Development of a Meat Tenderizer Based on Papaya Peel

Mir N. Islam
Escuela de Hospitalidad, Universidad Interamericana de Panamá, Panamá, República de Panamá
mislam@laureate.edu.pa

Eunice M. Molinar-Toribio
Institute of Advanced Chemistry of Catalonia (IQAC-CSIC), Jordi Girona 18-26, 08034, Barcelona, Spain
eunice.molinar@iqac.csic.es

Abstract- *Green papaya (Carica papaya L.) peels, obtained as a waste product in the processing of papaya pickles, were dried and their proteolytic activity was compared with that of the enzyme in the papaya latex. The proteolytic activity of the enzyme in papaya peel was about 10 times lower than that in the latex. Taking into account the activity of the enzyme, spice batches were mixed with 30% and 45% papaya peels, in order to formulate meat tenderizers. According to the sensory evaluation of the cooked samples, the meat marinated with 30% of green papaya peel, for 2 h at room temperature had the highest level of acceptance for its soft texture and good flavor. In conclusion, green papaya peel, dried, ground, and mixed with various spices showed a great potential for use as a low-cost meat tenderizer. Furthermore, the process described here allows the conversion of papaya peels with a negative value to an essential value added ingredient.*

Keywords - *Green papaya peel, meat tenderizer, papain, sensory evaluation.*

Resumen-*La cáscara de papaya (Carica papaya L.) verde, obtenida como desecho en el procesamiento de los encurtidos, fue deshidratada y su actividad proteolítica fue comparada con la del látex de la fruta. La actividad proteolítica de la enzima en la cáscara de papaya fue casi 10 veces menor que la del látex. Tomando en cuenta la actividad de la enzima, se mezclaron diferentes especies con 30% y 45% de cáscara de papaya, para elaborar ablandadores de carne. Según la evaluación sensorial de las muestras cocinadas, la carne marinada por 2 horas a temperatura ambiente con un 30% de cáscara presentó la mejor aceptación por su suave textura y buen sabor. En conclusión, la cáscara de papaya verde deshidratada, molida y mezclada con diversas especies mostró un gran potencial de ser utilizada como un ablandador de carne de bajo costo. Por otro lado, el proceso aquí descrito permite la conversión de las cáscaras de papaya de valor negativo a un ingrediente esencial de valor agregado.*

Palabras claves - *Ablandador de carne, cáscara de papaya verde, evaluación sensorial, papaína*

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1. Introduction

Papaya (*Carica papaya* L.) is a common fruit grown all over the tropical world and it is well known for its health promoting properties [11]. Papaya peels are excellent sources of the enzyme papain [7]. Papain is an active endolytic cysteine protease (EC 3.4.22.2). It has a broad range of specificity among proteolytic enzymes and is relatively heat stable [14]. It has wide ranging commercial applications in the leather, cosmetic, textiles, detergents, food and pharmaceutical industries [8, 14, 3, 18]. In the food industry, papain is used as an active ingredient in many commercial meat tenderizers, because it is more active than other proteases [9]. However, the papain used in the formulation of meat tenderizers is usually derived from the latex of green fruit rather than from peels. The enzyme is commercially extracted by tapping the mature unripe fruit of the papaya tree making a series of incisions on each fruit with a sharp stainless steel blade. The latex which flows out is then collected and dried. This crude latex is further processed to produce eventually a spray-dried powder or concentrated into a stabilized preparation to incorporate into various products [17]. The tapping of papaya fruit and the subsequent steps for purification of the latex are labor intensive and require technically qualified personnel. As a result, the purified papain is far more expensive than the original crude material. If the final application of the enzyme does not require a high degree of purity, then it would be economically advantageous to utilize the crude material for the same intended effect. Commercial meat tenderizers usually contain a large amount of ingredients such as salt, dextrose, garlic powder, monosodium glutamate, etc. as fillers and only a small amount of the active ingredient (papain) which on a weight basis is the most expensive component of the entire formulation. Meat tenderness is a very important factor in consumer perception of meat quality [6]. In a tropical country like Panama, there are more grass-fed cattle than those raised on grain-fed lots. For a variety of reasons, grass-fed beef is preferred [5]. However, the grass-fed beef tends to be tougher especially if it comes from the areas like the chuck, brisket, round and shank which are the most exercised muscles. Meat tenderizers allow the meat to be cooked at lower temperature and for a shorter period of time, thus reducing the formation of heterocyclic amines and polycyclic aromatic hydrocarbons which have been implicated to promote cancer [4, 12].

