Legerete

LEgume GEnetic REsources as a tool for the development of innovative and sustainable food TEchnological ABSYS

ABSTRACT

The project LeGeReTe contributed to the valorization and preservation of the biodiversity of legume genetic resources through the increase of knowledge on available but unknown legume accessions and the application of these resources in the food system. “Increase of knowledge” and “introduction in food system” have been the key words of the project, because we believe that to preserve biodiversity is necessary that the legume varieties and/or accessions stored in the gene banks are introduced in the food chains. Smykal et al. (2015) report that about 1.1 million grain legume accessions are stored in various gene banks. For this reason, it is essential to study the agronomical, chemical, nutritional, and technological characteristics of such genotypes in order to identify their best food application (either as whole seeds or ingredients for processed products). So, together with the study of legume biodiversity, the other aims of the project have been: i) the identification of legume genotypes suitable for low-input farming systems and characterized by superior traits (agronomical, nutritional, technological); ii) the chemical, nutritional and functional characterization of more than 200 accessions of pulses, most of them at risk of genetic erosion; iii) the assessment of the potential beneficial effect of selected legume accessions by “in vitro” and "in vivo" approaches; iv) the development of new technological applications for legumes, ultimately leading to innovative legume-based foods and food ingredients, so as to increase legume consumption; v) the improvement of economic and environmental sustainability through life cycle assessment (LCA) indicators and consumer’s studies. The project started in 2017 with in field trials aimed at the agronomical selection and the constitution of a core collection, that was then characterized in terms of chemical, nutritional, and technological properties. Then, a selection of accessions were subjected to in vitro and in vivo assessment to evaluate the potential beneficial effect on human health. At the same time, on the basis of the results of the technological evaluation, some promising legume types, at risk of genetic erosion, have been utilized for the production of traditional and innovative food products, which have been also the object of an evaluation of sustainability by the LCA analysis, as well as consumer acceptance tests. Regarding the traditional legume-based foods, the case study of faba bean has been considered to rediscover its use in the Mediterranean Basin and the Middle East.

Keywords : Genetic Resources, Innovative Legume-Based Foods, Italy, Faba, Legumes, Analysis, Consumers, Sustainable evaluation, Legumes

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Project leader : Riccardo Guidetti
Project leader's institution : University of Milan
Project leader's RU : Hors_réseau

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GOAL

The goal of the project proposal has been the identification and valorization of genotypes with high agronomical, technological and nutritional value, together with the development of innovative legume-based food applications of the selected accessions on semi-industrial scale. These food applications, with high service value, will be able to induce the increase of legume consumption. The proposed approach, based on increasing the knowledge and subsequent introduction in the food chain for preserving the biodiversity of legumes, can be applied to the preservation of other vegetable or animal genetic resources, and could represent a step towards increasing the food system sustainability.
The principal scientific questions/statements and relative results/solutions given through the LeGeReTe project are listed below:
Q1: Is the knowledge of the chemical composition and of the technological properties of legume flours helpful for the identification of their best application as raw material or ingredient?
Q2: The potential beneficial effect of pulses on human health, is translated in in-vivo effect? Considering the differences among the pulse's species and, within the species among the difference accessions, are there also differences in the human health effects?
Q3: Are there solutions to increase the legume consumption that means, for some traditional accessions, the prevention of risk of genetic erosion?
Q4: Are pulses suitable for the use in innovative products, or their utilization and consumption is related only to traditional foods?
Q5: Are the solutions proposed sustainable and are the consumers ready for this new trend?
Q6: Could the project be considered the starting point for establishing new collaborations with research groups or private enterprises? Were young researchers trained?

