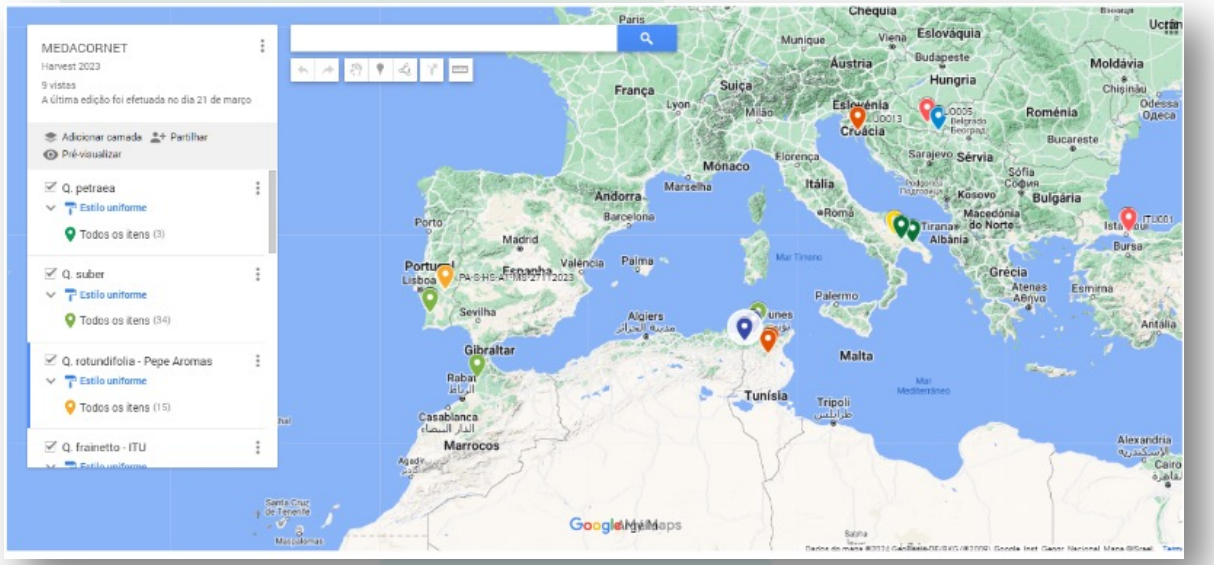
The consumption of these acorns is primarily driven by famine

Inventory of acorn-production forests distribution in the Mediterranean basin and value chain mapping in the region

- Metadata distribution of *Quercus sp.*
- Visual data collected by partners.
- Development of AI Algorithms to identify productive forests and predict productivity and maturation.



