Production of Lactic acid as a Sustainable Approach to Valorize organic waste

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1. Introduction

The amount of food that is being wasted in Europe is high. Greeks waste on average a staggering 142 kilograms of food every year, compared to 74 kilograms, which is the global average. Sakai et al., 2000 converting solid domestic and industrial food wastes into valuable products showed that municipal food waste is a good source of natural lactic acid bacteria.

Lactic acid (LA) acid is the simplest hydroxycarboxylic acid and perhaps the most widely occurring in nature. Lactic acid has both hydroxyl and carboxyl groups with one chiral carbon atom, and it is widely used in the food, pharmaceutical, and general chemical industries (Litchfield 1996). Moreover, LA is produced at commercial scale by bacterial fermentation of starch-derived glucose having a negative impact on the food supply chain – using homofermentative lactic acid bacteria (LAB) (Singhvi et al., 2018).

Cheese is a very valuable food product for its high nutrition value. Cheese whey (CW) is a by-product during cheese manufacturing. Milk whey is the watery portion after the precipitation of casein and fat from whole milk, and it is rich in lactose, lactoglobulins and lactoalbumins, minerals, and vitamins (Guimarães et al., 2010).

To this respect, the above waste are rich in sugars, protein, and lipids, and thus it could be a promising feedstock for lactic acid production (Probst et al., 2013; Tashiro et al., 2013). So, the aim of this study was to investigate the exploitation of different waste for lactic acid production. Various strategies such as *Lactobacillus Rhamnosus* addition, pH adjustment, autoclavation, and their combinations were investigated to elucidate the impact on fermentation conditions that can lead to high lactic acid productivity and yield.

2. Materials and methods

2.1. Substrates and Microorganisms

Food waste (FW) and spaghetti (S) used in the present study was collected from the students' restaurant at the Hellenic Mediterranean University (HMU), Heraklion. The FW composition was 62% cooked meals, 12% bread and bakery and 26% vegetables and salads (on a wet-weight basis). FW and S were homogenized using a mechanical mixer (approximately 4.0 mm). The cheese whey (CW) was obtained from a local cheese-producing factory located in the same region, which uses traditional cheese manufacture technologies. For the present experiment, the substrates were diluted (1:1) with tap water to prevent clogging, and stored in plastic bottles at −20 °C until usage. For substrate cheese whey with spaghetti, spaghetti was diluted (1:1) with cheese whey.

Lactobacillus Rhamnosus KY-3 (Hanchen, Germany) was used in the current study. Lactobacillus granules were added to 50 ml sterilized BHI nutrient medium and incubated at 37 °C for 18h under stirring at 200 rpm. The optical density (OD) is measured and compared to that of the blank nutrient. Brain Heart Infusion medium (BHI) contains infusion of beef or pig heart and calf brain, a source of amino acids (often either digested gelatin or other animal tissue), salt, disodium phosphate as a buffer and glucose as a source of sugar.

2.2. Fermentation experiments

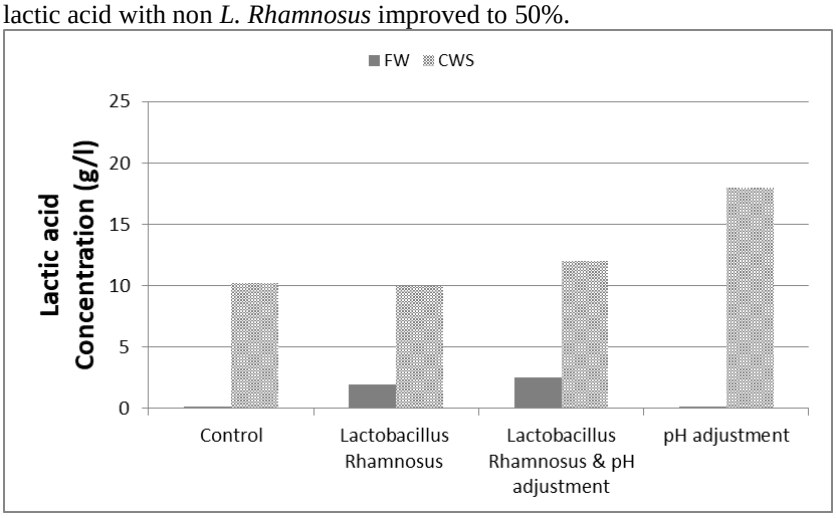
The experiments were conducted in 120 ml serum bottle reactors. Experiments were carried out at mesophilic conditions (37 °C). The working volume of the serum bottles was 100 mL. The serum bottles were first filled with 90% (v/v) substrate. The batch fermentations were inoculated with 10% (v/v) of exponentially growing inoculum at mesophilic (37 °C). Regarding the experiments, inoculation with *L. Rhamnosus*, pH adjustment and substrate autoclavation were investigated. The pH was adjusted to 6.6 using a 7% NH_4OH solution before starting the batch experiment. The autoclavation was carried out at 121 °C for 20 min. The experiments lasted 72 h.

2.3. Analytical Methods

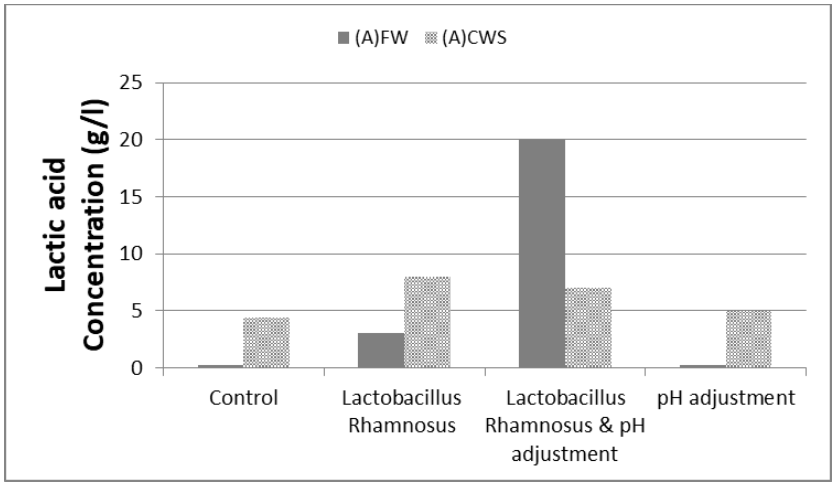
The pH was analyzed according to APHA (2005) using a pH-meter (model GLP21, Crison). COD were determined spectrophotometrically by use of standard test kits (Hach). TS and VS were measured gravimetrically according to APHA (2005).

3. Results and Discussion

In FW and CWS control experiment without *Lactobacillus Rhamnosus*, after 72 h lactic acid was 0.2 g/l and 10.2 g/l, respectively. By adding *L. Rhamnosus*, lactic acid production was improved to 2 g/l 1 only for FW. Adjusting pH had a significant effect on lactic acid production only for CWS. With pH adjustment and *L. Rhamnosus* the production of lactic acid improved to 25% for FW to non *L. Rhamnosus* addition and for CWS the production of lactic acid with non *L. Rhamnosus* improved to 50%.



a)



b)

Figure 1: Lactic acid Production using a) non autoclaved and b) autoclaved FW and CWS.

In comparison with non - autoclaved wastes, the overall yield of lactic acid was lower in the autoclaved CWS samples. Only in FW with pH adjustment and *L. Rhamnosus* the production of lactic acid improved.

Overall, the present research demonstrates that lactic acid production can be achieved using bio-waste and cheese waste with bio-waste. The results obtained in the current research can be exploited to expand the utilization of bio-waste and cheese waste for lactic acid production.

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