Papain, obtained from the latex, is a very common ingredient in most commercial meat tenderizers. Papaya peels, representing only about 5% by weight of the green mature fruit, are not processed industrially for papain because of the lack of simultaneous commercial utilization of the remaining pulp. Recently a project was implemented to diversify the utilization of papaya by developing a series of products based on the green mature fruit. As part of this project, Islam & Molinar-Toribio [10] developed two pickle-type products based on the papaya pulp where the peels are a waste by-product and need to be disposed of with additional expense. The purpose of this particular study was to process the peels into a stable crude papain product and assess the feasibility of using it as a meat tenderizer.

2. Materials and Methods

2.1 Processing of Peel

Papaya used for this study was of the variety known as "Chola roja" which upon maturation weighs about 4-5 kg. The mature fruits (evidenced by appearance of slight yellowish color) were harvested manually in a farm located in San Carlos (Panama province) and brought to the laboratory in the city of Panama, Republic of Panama. The fruits (figure 1) were peeled within 24 h of the harvest scraping about 2.5-3.0 mm off the surface. A papaya weighing 4.5 kg yielded about 250 g of peels. Peels were finely ground utilizing a meat grinder (National Panasonic MK-G20NR-W) and based on earlier experience [7], sodium metabisulfite ($Na_2S_2O_5$) [16], at the rates of 0.0, 0.25, 0.5 and 0.75%, respectively were mixed to stabilize the papain therein. Samples of crude papain were dried at 50ºC in a fruit drier (Farberware Turbo oven model 460) for 5 h and then finely powdered using a spice blender (Osterizer 4937). They were packed in double layered stand-up pouch, sealed and stored at -20ºC until used. For comparison of papain activity, simultaneously about 100 g latex were collected in a plastic container at the papaya plantation and subsequently dried without any metabisulfite.

2.2 Assessment of Papain Activity

The proteolytic activity of crude papain samples were determined by measuring at 410 nm the amount of p-nitroaniline hydrolyzed from the substrate, N-benzoil-D-L-Arginine-p-Nitroanilide (BAPNA) by the papain [19, 13].

Figure 1. Papaya variety "Chola roja" and papaya peel as a waste by-product.

2.3 Formulation of Meat Tenderizer and Cooking

Based on general observations and ingredient lists of several commercial meat tenderizers, the following formulations were adopted to compare the efficacy of papaya peels.

Table 1. Formulation of meat tenderizer mixes.

Ingredients	Tenderizer A (g)	Tenderizer B (g)	Tenderizer C (g)
Powdered papaya peels	30.0	60.0	0.0
Indian Garam masala (*Swad*)	30.0	30.0	30.0
Salt	35.0	35.0	35.0
Sodium glutamate (*Ajinomoto*)	5.0	5.0	5.0
Total (g)	100.0	130.0	70.0

A total of 2 kg beef cubes for stew were purchased from the local supermarket. They were washed, drained, and three 500 g portions (A, B, C) were placed in glass bowls. To sample A, 10 g of the tenderizer A (table 1) was mixed in thoroughly. Similarly, to sample B, 13 g of the tenderizer B was mixed in.

Sample C or the control received 7 g of tenderizer C without any papaya peel.

That way every sample received equal amounts of spices, salt and monosodium glutamate which are typically added to commercial meat tenderizers to develop desirable flavor (table 1).

The meat samples were pricked by fork in equal manner, placed on aluminum foil and then left to marinate for 2 h at room temperature. Samples were cooked in an oven for 1 h at a temperature of 150°C (figure 2).

Figure 2. Cooked beef samples containing different levels of papaya peel.

2.4 Sensory Evaluation

A six-member panel (trained to evaluate cooked meat) judged the flavor, color and general acceptance of the cooked samples using a 5-point hedonic scale where 1 = poor and 5 = best desirable attribute. This being a study on meat tenderization, special emphasis was placed on texture, where 1 represented the toughest and 5 represented the most tender (not necessarily most desirable) as perceived by the teeth and palate. Data were analyzed statistically (ANOVA) to find any significant difference among the samples.

3. Results and Discussion

3.1 Enzyme Activity in Dried Peel

As expected from a previous study [7], sodium metabisulfite ($Na_2S_2O_5$) demonstrated a protective effect on papain activity during the drying of peels.
Also, $Na_2S_2O_5$ prevents the enzymatic browning of the papaya peels during dehydration.

