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ORIGINAL RESEARCH

Hydrolysis of fish waste using fruit wastes of *Ananas comosus* and *Carica papaya* for the formulation of liquid fertilizers

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Abstract

Purpose Fish waste is a protein-rich source that can be used as a value-added product in the formulation of organic liquid fertilizers. This study carried out to investigate the utilizing potential of fruit wastes of *Ananas comosus* and *Carica papaya* that contain bromelain and papain as major proteases in order to hydrolyze fish waste proteins to fulfill plant nitrogen requirements.

Method Proteases were extracted from *A. comosus* (leaves, crown, unripe fruit pulp, ripe fruit peels and pulp) and *C. papaya* (leaves, ripe fruit peels and unripe fruit peels). The optimum temperature and pH for the enzymatic activities were determined. Four liquid organic fertilizers were produced with hydrolyzed fish waste that enriched by adding *Gliricidia sepium, Chromolaena odorata, Tithonia diversifolia*, *Mikania scandens* and coconut husk-ash. Fertilizers were tested on the growth of *Basella alba* comparing with a standard fertilizer.

Results *Ananas comosus* ripe fruit peels and the mixture of *(A. comosus + C. papaya)* showed the highest enzyme activities (0.33±0.02 and 0.36±0.01 U mL^{-1} enzyme respectively) at 55 °C and 70 °C. The optimum pH for all the studied extracts was 7.5 at 37 °C. The highest plant fresh and dry weights were recorded in the foliar-applied fertilizer produced by hydrolyzing the fish waste using *A. comosus* and *C. papaya,* showing no significant differences to the standard fertilizer.

Conclusion Hydrolysis of fish waste using the fruit wastes of *A. comosus* and *C. papaya* could be effectively used as an organic fertilizer for the growth of *B. alba* that leads towards sustainable waste management.

Keywords *Ananas comosus, Carica papaya,* Fish wastes, Plant-derived proteases, Organic liquid fertilizers

Introduction

Proteolytic enzymes are widely used in the hydrolysis of different protein substrates. Since ancient times, different fruit extracts were used to tenderize hard textured meat or fish flesh; however, it is now deliberately and more systematically practiced using plant, animal or microbial-derived proteolytic enzymes, i.e., papain, bromelain, ficin, pepsin, trypsin, pancreatin and alkalase (Islam and Molinar-Toribio 2013; Himonidase et al. 2011) to hydrolyze different collagen materials, i.e., fish scale, animal bones, leather waste, horns and feathers (Ekram and Prasetyo 2016; Damrongsakkul et al. 2007). Among them, papain is a major plant-derived endolytic cysteine protease that can be extracted from latex, fruits, leaves and roots of *Carica papaya* to degrade proteins into short-chain peptides, amino acid esters and amide links (Lambri et al. 2014; Vishal et al. 2013). Bromelain is another plant-derived cysteine protease from *Ananas comosus* that catalyzes the hydrolytic cleavages of the internal peptide bonds of the proteins (Ramalingam et al. 2012; Upadhyay et al. 2011).

Large amounts of *C. papaya* and *A. comosus* ripe fruit peels are generated as a by-product during the production of jams, jellies and cordials (Pathak et al. 2018; Lakshminarasimaiah et al. 2014; Thomas et al. 2008). Those fruit wastes are widely available in market complexes and agro-industrial yards as agro-waste produced during the harvesting, processing or post-har-

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