Could pre-treatments with sub-lethal stresses enhance the ability of lactic acid bacteria to survive after spray drying in orange juice?

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Introduction

The demand for new functional non-dairy based products makes the production of an orange juice powder with pre- and probiotic characteristics, an encouraging challenge.
Spray drying is a simple and inexpensive way to produce a dried orange juice incorporating probiotics (Barbosa et al., 2015). However, drying processes, and subsequent storage, greatly affect the viability of the dried probiotic cultures due to the exposure to various stresses such as high temperatures and rapid dehydration (Tripathi and Giri, 2014). Solutions are required since probiotic microorganisms should be present in foods in numbers of about 10^6-10^7 cfu/g or cfu/mL until the time of consumption and must remain viable during passage through the gastro-intestinal tract (GIT) of the consumer (FAO/WHO, 2002; Sanz, 2007).
The aim of this work was to investigate if the pre-exposure to sub-lethal conditions of temperature, acidic pH and hydrogen peroxide could influence the viability of *Pediococcus acidilactici* HA-6111-2 and *Lactobacillus plantarum* 299v during spray drying in orange juice and subsequent storage under different conditions. Also the survival of both lactic acid bacteria (LAB) through simulated GIT was determined at the end of storage.

Methods

1. Determination of the sub-lethal conditions

	L. plantarum	*P. acidilactici*
Temperature	49.5 ºC	50 ºC
Acid (HCl)	pH 2.8	pH 2.7
Acid (Lactic acid)	pH 3.0	pH 3.1
H_2O_2	45 mM	25 mM

*Loss of viability was lower than 1 log-unit after 60 minutes of exposure to each condition imposed (data not shown).

2. Spray drying of orange juice incorporated LAB after each sub-lethal condition exposure

Niro atomizer; Inlet air temperature 150 °C; Outlet air temperature 75 °C; Pressure 4 bar

1.5% (w/v) Soluble solids
2% (w/v) Maltodextrin

Storage (6 months)

Room temperature *vs* 4 ºC
Presence of light
a_w of 0.03 (silica)

3. Simulation of gastro-intestinal tract conditions

Results

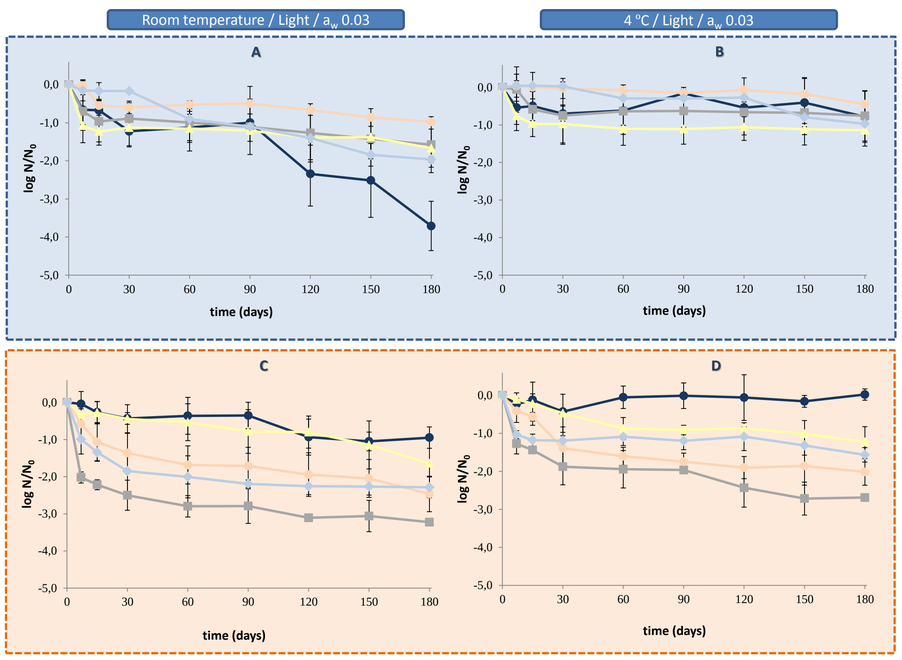

Figure 1. Logarithmic reductions of *L. plantarum* 299v (blue) and *P. acidilactici* HA-6111-2 (orange) without sub-lethal treatment (—●—), with acidic stress (HCl) (—■—), acidic stress (Lactic acid) (—▲—), temperature stress (—●—) and oxidative stress (—◆—) and incorporated in orange juice with 2% of 10DE maltodextrin after spray drying and during 180 days of storage in the presence of light with a_w of 0.03 at room temperature (**A** and **C**) and at 4 ºC (**B** and **D**).

Conclusions

For all the sub-lethal conditions investigated, there were no significant (p>0.05) reductions in cell viability during the drying process (data not shown).
Prior exposure of *L. plantarum* 299v to any of the sub-lethal stresses applied, increased their survival during 180 days of storage at room temperature (graph A); this effect was not observed (p>0.05) for cells stored at 4 ºC (graph B). At this temperature, cell inactivation was very low, as previously demonstrated by other researchers (Teixeira *et al.*, 1995). For storage at room temperature, initially, reductions in viable cell numbers were greater for cells exposed to lactic acid (about -2 log units), but from 90 days until the end of the storage, the reduction in viable cells not exposed to sub-lethal stress was greater (more than 3 log units). Temperature conferred the highest protection, followed by treatment with HCl, H_2O_2, and finally by lactic acid.
The exposure to any of the sub-lethal treatments prior to spray drying, did not result in the enhancement of survival of *P. acidilactici* HA-6111-2 during storage (graphs C and D). On the contrary, survival during storage was negatively influenced by previous exposure to all the sub-lethal conditions investigated.
After simulation of GIT conditions for the spray dried cells at the end of storage at 4 ºC, *L. plantarum* 299v and *P. acidilactici* HA-6111-2 were present in numbers of ca. 10^7 cfu/mL, despite the exposure to sub-lethal stresses did not have improved their viability.
As a conclusion of this study, the influence on the viability of two LAB after the exposure to different sub-lethal stress conditions prior spray drying and subsequent storage in orange juice was species/strain dependent. Considering that to have a beneficial effect on health, a probiotic must be present in minimum quantities of 10^7 cfu/mL in the product and remain viable during passage through the GIT, both *L. plantarum* 299v and *P. adicilactici* HA-6111-2 seem to be good candidates for use in the production of a new functional orange juice powder.

References

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