Enzymatic browning starts with the initial enzymatic oxidation of phenols to quinones by the enzyme polyphenol oxidase in the presence of oxygen. Then these quinones are subjected to further reactions, enzymatically catalyzed or not, leading to the formation of pigments. The papain is a proteolytic enzyme that effectively inhibits enzymatic browning. This inhibitory effect is due to the hydrolysis of certain sites necessary for the activity of the enzyme polyphenol oxidase [15]. table 2 presents the papain activities in the dried latex and the papaya peels containing various levels of sodium metabisulfite. Based on the cost benefit ratio, peels treated with 0.5 % $Na_2S_2O_5$ were selected for subsequent formulation as a meat tenderizer. Dried papaya latex presented about 10 times more papain activity than dried papaya peel. In a comparative study [2], the peel proteases were found to be more stable in pH ≥ 8 and at 80°C than the latex proteases.

Table 2. Proteolytic activity of dried papaya latex compared with that of the dried peels containing various levels of $Na_2S_2O_5$.

Samples of papaya peels	Papain activity* (moles of p-nitroaniline hydrolyzed/mg)
Control	$3.77X10^{-8}$
Control + 0.25% $Na_2S_2O_5$	$6.07X 10^{-8}$
Control + 0.5% $Na_2S_2O_5$	$8.64X10^{-8}$
Control + 0.75% $Na_2S_2O_5$	$8.83X10^{-8}$
Papaya latex (dried)	$9.23X10^{-7}$

* Average of two samples

3.2 Sensory Evaluation

Data on the sensory evaluation of meat containing various levels of papaya peel as tenderizer are presented in table 3. Texture was the most important attribute to consider in this sensory evaluation. Papaya peels clearly had a tenderizing effect on the beef samples. Tenderizer B, which had twice as much peel as in tenderizer A, provided the tenderest meat. However the level of tenderness was excessive leading to a relatively poor flavor score (1.8±0.8). Based on the comments of the sensory panel, the meat was somewhat mushy and grainy like chopped liver. Also, it had a slightly bitter taste, perhaps due to the breakdown of some of the protein fibers to amino acids like L-tryptophan & L-tyrosine [1].

Table 3. Effect of papaya peel tenderizer on the sensory attributes of stew beef based on a hedonic scale.*

Tenderizers	Texture	Flavor	Color	General acceptance
Tenderizer A	$4.0 \pm 0.6^{b\#}$	$4.5 \pm 0.5^{c\#}$	$4.7 \pm 0.5^{a\#}$	$4.7 \pm 0.5^{c\#}$
Tenderizer B	4.8 ± 0.4^{c}	1.8 ± 0.8^{a}	4.8 ± 0.4^{a}	3.7 ± 0.5^{b}
Control C	1.5 ± 0.5^{a}	2.8 ± 0.8^{b}	4.7 ± 0.5^{a}	1.5 ± 0.5^{a}

*Mean ± standard deviation of scores given by six panel members using a hedonic scale of 1 to 5 where for texture, 1 represented the toughest and 5 represented the tenderest (not necessarily the most desirable). For flavor, color, and general acceptance, 1 represented poor and 5 excellent. #Means followed by different letters in the same column are significantly different ($p<0.01$).

In regard to color, the presence or absence of tenderizer did not make any difference beyond the color contribution of Garam masala. Garam masala is an Indian spice mix and it typically contains cinnamon, cloves, cardamom, etc. Except for color, in all other organoleptic characteristics samples were significantly different ($p>0.01$). Looking at the general acceptance, tenderizer A had the best score. Thus, it is quite conceivable that a marketable meat tenderizer can be formulated based on the dried papaya peels which are a waste by-product of processing green mature papaya for novel products like pickles [10]. The peels as a waste by-product need to be disposed of the premise and thus have a negative value. Whereas in the manufacture of commercial meat tenderizers, papain, extracted from papaya latex, is the most expensive ingredient. The process described here allows the conversion of the negatively-valued waste peels into a positively-valued essential ingredient leading to a low-cost meat tenderizer.

4. Conclusion

The traditional method of extraction of latex from the green mature papaya requires a lot of manual labor. The subsequent handling and purification of the latex is a sophisticated process and requires technically qualified personnel. Thus the finished papain product becomes rather expensive. Whereas for final application as a meat tenderizer, the purity of the papain is not that important as it is diluted by other ingredients for flavor and for better distribution on the meat surface. In dry inexpensive papaya peels, the concentration of the papain is about 10 times lower than in latex. However, based on the sensory evaluation, the peels still provide sufficient proteolytic activity for tenderizing meat. As a matter of fact, at higher concentration (tenderizer B), the peels had the ability to over-tenderize the meat. Thus, in conclusion, dried papaya peel is a viable low-cost but effective ingredient in the formulation of commercial meat tenderizers. Coupled with the production of papaya pickles, the peels as a waste by-product could make a significant contribution toward the overall return from the investment in a papaya processing factory. The findings of this study further justify the diversification in the utilization of papaya which can lead to more job creations and greater economic welfare for the country.

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