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# Characterization of unsold *Lechon* as raw material for retort product development

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# ABSTRACT

Unsold Lechon of producers in Tacloban City reaches up to 200 kilograms, which necessitates a reworking process to prevent wastage, the additional cost of storage, and eventually profit loss. However, its characterization as a raw material needs to be conducted first to understand various properties, which would lead to the establishment of a suitable process and product formulation. The study objectives were to conduct an industry immersion and market assessment and determine the physicochemical, microbial, and organoleptic properties of unsold Lechon. The industry immersion exposed the need for improvement of food safety practices of the food handlers and revealed that the head, ham, butt, and picnic shoulder are the typically unsold parts. In terms of its physicochemical properties, the unsold Lechon is near neutral in pH and had high water activity and moisture content, which indicates susceptibility to microbial proliferation. Varying crude fat and crude protein levels specify that the meat and fat ratio should be included as variables in the product development stage. Meanwhile, the microbial analysis revealed a high microbial load with the possibility of toxin production; time series evaluation identifying sample collection to be before 4:00 pm, and freeze-thaw cycle recommending to store samples at <-18°C for not more than 48 hours. Quantitative Descriptive Analysis (QDA®) showed that pre-treatment of raw materials is not necessary with the identified important sensory descriptors through factor and principal component analysis. Lastly, the market assessment showed that Lechon paksiw is the preferred product to be developed with a market potential of 6.01kgs/household per annum.

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#### INTRODUCTION

'*Lechon*' is a very common pork dish in the Philippines, especially in different celebrations, such as birthdays, festivals or fiestas, weddings, or any get-togethers. The word '*Lechon*' is a Spanish term 'Leche,' which means milk, thus previously called 'Lechon de Leche' or 'suckling pig,' that is skewered and roasted over heated charcoal (Codiam, 2020). As such, every municipality and city in the Philippines has *Lechon* producers.

The Tacloban City Litson Industry Association (TACLIYA) is a group of micro-entrepreneurs producing 'Lechon' (roasted pig) in Tacloban City. On the daily production, an average excess 'Lechon' of 30 kilograms is collated and surges up to 200 kilograms during off-peak season. These unsold products triggered problems of storage, storage cost, spoilage and wastage, and eventually profit loss. Thus, the need for processing techniques to rework the unsold 'Lechon' is imperative. Reworking will introduce additional preservation methods, create convenience, and generate value addition to the product that will ultimately increase income for the association.

Ingredients, processing, and packaging materials used in manufacturing food products are the foundation for producing quality finished goods. To ensure this, raw materials must satisfy regulatory requirements, safe and legal for intended use, and have the characteristics for processes to function as well as the maximum quality for product development (Amsbary, 2013). As such raw materials influence the quality of the end products to the highest degree. According to USFDA GMP, 110.80 "raw materials and other ingredients shall either not contain levels of microorganisms that may produce food poisoning or other diseases in humans, or they shall be pasteurized or otherwise treated during manufacturing operations so that they no longer contain levels that would cause the product to be adulterated within the meaning of the act". Meat as raw material is highly perishable due to its high moisture and water activity, thus susceptible to microbial proliferation (Hui, et. al. 2012).

Thus, to assure the quality and safety of the unsold *Lechon* as a starting material, characterization before and after freezing was performed. This will also be the basis for storage and treatment of the 'unsold *Lechon*' before processing, product formulation, and profiling as characterization is not limited to the microbial quality, but also the physico- chemical and organoleptic characteristics of the raw material.

#### **OBJECTIVES OF THE STUDY**

Generally, this study aimed to characterize unsold *Lechon* as raw material to develop a retorted product. Specifically, it aimed to: 1) conduct a *Lechon* industry immersion and documentation; 2) determine the Physico-chemical characteristics of the unsold *Lechon*; 3) determine the microbiological quality of the raw material; 4) evaluate the organoleptic properties through Sensory Evaluation; and 5) conduct market assessment as a basis for product development.