Identification of harvesting points and methodology for acorn sampling

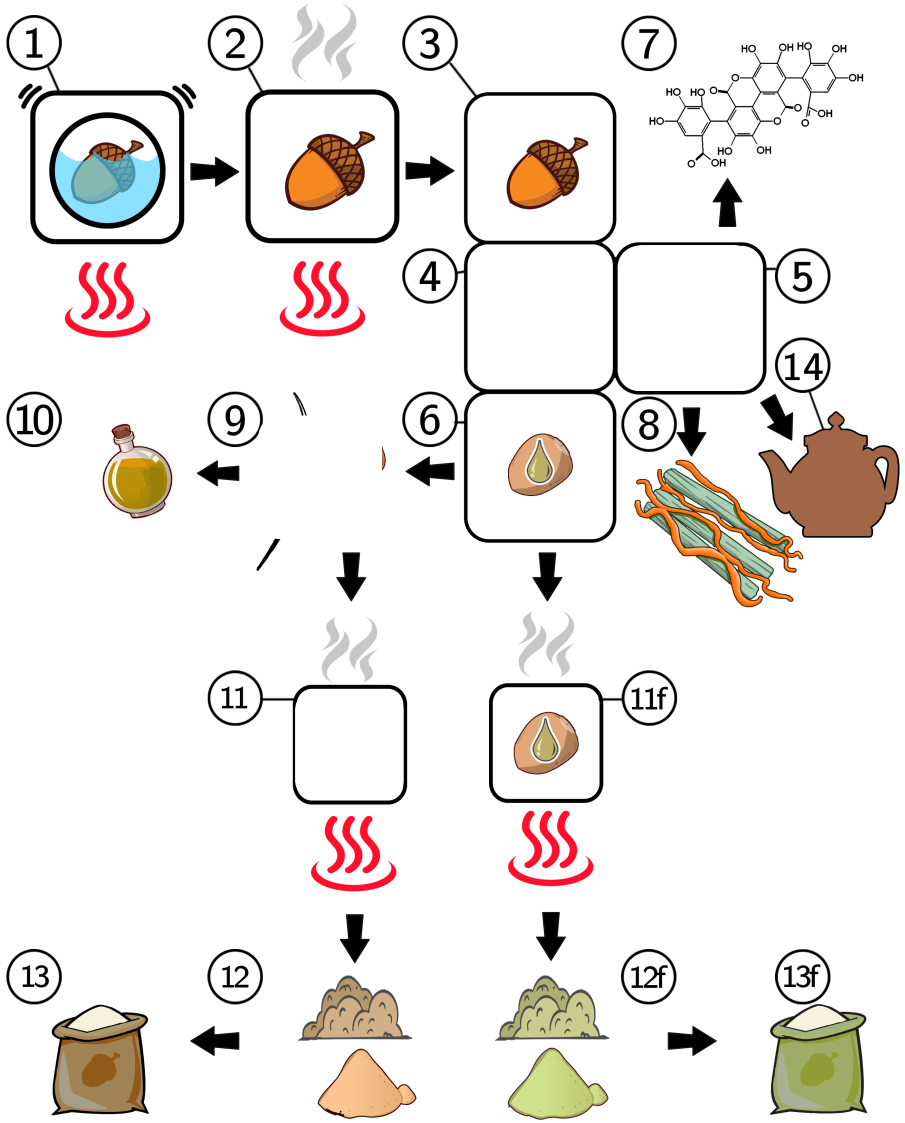


- Georeferentiation of harvesting sites.
- Agronomic data collection (e.g. yield/m2, maturation date).
- Test of traditional and industrialized harvesting methodologies.

Work Package 2

Design of an acorn transformation line into edible gluten-free granulate

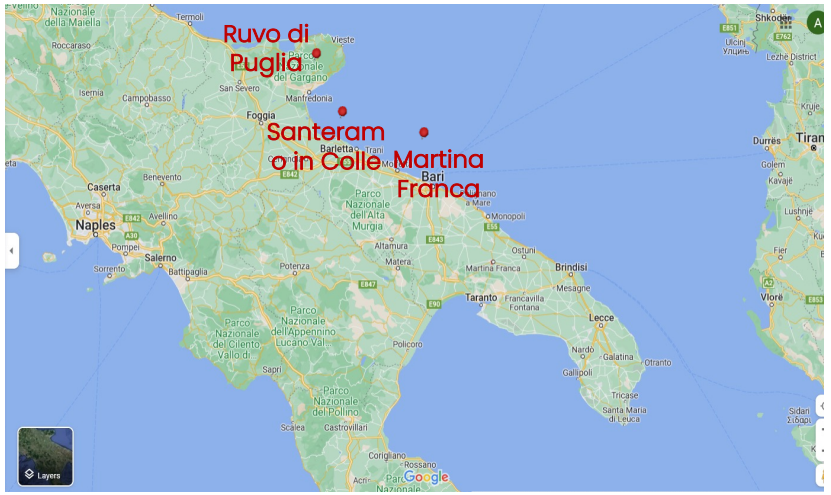
Acorn processing steps



Work Package 3

Biochemical, nutritional and functional characterization of acorns and acorn flour/granulate from different species

