Track 11/SubTrack 11-5: Probiotic foods and beverages

Probiotic vegetable foods containing health promoting molecules.

Vegetables as carriers of probiotic cells and bioactive compounds

The functional benefits of probiotic vegetable foods are linked to the presence of health promoting molecules - polyphenols, glucosinolates, vitamins, monounsaturated fatty acids, prebiotic sugars, etc. - as well as to the high count of live probiotic cells able to colonize the human gut (Lavermicocca et al., 2005; Valerio et al., 2011).

The use of a probiotic strain as a starter can allow the consumption of probiotics in fermented vegetables as an alternative to the milk-based products.
Secondary Plant Metabolites

Some examples from > 10,000 compounds:

- **Broccoli** *Sulforaphane*
- **Garlic** *Diallyl sulphide*
- **Green Tea** *Epigallocatechin-3gallate*
- **Cabbage** *Sindole-3carbinol*
- **Ginger** *Gingerol*
- **Soybeans** *Genistein*
- **Chilli peppers** *Capsaicin*
- **Grapes** *Resveratrol*
- **Tomatoes** *Lycopene*
- **Olives** *polyphenols*
- **Artichokes** *hydroxycinnamic acids*

Support the survival of the probiotic *L. paracasei* LMG P22043
L. paracasei IMPC 2.1
LMGP22043

Human isolate

Ability to adhere to Caco-2 cells, survival to low pH and bile salts, survival during simulated gastric and intestinal digestion

Inhibition of bacterial pathogens

Good survival on vegetable surface

Colonization of the human gut

Immunomodulatory activity in transgenic mice

Realization of probiotic vegetable gastronomy

Application of the strain in the manufacturing process of debittered green olives cultivar “Bella di Cerignola”
Vegetables as probiotic carriers

The efficacy of a probiotic food mainly depends on the ability of the probiotic strain to survive during processing and/or to compete with metabolically active microorganisms occurring in the food.
Probiotic table olives: Microbial populations adhering on olive surface in fermentation sets inoculated with the probiotic strain *Lactobacillus paracasei IMPC2.1* in an industrial plant

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Bioprotection of Ready-to-eat Probiotic Artichokes Processed with *Lactobacillus paracasei* LMG P22043 against Foodborne Pathogens

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Brassica vegetable as a carrier for delivering probiotic cells into the gut

1. Cabbage (*Brassica oleracea var. capitata*) is a cruciferous vegetable.


3. The GS content and pattern will differ between varieties, but depend also on breeding location and conditions.

4. Sauerkraut: spontaneous or started lactic acid fermentation of shredded and salted white cabbage, which allows a rapid decline in pH of the product and prevents spoilage.

5. Traditional fermentation of cabbage (sauerkraut): no detectable GSs left in final product.
Glucosinolate’s hydrolysis

up to 40% of ingested GSs can be hydrolyzed by the human gut flora as well (Fahey et al, 2012) and the bioactive breakdown products can enter the human body.

Isothiocyanates (ITC) recognized as bioactive compounds
Glucosinolate loss during processing

Processes affecting GSs

Initially:
Cell lysis
Diffusion of enzymes
Diffusion of GSs
Enzymatic GSs hydrolysis

At higher T:
Enzyme denaturation
GSs degradation
Process Simulation

in-can sterilization (veg:water=1.75:1)

- Concentration/Fraction (-)
- Temperature (°C)

- 5%
Process Simulation

domestic cooking (veg:water=1:2)

Temperature (°C)

Concentration/Fraction (-)

Time (min)

- fraction intact cells (-)
- GS vegetable (-)
- GS water (-)
- BDP vegetable
- BDP water
- active myrosinase veg
- active myrosinase water
- Temperature

25%
Process Simulation

**blanching (veg:water = 1:9)**

- Concentration/Fraction (-)
- Temperature (°C)
- Time (min)
- Fraction intact cells (-)
- GS vegetable (-)
- GS water (-)
- BDP vegetable
- BDP water
- Active myrosinase veg
- Active myrosinase water
- Temperature

65%
Probiotic Fermented Cabbage with GSs

• Develop a ‘functional’ sauerkraut!
  – Containing probiotic bacteria
  – Containing GSs

• Assumption:
  – Endogenous myrosinase is cause of GS loss
  – Blanching can inactivate myrosinase
  – Blanching can reduce the presence of contaminants
  – Probiotic strain can be added after blanching and before fermentation
Behaviour of *L. paracasei* LMGP22043 during storage of blanched white cabbage and fate of GSs content

- Inoculum with *L. paracasei* (1x10^5 CFU/g) (4% brine)
- Cabbage drained from brine after fermentation (71 h) vacuum packed and stored at 4°C

**Inactivation of myrosinase**

- Blanching: cooking at 100°C for 5 min

**Growth kinetic at 25°C**

- Glucosinolate content
- *L. paracasei* monitoring
L. paracasei LMG P22043 growth during blanched cabbage

Fig. 1. Growth curve at 25 °C of the strain Lactobacillus paracasei LMG P22043 inoculated at 5 log_{10} CFU/g of cabbage and relevant pH values.
FERMENTATION OF BLANCHED CABBAGE

LOW pH VALUES

INHIBITION OF UNDESIRABLE MICRORGANISMS

GOOD FINAL QUALITY

Inoculum load 1000 times lower than that usually used in industrial practices for vegetable fermentation.
Probiotic survival in vacuum packed cabbage during refrigerated storage

- The probiotic population remained steady over 8.00 log 10 CFU/g Vacuum packaging and storage at 4°C.
- 9 log CFU of live probiotic cells should be daily consumed to have functional effects.
- Days of storage
- No. L. paracasei in control cabbage

- 10 g of probiotic cabbage could be enough to deliver 9 log CFU of probiotic cells.

Control

Probiotic cabbage
Glucosinolate content

About the 50% of GS was preserved

About the 35% of GS of the blanched material was preserved after fermentation
FUNCTIONALKRAUT
CNR-ISPA & WUR

Probiotic & Glucosinolates
Conclusions

• Glucosinolates (GSs) are important for human health and cabbage is a rich source
• Processing affects the GSs content
• Traditional sauerkraut does not retain GSs
• Inactivating cabbage myrosinase retains GSs during fermentation
• A probiotic bacteria can be used to ferment blanched cabbage
• The final probiotic sauerkraut contains an adequate amount of live probiotic cells which can ensure a daily consumption of 9 log cfu of cells
• A ‘functional’ sauerkraut is produced containing both GSs and probiotics!
Questions?