#### MATERIALS AND METHODS

# Industry Immersion and Documentation

Characterization of 'unsold *Lechon*' as raw material started with the observation of TACLIYA members' whole process, from slaughter until the products has deemed unsold. Practices were evaluated using FDA Administrative Order 0153 series of 2004 in terms of storage means, typical parts of meat usually left unsold, profits and losses, and others were also documented. Interviews were done face-to-face under strict COVID-19 protocols, and through phone discussions. Basic food safety and GMP training were also conducted for all members of the association.

Sample collection

From the result of the industry immersion, 'unsold *Lechon*' are generally frozen or sold in the evening or the next day at a lower price. Thus, in determining the characteristics, both freshly unsold and frozen samples were collected, based on the pork meat sections where muscles differ in rigidity and structure (Figure 1). The time of collection was 3-5 pm when products are deemed unsold and no sales are reached.

## Sample preparation

Different samples of the different meat parts were sliced using a sanitized tool and placed in freezer bags for further analysis. Samples intended to be frozen were placed in a chest freezer with a temperature of  $\leq$ -12.

Determination of Physico-Chemical Characteristics

- i *pH determination* was performed in Eastern Visayas Food Innovation Center (EVFIC) using a benchtop electrode pH Meter (Thermo-Scientific Orion Star A211, USA). Readings were done in triplicate.
- ii. *Water activity* was determined using a benchtop water activity meter (Smart Water Activity HD- 3A). Triplicate readings were performed and the means were recorded as the Aw of the samples.
- ii. *Proximate Analysis* samples of typically unsold *Lechon* parts (Ham, Head, Picnic, and Butt) were submitted to the Animal Science Laboratory of Visayas State University for proximate analysis which included determination of Moisture Content, Dry Matter, Ash Content, Crude Protein, and Ether Extract (Crude Fat)

Significant differences in Aw and pH of samples in terms of the parts, stalls, and type (fresh and frozen) were determined using Analysis of Variance for the main factor, two-factor, and three-factor interactions.



Fig. 1. Division of pork cuts as sampling protocol (Source:https://metropolitanmarket.com/departments/seattle-butcher-shops-new/pork/)

# Determination of Microbial Quality

Three (3) samples per part of usually 'unsold lechon' were collected and microbiologically analyzed. Analysis conducted were Aerobic Plate Count, Coliform Count / *Escherichia coli* Count, *Staphylococcus aureus* Count, Molds and Yeast Count, and Listeria detection with a combination of rapid (3M<sup>TM</sup> Petrifilm<sup>TM</sup>) and conventional methods according to the Bacteriological Analytical Manual Online, performed at DOST Region 8 RSTL.

Freeze and Thaw Sequence was also conducted since the numbers of vegetative microorganisms were expected to decline when frozen but were possible to increase when thawed. One microorganism particular in food handlers is *Staphylococcus aureus*, which may produce enterotoxins at critical levels. To determine the magnitude

of the problem with pathogens, 'unsold lechon' samples were pre-inoculated with 0.1 mL 4th passage of revived ATCC® 25923<sup>TM</sup> *Staphylococcus aureus* and ATCC® 25922<sup>TM</sup> *Escherichia coli* on Tryptic Soy Broth (TSB, Merck). Freezing and abusing of prepared samples were sequenced as in (Table 1):

Table 1. Freeze-thaw sequence								
Day	Abuse temperature cycle	No. of packages remaining						
1	24 hr at -18°C	5						
2	20 hr at -18°C, 4 hr at 38°C	4						
3	20 hr at -18°C, 4 hr at 38°C	3						
4	20 hr at -18°C, 4 hr at 38°C	2						
5	20 hr at -18°C, 4 hr at 38°C	1						

Table 1. Freeze-thaw sequence

Source: Fennema, 1996.

Five (5) packages of samples were placed at -18°C for 24 hours. A single package was removed at the end of day one (1) and analyzed for microbiological indicators, while others are left at -18°C. The next day, the remaining samples were abused at 38°C for 4 hours and were returned to -18°C. Another package was then removed for microbial analysis and the cycle was repeated for the other packages. The calculated values of each microorganism on different days were statistically analyzed and if there was no significant increase after five (5) days, the sample was deemed safe microbiologically (Fennema, 1996).

