The valorization of sustainable food matrices for the development of new food ingredients and products

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Lemon peel flour (LPF), produced from a by-product of limoncello production, was used as ingredient in the formulation of different meat-analogues. A soybean burger and soybean strips were taken as control samples. A proportion of 2-4% of LPF was added to the base recipe of the burger to replace completely the fibers and partially the fat. For the soybean strips, LPF was added at 2% as part of the coating. The digestibility of the meat-analogues was assessed by in vitro digestion. The addition of LPF showed promising results as replacer of commercial fibers and fats when added at 2%.

La valorizzazione di matrici alimentari sostenibili per lo sviluppo di nuovi ingredienti e prodotti alimentari

La farina di bucce di limone (FBL), ricavata da un sottoprodotto della produzione di limoncello, è stata utilizzata come ingrediente nella formulazione di analoghi della carne. Un burger di soia e straccetti di soia sono stati presi come campioni di controllo. La FBL è stata aggiunta (2%; 4%) al burger per sostituire completamente le fibre e parzialmente il grasso; per gli straccetti di soia, è stata aggiunta al 2% come parte del condimento. Si è studiata la digeribilità dei prodotti mediante digestione in-vitro. La FBL ha dato risultati promettenti come sostituto delle fibre e dei grassi, se aggiunta al 2%.

**Key words**: Citrus limon wastes, soybean burger, meat analogues, in vitro digestion, fat replacer.

# **1. Introduction**

In accordance with the PhD thesis project, this poster reports the main results of the first activities concerning:

- the use of lemon peel flour as an ingredient in the formulation of a meat analogue;   
- the digestibility of the meat analogues.

# **2. Materials and Methods**

Lemon peels residual from the production of “limoncello” were freeze-dried and ground to obtain flour with particle size < 1 mm. The lemon peel flour (LPF) was used as an ingredient in two base meat analogues recipes. The soybean burger (SB) recipe ingredients were: soy protein concentrate, vegetable oils (sunflower, coconut), natural flavors, soy protein isolate, methylcellulose, starch (potato, tapioca), dried yeast, vegetable fiber (pea and bamboo), burnt sugar, salt. LPF was introduced at different percentages, 2% (LPF 2% SB) and 4% (LPF 4% SB) by fully replacing the fiber and partially the fat respectively at 12% and 36%.   
The soybean strips (SS) recipe ingredients were: soy protein extract (water, soy protein 35%, vegetable fiber), sunflower seed oil, natural flavors, yeast extracts and salt. LPF was added (2%) in the coating of the soybean strips (LPF 2% SS). All the samples were produced in an industrial plant. The main ingredients contributor for the protein and carbohydrates were not changed in the formulation do to have comparable protein and carbohydrates content cross the evaluated samples. The protein content was determined by the Kjeldahl method (N × 5.71). The different meat analogues were digested according to the INFOGEST in vitro digestion protocol (Brodkorb et al., 2019). After digestion, glucose release was assessed by enzymatic assay for D-Glucose Enzytec™, total protein digestibility was determined after acid hydrolysis by total amino groups (o-phthalaldehyde method).

# **3. Results and Discussion**

## **3.1 Nutritional composition** The nutritional composition of soybean burger and soybean strips used as control samples is reported in Table 1 and Table 2. The protein content of the samples was confirmed by the Kjeldahl method. **3.2 Carbohydrates digestibility**

**Table 2** Nutritional table of soybean strips.

**Table 1** Nutritional table of soybean burger.

Free glucose release at the end of the duodenal digestion phase (120 min) was quantified, being a useful information to understand the effect of the lemon fibre on the release of glucose. For the burgers (SB, LPF 2% SB and LPF 4% SB) the presence of LPF resulted in a lower release of glucose which was proportional to the increasing amount of LPF. As shown in Figure 1, the quantity of free glucose in the three samples was found significantly different with a p value < 0.01.

For soybean strips the statistical analysis showed no differences in terms of glucose release considering a significance level of 0.05 as reported in Figure 2.  **3.2 Total protein digestibility**

**Figure 2** *D-Glucose (mg/5g sample) in soybean strips.*

**Figure 1** *Effect of LPF addition to the formulation of soybean burger on the release of glucose through the digestion, D-Glucose (mg/5g sample).*

Total protein digestibility was calculated using the following equation:   
   
  
Digestibility [%] = Fs – Cs x 100 Fs=NOPA of the supernatant of digested food (mg) (1)  
 Food Cs=NOPA of the supernatant of the enzyme blank (mg)

Food=NOPA of the food as is (mg)   
  
  
Previous *in vivo* and *in vitro* studies demonstrated high digestibility scores both in terms of total digestibility of the proteins and digestible essential amino acids for soybean protein isolates, ranging from 84 to 90.6% (Van den Berg et al., 2022).   
The protein digestibility was found to be 70% and as showed in the Figure 3 is concordant among the burger samples. For soybean strips, the digestibility was 68%. This lower digestibility can be attributed either to the structure of the food matrix or to the changes the proteins undergo during the extrusion process. These promising data support the introduction of lemon wastes to improve the nutritional quality of plant-based meat analogues.   
These data suggest that LPF could be a valid replacer of commercial fiber and fat. However, further sensorial and rheological analysis are needed.   
The experimental results are promising for the prosecution of the designed PhD thesis project and for proceeding with the scheduled analysis workflow.

**Figure 3** Total protein digestibility of soybean burgers.

# **4. References**

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