Beyond coffee production – Utilization of coffee residues

Different biomasses have been tested in the past for the production of platform chemicals which have the potential to substitute petroleum-based chemicals in chemical reactions. Predominant approaches thereby are the hydrolysis and subsequent conversion of hydrolytic products using biological methods. Annually 15 million tons of residues from coffee production appear worldwide, whereby 9.4 million tons are formed by coffee pulp. Coffee pulp can contain (w/w) cellulose (13-27%), pectic matter (6.5%) and reducing sugar (12.4%), and thus is a promising source of carbon in fermentations. In the present study we used coffee pulp in fermentative L(+)-lactic acid production using *Bacillus coagulans* at laboratory (2 L) and pilot scales (50 L) (Fig. 1). The aim of our study was to contribute to the development of decentralized biorefineries for coffee residues valorization in regions where it appears in large amounts.

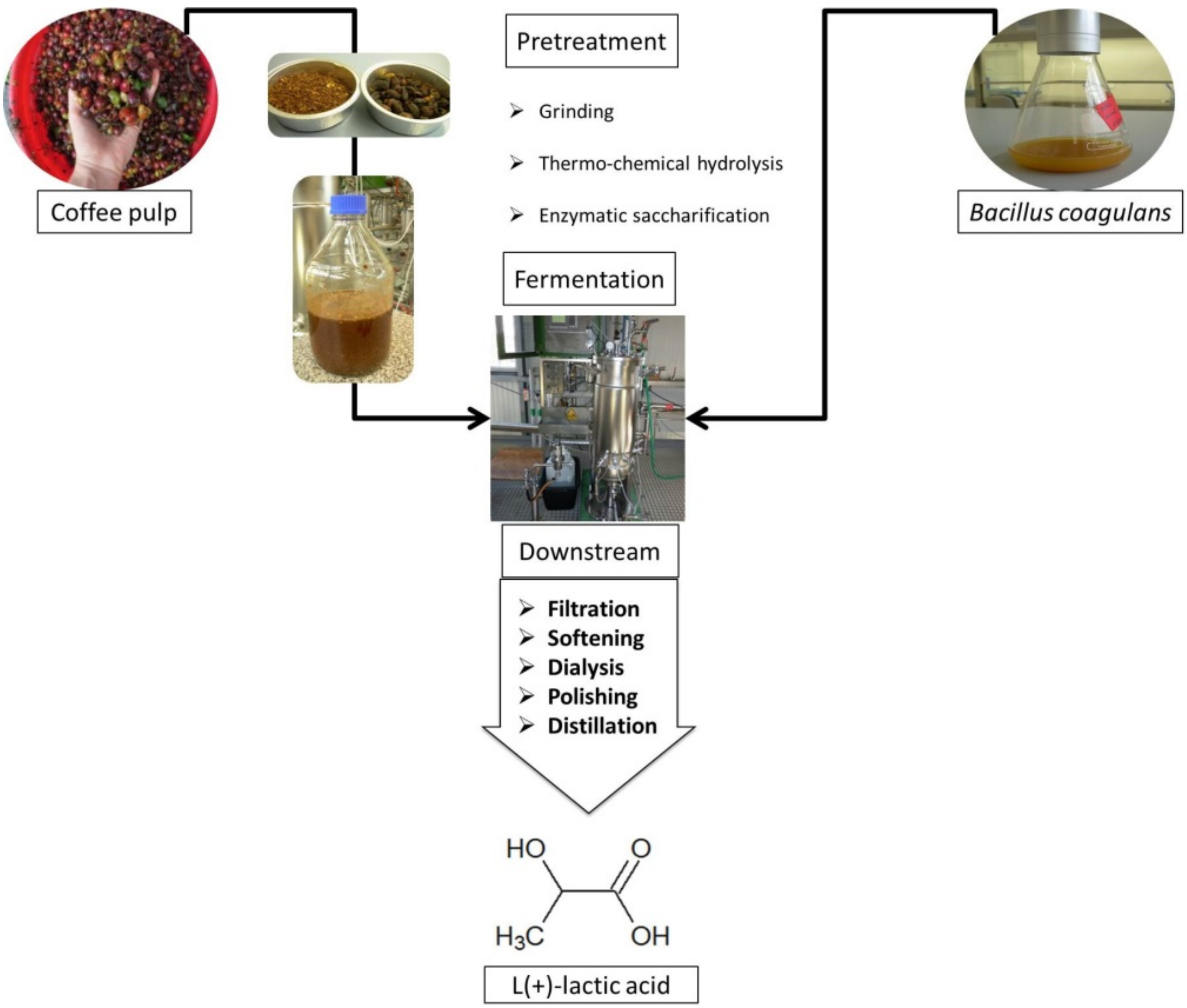

Fig. 1. Approach of fermentative production of L(+)-lactic acid from coffee pulp using.

We first treated the coffee pulp at 121 °C for 30 minutes in presence of 0.18 mol L^{-1} H_2SO_4 and second enzymatically digested the products using Accellerase 1500. This approach was found to make up almost 90% of the theoretically present sugars available as carbon source in fermentation. The concentration of sugars in the used hydrolysates were up to 30 g L^{-1} glucose, 25 g L^{-1} xylose, 11 g L^{-1} sucrose and 10 g L^{-1} arabinose. Fermentations were carried out in presence of 10 g L^{-1} yeast extract as nitrogen source, which might be substitutable by coffee mucilage a material recently investigated by our group. In all fermentations glucose was the preferred carbon source, followed by xylose and arabinose. Sucrose was obviously not preferred as carbon source.

At pilot scale carbon utilization and lactic acid yield per gram of sugar consumed were 94.65% and 0.78 g g^{-1}, respectively, at a productivity of 4.02 g L^{-1} $hour^{-1}$. Those values exceeded the performance at laboratory scale probably due to better mixing and culture conditions. Within 23 hours we obtained a lactic acid concentration of 45.3 g L^{-1}.

Complex substrates which contain high amounts of impurities can complicate downstream processes. In order to separate impurities and salt ions from lactic acid and to provide an optical pure formulation we applied micro- and nanofiltration steps, softening, mono- and bipolar electrodialysis, decolorization, anion- and cation-exchange chromatography. Distillation was carried out after downstream processing to concentrate lactic acid. Starting with a volume of around 50 L and a concentration of 45 g L^{-1} we obtained after downstream processing 0.8 L of a L(+)-lactic acid formulation with a concentration of 937 g L^{-1} and an optical purity of 99.7%. Using an optimized downstream processing and recovery we expect that between 200 and 300 kg lactic acid can be obtained from 1,000 kg dry coffee pulp. This offers an alternative to current utilization approach, such as fertilizer, livestock feed and compost productions.

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