Sampling of acorns from different oak species



Four collection sites, in the Apulia region of Southern Italy, located NW, SW and SE of the capital town, Bari

A) ***Quercus pubescens*** **W. (Roverella)** - masseria La Ferrata - **Ruvo di Puglia** (Bari) Italy;

B) ***Quercus ilex*** **L. (Leccio)** - masseria Trazzonara - **Martina Franca** (Taranto), Italy;

C) ***Quercus trojana*** **W.** (Fragno) - masseria Pezze Mammarella - **Martina Franca** (Taranto), Italy;

D) ***Quercus trojana*** **W.** (Fragno) – **Santeramo in Colle** (Bari), Italy.

Acorn flour preparation

1. **First drying** of fresh whole acorns at 45°C for 24 hours
2. Manual **shelling**
3. **Second drying** at 45°C to archive a moisture <14%
4. **Milling**
5. **Sieving** (particle size 300 μm)

Proximate composition

Parameter	*Quercus ilex* L. (Leccio)	*Quercus pubescens* W. (Roverella)	*Quercus trojana* W. (Fragno - Santeramo)	*Quercus trojana* W. (Fragno - Martina)
Moisture (g/100 g)	12.10±0.32^{b}	12.47±0.18^{b}	11.96±0.11^{b}	14.47±0.33^{a}
Dry matter (g/100 g)	87.90±0.32^{a}	87.53±0.18^{a}	88.04±0.11^{a}	85.53±0.33^{b}
a_w	0.55±0.00^{d}	0.60±0.00^{c}	0.72±0.00^{a}	0.70±0.01^{b}
Parameter (g/100 g d.m.)	***Quercus ilex* L. (Leccio)**	***Quercus pubescens* W. (Roverella)**	***Quercus trojana* W. (Fragno - Santeramo)**	***Quercus trojana* W. (Fragno - Martina)**
Lipid	5.21±0.08^{b}	5.39±0.04^{b}	**3.67±0.35^{c}**	**6.23±0.15^{a}**
Protein	3.26±0.11^{c}	**6.42±0.17^{a}**	5.47±0.04^{b}	5.36±0.08^{b}
Ashes	1.94±0.18^{ab}	2.32±0.03^{a}	2.13±0.18^{ab}	1.78±0.18^{b}
Carbohydrates	89.60±0.15^{a}	85.87±0.24^{d}	88.73±0.48^{b}	86.63±0.11^{c}
Fiber	7.35±0.97^{d}	11.57±0.36^{b}	9.56±0.17^{c}	**14.52±0.31^{a}**

Phenolic composition

Bioactive compounds	*Quercus ilex* L. (Leccio)	*Quercus pubescens* W. (Roverella)	*Quercus trojana* W. (Fragno - Santeramo)	*Quercus trojana* W. (Fragno - Martina)
TPC (mg GAE/g d.m.)	55.78±2.72^{a}	18.15±0.55^{c}	22.95±1.89^{b}	20.01±0.07^{bc}
DPPH (µmol TE/g d.m.)	233.84±5.21^{a}	147.93±2.53^{bc}	143.94±13.99^{c}	164.07±0.59^{b}
ABTS (µmol TE/g d.m.)	130.00±2.87^{a}	45.54±0.77^{c}	57.12±1.98^{b}	46.30±1.23^{c}
β + γ-tocoferols (mg/kg of oil)	3206.32±147.61^{a}	2191.53±21.97^{b}	2037.14±0.10^{bc}	1934.18±18.70^{c}

TPC = Total phenolic content; T.E. = Trolox equivalents; DPPH = 2.2-diphenyl-1-picrylhydrazylcrylhydrazyl; ABTS =2.2'-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid. Different letters in the same row indicate significant differences at $p < 0.05$.