**Evaluation of Organoleptic Properties** 

Since discriminative and descriptive tests were used to characterize the organoleptic properties of the raw material, a sensory panel was formed. Activities conducted were:

a) Panel Recruitment

Willing prospective panelists were given Pre-Screening Questionnaires and Product Attitude Survey Forms to determine availability, health and allergy issues, diet restrictions, sensory impairment, and others.

b) Screening and Selection

Pre-screened individuals with no health and other concerns underwent different screening tests at DOST 8 RSTL Sensory Evaluation Laboratory to assess their sensory acuity which included: the Ishihara test; Color Threshold test; Odor Recognition test; Basic Taste Recognition test, and Taste Threshold test. Methods used were taken from ISO 8586-1:1993 and ISO 22935-1 IDF99-1: 2009.

c) Training of Screened and Selected Assessors

Selected and trained assessors were invited and were given the Study Protocol and Voluntary Consent Form that was previously approved by the Ethical Review Committee of Eastern Visayas Health Research and Development Consortium (EVHRDC).

Selected assessors were invited for a 2-day webinar discussing the basic concepts and methods used in sensory evaluation, as well as protocols and factors influencing sensory measurements, and trained on discriminative and descriptive analysis. Repeated measurements and discussion were performed until each value was as close as the mean of the whole group.

d) Triangle Test

Assessors were asked to choose the one that differed from the other two randomly coded samples to confirm if there was a difference between the freshly unsold and frozen *Lechon* as raw material or if they can be processed as either fresh or frozen. From Table A.3 of ISO 4120:2004, 25 assessors ensured that the test had a 95% ( $\alpha = 0.20$ ,  $\beta=0.05$  and Pd=50% is n=25) chance of detecting in which 50% of the assessors can distinguish a difference between samples.

#### e) Quantitative Descriptive Analysis (QDA®)

i. Descriptive Terminology Generation

Since '*Lechon*' is very common in Filipino cuisine, assessors were expected to be well acquainted with the profile of the product. Samples were provided to observe, detect, evaluate, perceive, and list down terms, which came to mind on five (5) categorical parameters namely: Appearance; Aroma; Taste; Mouthfeel; and Residual. From the generated descriptors, an open discussion was conducted to have a consensus on terms to use and a definition of the attributes best suited to describe the raw material.

ii. Descriptive Evaluation

The 6-inch line scale anchored at 0.5 inches at each end with intensity reading from left to right (Stone and Sidel, 2004) was used. With each descriptor evaluated, assessors were tasked to place a vertical line on the scale complementing the intensity of each descriptor.

The lines were measured numerically and graphed in spider plots. Mean sensory ratings were subjected to analysis of variance and were run with factor and principal component analyses to determine important descriptions of the samples.

#### Market Assessment

At least 300 respondents were discussed with and given the survey questionnaires adapted from several market assessment studies in the Department of Food Science and Technology of Visayas State University. The number of respondents considered was according to the 2015 Census of Population by the Philippine Statistics Authority (PSA). The City of Tacloban has a total population of 241,089, meanwhile, statistical reliability at the 95% confidence level, with an accuracy of  $\pm$  5% is normally recommended, as reflected by Hardwick Research in 2020 (Figure 2).

	Population									
Sample Size	100	500	1,000	5,000	10,000	100,000	1 Mill+			
30	±14.7%	±17.1%	±17.3%	±17.6%	±17.7%	±17.8%	±17.9%			
50	±9.7%	±13.1%	±13.5%	±13.8%	±13.9%	±14.0%	±14.1%			
75	±5.6%	±10.4%	±10.9%	±11.3%	±11.4%	±11.5%	±11.6%			
100		±8.8%	±9.3%	±9.7%	±9.8%	±9.9%	±10.0%			
200		±5.4%	±6.2%	±6.8%	±6.9%	±7.0%	±7.1%			
300		±3.6%	±4.7%	±5.5%	±5.6%	±5.7%	±5.8%			
400		±2.2%	±3.8%	±4.7%	±4.8%	±4.9%	±5.0%			
525			±3.0%	±4.1%	±4.2%	±4.3%	±4.4%			
725			±1.9%	±3.4%	±3.5%	±3.6%	±3.7%			
800			±1.6%	±3.2%	±3.4%	±3.5%	±3.6%			

Statistical Reliability at the 95% Confidence Level (50/50% proportion characteristic)

Fig. 2. Statistical Reliability at the 95% Confidence Level (Hardwick Research, 2020)

# **RESULTS AND DISCUSSION**

Industry Immersion and Documentation

Table 2 presents the summary of the responses gathered using industry immersion guide questions. The maturity of the pig they culled usually ranged from 2 to 5 months of which were either mistiso, largely white, semi-native or native, which were delivered by their contacts from nearby municipalities. The pigs usually ranged from 17kgs to 70 kgs and took about 2 to 2.5 hours of cooking. Commonly unsold *Lechon* parts are the head, ham, butt, and picnic shoulders, which are displayed up to 9 p.m.

