CHAPTER 2: INITIAL HYPOTHESIS AND RESEARCH OBJECTIVES

2.1. Context and research gap

This Doctoral Thesis focuses on the valorization of the OFMSW by coupling thermal and biological treatments into bioplastics (PHA) and other high-value-added products. It applies the concept of a circular economy for the holistic treatment of this waste, tackling two problems simultaneously, the OFMSW management and disposal concerns and the environmental burden posed by petroleum-based plastics. The key biological treatments are anaerobic digestion, acidogenic fermentation, and photoheterotrophic process with PPB, the latter being the keystone of the Thesis. Hence, the main objective of the research was to design a photobiorefinery using that keystone as its core and optimize PHA accumulation. Before this Thesis, PPB growth on OFMSW derivates had never been studied, nor the preliminary design of a PPB-based photobiorefinery for the OFMSW valorization had been attempted. Therefore, the following questions have arisen:

1) Is it possible to grow a mixed culture of PPB and accumulate PHA using OFMSW hydrolysates?

2) How does using a carbohydrate-based residue such as lignocellulosic waste affect the PHA accumulation by PPB?

3) How do high percentages of lignocellulosic residue affect the acidogenic co-fermentation of the OFMSW?

4) Is it possible, and which parameters are key to maintain a good PHA productivity from OFMSW fermentate?

5) Is the anaerobic digestion process suitable to close the biorefinery's carbon cycle and energy balance?

6) What are the major challenges in scaling up this technology?

With the purpose to answer these questions, the discussion Chapter of the Thesis was organized in four different sections with the following objectives:

Section I: A preliminary proof of concept was designed consisting of thermal pretreatment of the OFMSW coupling with an anaerobic digestion process of the solid fraction and the growth and accumulation of PHA by mixed cultures of PPB from the liquid fraction in batch tests. OFMSW and lignocellulosic wastes were used as feedstock. In addition, preliminary mass and energy balances of the process were accomplished to check the energetic sustainability of the process.

Section II: The acidogenic co-fermentation of food waste (FW) and lignocellulosic waste (LW) was performed. Due to the lack of knowledge on how an increase in lignocellulosic waste can affect the acidogenic fermentation process, several mixtures were studied. Synergies in the SCCA and H2 production and the effect of a pilot-scale steam explosion pretreatment on the process were analyzed for the first time.

Section III: A conceptual design of a photobiorefinery was studied based on the integration of a photoheterotrophic process in an MPBR with mixed cultures of PPB and fed with the liquid effluent coming from the acidogenic fermentation. The initial feedstock was thermally pretreated in a steam explosion reactor before the fermentation step. PHA production optimization was addressed with a special focus on the effect of microbial communities as well as carbon and electron allocation. This section finalizes with a conceptual flow diagram of the overall process including preliminary mass and energy balances.

Section IV: A critical literature review was carried out to identify possible strategies for the industrial scale-up of the photoheterotrophic process with PPB. Key parameters were analyzed as well as possible strategies used in other technologies to understand the prospects of the project.

The following scheme shows the working plan with the integration of the aboved-mention sections.

2.2. Working plan