Fatty acid composition

Fatty acids %	*Quercus ilex* L. (Leccio)	*Quercus pubescens* W. (Roverella)	*Quercus trojana* W. (Fragno - Santeramo)	*Quercus trojana* W. (Fragno - Martina)
C13:0	0.14±0.01^{a}	0.12±0.00^{a}	0.12±0.00^{a}	0.17±0.04^{a}
C14:0	0.12±0.01^{b}	0.08±0.00^{c}	0.11±0.02^{bc}	0.20±0.01^{a}
C14:1	0.12±0.00^{b}	0.05±0.00^{c}	0.05±0.00^{c}	0.29±0.05^{a}
C16:0	19.61±0.08^{a}	14.98±0.12^{b}	19.75±0.53^{a}	14.06±0.15^{c}
C16:1	0.32±0.00^{a}	0.11±0.00^{b}	0.14±0.00^{b}	0.18±0.05^{b}
C17:0	0.14±0.00^{c}	0.26±0.01^{a}	0.14±0.01^{c}	0.20±0.01^{b}
C17:1	0.13±0.01^{ab}	0.10±0.01^{b}	0.16±0.02^{a}	0.11±0.03^{b}
C18:0	1.92±0.02^{b}	1.85±0.02^{c}	2.11±0.03^{a}	1.67±0.01^{d}
C18:1	57.42±0.05^{c}	62.75±0.00^{a}	59.54±0.79^{b}	62.04±0.37^{a}
C18:2T	0.43±0.00^{a}	0.13±0.00^{c}	0.14±0.01^{bc}	0.21±0.06^{b}
C18:2	17.79±0.13^{bc}	17.87±0.07^{b}	17.45±0.23^{c}	18.96±0.10^{a}
C18:3 (n-3)	1.40±0.01^{c}	1.36±0.02^{c}	1.70±0.06^{a}	1.60±0.04^{b}
C20:0	0.23±0.03^{bc}	0.29±0.00^{a}	0.24±0.01^{b}	0.19±0.00^{c}
C20:1	0.22±0.00^{a}	0.05±0.00^{c}	0.05±0.00^{c}	0.13±0.04^{b}

%	*Quercus ilex* L. (Leccio)	*Quercus pubescens* W. (Roverella)	*Quercus trojana* W. (Fragno - Santeramo)	*Quercus trojana* W. (Fragno - Martina)
∑MUFA	58.22±0.05^{c}	63.05±0.00^{a}	59.95±0.81^{b}	62.75±0.19^{a}
∑PUFA	19.63±0.13^{b}	19.36±0.09^{b}	19.29±0.31^{b}	20.77±0.01^{a}
∑SFA	22.15±0.08^{a}	17.59±0.09^{b}	22.47±0.58^{a}	16.49±0.20^{c}

∑SFA, sum of saturated fatty acids; ∑MUFA, sum of monounsaturated fatty acids; ∑PUFA, sum of polyunsaturated fatty acids. Different letters in the same row indicate significant differences at $p < 0.05$.

Functional properties

Parameter	*Quercus ilex* L. (Leccio)	*Quercus pubescens* W. (Roverella)	*Quercus trojana* W. (Fragno - Santeramo)	*Quercus trojana* W. (Fragno - Martina)
WAC (g/g of flour)	1.15 ± 0.01^{b}	1.23 ± 0.05^{b}	1.38 ± 0.00^{a}	1.35 ± 0.03^{a}
OAC (g/g of flour)	0.60 ± 0.01^{c}	0.73 ± 0.02^{b}	0.89 ± 0.03^{a}	0.85 ± 0.04^{a}
WSRC (%)	112.56 ± 0.05^{c}	129.86 ± 0.30^{b}	143.88 ± 0.10^{a}	143.13 ± 0.03^{a}
SCSRC (%)	118.04 ± 0.05^{d}	150.51 ± 0.05^{c}	158.58 ± 0.09^{b}	177.43 ± 0.02^{a}
LASRC (%)	149.80 ± 0.04^{c}	164.27 ± 0.10^{b}	77.43 ± 0.05^{d}	180.04 ± 0.04^{a}
SuSRC (%)	129.14 ± 0.01^{b}	112.32 ± 0.06^{d}	142.60 ± 0.05^{a}	128.48 ± 0.08^{c}

WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity; Solvent Retention Capacity (SRC) [Water Retention Capacity (WRC), 5% (w/w) Sodium Carbonate SRC (SCSRC), 50% (w/w) Sucrose SRC (SuSRC) and 5% (w/w) Lactic Acid SRC (LASRC).
Different letters in the same row indicate significant differences at $p < 0.05$.