ACTION

The project worked at different steps of the legume chain :
- agronomic resources : Starting from the in-field trials, the principal aim was the selection of the core panel of accessions (about 200) representative of the legume biodiversity present in the project starting collection (encompassing 665 accessions). Performing this step was of crucial importance because the availability of genetic diversity increases the chance to find individuals displaying superior traits and genes of interest for plant breeders. We addressed this aim by performing a selection in the field based on morphological descriptors poorly influenced by the environment, such as and the flower color, and based on the characterization of DNA.
The core collection has been evaluated from a chemical, nutritional and functional point of view. A total of 196 accessions of the principal pulse's species - 57 accessions of chickpea (Cicer arietinum L), 80 accessions of pea (Pisum sativum L), 41 accessions of faba beans (Vicia faba L) and 18 accessions of lentils (Lens culinaris Medik) characterized by high phenotypic diversity (attachment n.3) and characterized by low input farming have been considered. The characterization has been performed to select key accessions or type "worthy" to valorization because characterized by high nutritional value and valuable functional properties (oil and water absorption capacity, bulk density) that make them able to be used as ingredients in traditional and innovative food formulations.To assess the potential beneficial effect of a panel of selected accessions we have choose both the "in vitro" and "in vivo" approaches and several methodological strategies.
- processing food : A strategy to increase the legume consumption is the formulation of attractive, nutritious and convenient ready-to-eat legume-based foods, so as to solve the problem of long time of preparation and cooking. In the frame of LeGeReTe project we prepared some traditional and innovative foods from pulses, considering, in particular, legume types and accessions at risk of genetic erosion. The formulations and the process have been performed preliminary on laboratory scale and after, for some formulations, also on industrials scale, thanks to the collaboration of the industrial partner of our team, in order to verify the behavior in the industrial processing. On several food solutions we have evaluated the Economic and Environmental Sustainability for semi-industrial scale up by means the application of the LCA analysis and the Consumer attitudes related to innovative legume-based products. The environmental assessment through the Life Cycle Assessment was used as methodology to study the industrial and agricultural production.
Finally, recommendations and improving activities were suggested to increase substantially the sustainability of all the production processes.
- consumption and acceptance : The study of the consumer attitude was based on four different data collection events. The exploratory phases were done with interactive approaches and with small and

manageable samples. Results from these exploratory phases were then tested on larger and multi-country samples. The whole research was indeed conceptualized so that each data collection depended on the results of the previous steps, allowing more robust data for the final results.

RESULTS

This project has shown that it is possible to use legume types/accessions (even the neglected ones but with interesting characteristics) for producing foods with high nutritional and service values (ready-to-cook and/or ready-to-eat), leading to the promotion of the consumption of these valuable crops. The project proved that a multidisciplinary approach (agronomical, nutritional, technological, and socio-economical) is a fundamental preliminary step for the introduction of new genetic resources in the food chain.
There are some “barriers” that we have observed towards legumes, in particular regarding consumer attitudes:
Taste and price hamper the consumption of legume-based foods.
There is a preference for unprocessed legumes; legume-based processed foods are not perceived as particularly healthy.
Health-concerned and environmentally conscious consumers are more likely to consume and buy legume-based products. Women and heavy meat reducers are more inclined to accept such products.
More information should be provided on the benefits of legumes to attract more attention, as their use is not part of some culinary habits.

PERSPECTIVES

The results of the project constitute the basis of further researches according to the Sustainable Development Goals.
From a genetic point of view, significant genetic redundancy was found among accessions conserved in germplasm collections, thus indicating that further studies using molecular markers will be of great value for the rational management of material stored in gene banks. The use of genotyping-by-sequencing proved to be a cost-effective strategy for the genetic characterization of legume germplasm, and thus might be exploited.The detection of individuals and markers associated with superior traits (such as adaptation to drought and cold stresses, flowering time, seed chemical composition) might fuel new research addressing the characterization of genes and molecular mechanisms underlying these features.
There are several technological issues that must be solved for the introduction of the legume genetic resources in the food chain. First of all, the sensory characteristics of legume-fortified food need to be improved and this is true especially for the traditional products. As also showed from the consumers studies, the taste hampers the consumption of legume-based foods.As new legume-based foods will become more popular, it is reasonable that this discrepancy will fade out. However, further study can investigate how to smooth the flavor of legume-based food, by using technological or biotechnological approaches. The acknowledging of the importance of legumes will attract more consumers, leading to a general more appreciation of the taste and to new culinary traditions.
From processing point of view, further research should better evaluate the evolution of the antinutritional factors during the processing of legumes. Indeed, in our study we found how different technologies lead to a reduction or to an increase of such compounds. Another important aspect that requires further investigation is linked to the definition of the technological and rheological parameters and the relative ”limits” for the use of legume flour in bakery products.
FInally, from consumption acceptance point of view, future research could investigate more deeply consumer preferences with respect to legume-based convenience food. Moreover, preferences could be studied in real-life settings to analyse actual consumer choices and overcome the biases of stated preferences. In this direction, nudging types of interventions (Thaler and Sunstein, 2008) could be devised to test consumer response to different stimuli.