Work Package 4

Study of storage and conservation conditions of acorn flours and granulates

Oxidation is an issue for acorn long-term storage

Compounds	µg/g
Aldehydes	
Hexanal	389.75±9.03
Heptanal	59.01±5.43
Octanal	102.25±4.96
Nonanal	55.93±3.00
2-Octenal, (E)-	4.89±0.09
Pentanal	13.69±0.67
Esters	
Acetic acid, pentyl ester	2.91±0.02
Acetic acid, hexyl ester	1.46±0.17
Hexanoic acid, ethyl ester	4.03±0.20
Ethanedioic acid, bis(trimethylsilyl) ester	9.77±0.14
1-Butanol, 3-methyl-, acetate	9.27±1.06
Furans	
2-pentylfuran	22.13±0.23
Terpenes	
Ketones	
2-Octanone	2.61±0.19
3-Octen-2-one	4.09±0.01

Parameter	Value
Lipid (%)	11.79±0.18
Peroxide value (meq O_2 kg^{-1} oil)	18.85±0.63

Fatty, oil, herbal, green odor notes

Acorn flour had significant concentrations of **aldehydes**, compounds associated with **oxidative processes** in the lipid fraction

However, the flour **did not have** an unpleasant odor and taste.

General aim: determination of the **optimal storage and conservation conditions** of acorn flours and granulates, monitoring the **oxidative degradation** of the products during storage.

Effect of processing on fatty acids oxidation

Parameter	GMA23.1	HFM23.1	HFM23.1 Kernel
Lipid (%)	11.56±0.05a	11.39±0.31a	
Peroxide value (meq O2 kg-1 oil)	5.84±0.13c	14.48±0.71a	12.03±1.79b

Volatile compounds

Compounds (µg/g)	GMA23.1	HFM23.1	HFM23.1 kernel
Aldehydes			
Benzaldehyde	16.56±0.21a	7.23±0.21b	5.11±0.09c
Phenylacetaldehyde	9.92±0.13b	2.64±0.13c	10.65±0.03a
Hexanal	51.27±0.66c	98.08±0.66 a	54.69±1.25b
Nonanal	26.08±0.34b	34.06±0.34 a	26.66±0.43b
Nonadienal	5.38±0.07a	4.33±0.07b	1.21±0.06c
Octanal	9.09±0.12b	17.69±0.12a	5.58±0.23c
Alkanes			
Dodecane	15.06±0.19b	23.53±0.19a	n.d.
Undecane	23.34±0.3b	24.25±0.30a	0.63±0.31c
Alchols			
2 methyl 1 propanol	8.22±0.11a	8.28±0.11a	n.d.
Phenethyl alcohol	5.34±0.07a	4.10±0.07b	1.80±0.05c
2 Heptanol	11.82±0.15b	15.04±0.15a	7.56±0.19c
Acids			
Benzoic acid	4.9±0.06b	3.01±0.04c	12.95±0.15a

From the kernel to the flours an increased in the volatile compounds associated with the oxidative phenomena have been observed.

Significant differences were observed between the two acorn flour batch in the volatile compounds associated with the oxidative phenomena.

Work Package 5

Development of innovative methods to produce novel acorn-based food

Acorn flour – technical challenges

Parameter	%
Lipid	11.79
Protein	5.12
Fiber	10.70

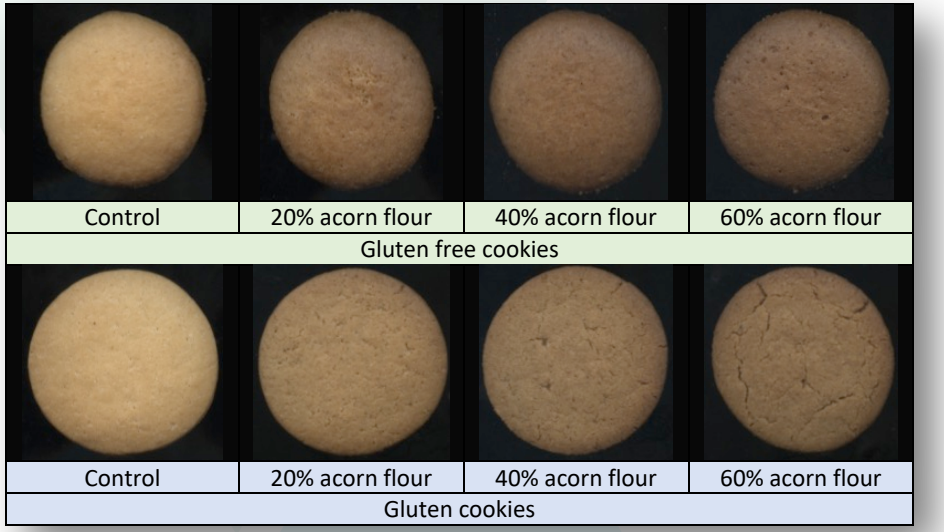
The composition of acorn flour, compared with cereal flours, is distinctive primarily due to the low proportion of **protein** and a high proportion of **lipid** and **fiber**

One option is to **combine acorn flour** with alternative **protein-rich flours**, such as **legume flour**.

However, to improve the protein content, a **large amount** of flour would have to be added. This option would have a **negative effect** on the **odor and taste** of the products.

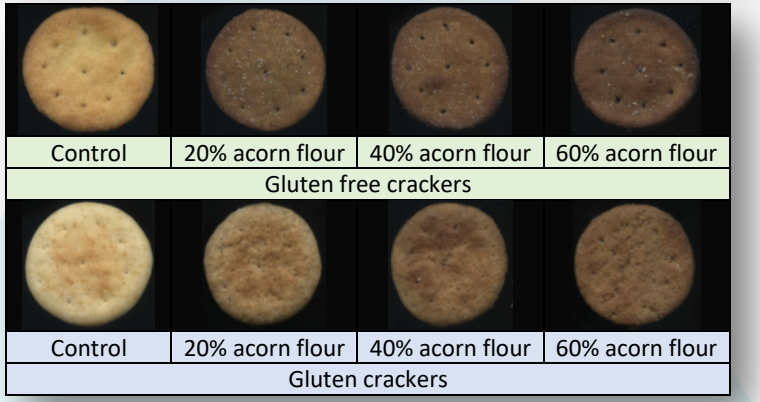
One possible solution could be the use of **legume protein concentrates**, which can significantly increase the nutritional value of products, even when added in small quantities.

Prototype development

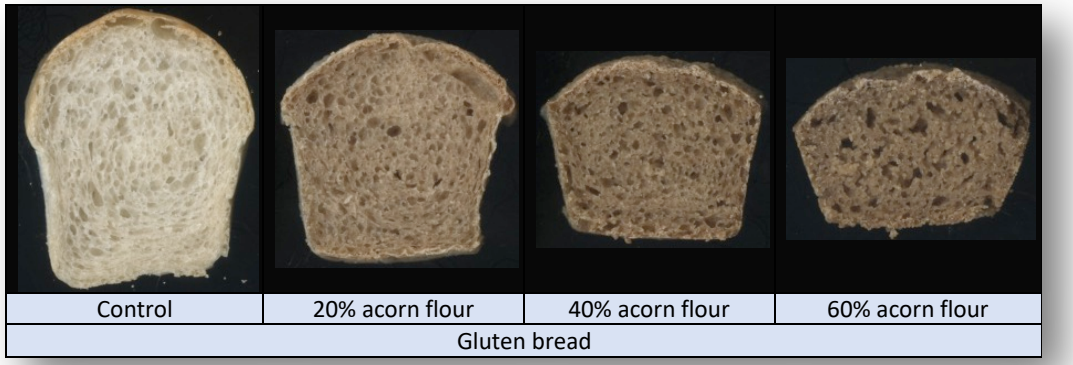


Control	20% acorn flour	40% acorn flour	60% acorn flour
Gluten free cookies			
Control	20% acorn flour	40% acorn flour	60% acorn flour
Gluten cookies			

Control	50% acorn flour	100% acorn flour
Gluten free bread		



Control	20% acorn flour	40% acorn flour	60% acorn flour
Gluten free crackers			
Control	20% acorn flour	40% acorn flour	60% acorn flour
Gluten crackers			

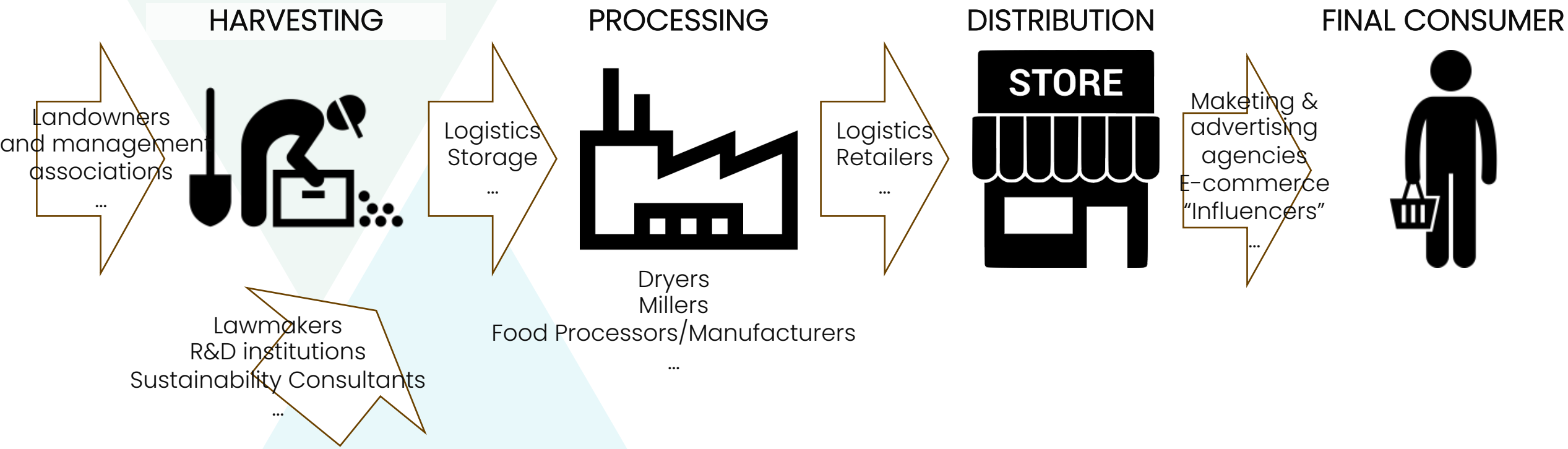


Control	20% acorn flour	40% acorn flour	60% acorn flour
Gluten bread			

Work Package 7

Communication, dissemination, impact assessment and exploitation

Mapping of acorn food value chain



- 14 classes of stakeholders identified.
- Identified 564 stakeholders from 14 Mediterranean and neighboring countries.
- Value chain mapping and missing links analysis – 19 more stakeholder classes.

Kick-off Meeting
Guimarães, Portugal (July 2023)

1st Year Meeting/ 1st awareness action
Tunis, Tunisia (June 2024)

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Rescuing acorns as a Mediterranean traditional superfood

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