Industry Immersion Guide	Responses
1. Maturity/age of culled pig	2-5 months
2. Breed of pig	Mistiso, Bisaya, Native, Large White, Semi native, Mixed Bisaya,
3. Weight of pig usually culled	17-70 kgs.
4. Ingredients	Garlic, Onion, Pepper, Salt, Lemongrass, Seasoning,
5. Weight of unsold <i>Lechon</i> in peak season (monthly)	2-3kgs.
6. Weight of unsold <i>Lechon</i> off-peak season (monthly)	5-20 kgs.
7. Usually unsold part	Head, Shoulder, Picnic, and Ham
8. Selling of unsold Lechon	Sold to canteen, restaurants
9. Means of handling	Frozen
10. Means of storage	Freezer
11. Means of transport	Motor vehicle
12. Duration of <i>Lechon</i> displayed in stalls	7:00 AM to 9:00 PM

Table 2. Industry Immersion Guide Questions and Responses

Their handling, personnel, facility, equipment, and others about food safety were observed and recorded from the slaughter until the '*Lechon*' is deemed unsold. The activity was somewhat of a food safety audit following the GMP AO153 series of 2004. Areas inspected were: Food safety systems; Equipment; Pest control; Personnel practices; and Cleaning and Sanitation. Recurring observations and deviations detected towards food safety and needed to be addressed were the following: no pest and animal control system; no water potability testing of inprocess water (slaughter and stall); no proper sanitation of equipment used especially food contact surfaces, and use of wooden materials and surfaces; no proper storage areas for materials used; no proper drainage system; no proper PPE's; no proper personal hygiene; and no proper waste or garbage disposal. Actions taken due to the results of the inspection were: Water Potability Testing; Food Safety Training; Posting of Infographics and in-depth discussion on personnel hygiene.

#### Physico-Chemical Characteristics

pH and Aw determination for both freshly unsold and frozen *Lechon* samples were tested to assess whether there is a difference between them as the starting raw material or if further pre-treatment is needed before processing. The results of the performed analysis are presented in Table 3. The results showed significant differences in the main factors, two-factor, and three-factor interactions of the variables at a 5% level of significance. These can be attributed to the difference in muscle structures of the six (6) divisions of the meat. The hind part tends to have more relaxed muscles than the front part, while the belly and loin have more loose muscle strands. Rigid muscles take in and bind more moisture or water, thus having a low water activity. When frozen, free, and some bound water crystalized, then melt when thawed thus, lowering the pH.

Meanwhile, Table 4 presents the proximate analysis results of the unsold '*Lechon*' samples. High moisture content indicates susceptibility to microbial proliferation, thus proper handling and further processing are recommended. The deviation of % protein and % fat per part suggest inclusion as variables in the product formulation in developing the product.

Table 3. Analysis of Variance for the pH and Aw determination							
Source of Variation	pH p-value	Aw p-value					
Main Factor							
Sample (diff. stalls)	0.000	0.051					
Part (6 divisions)	0.000	0.000					
Type (fresh vs frozen)	0.000	0.002					
Two-factor Interaction							
Sample * Part	0.000	0.100					
Sample * Type	0.000	0.018					
Part * Type	0.000	0.000					
Three-factor Interaction							
Sample * Part * Type	0.000	0.000					

*Note: Red font color indicates significance > 95% level of confidence* 

Sample	Moisture Content (%)	Dry Matter (%)	Ash (%)	Crude Protein (%)	Ether Extract (%)
Ham	64.1357	35.8643	4.5372	70.8743	49.1005
Butt Shoulder	66.2474	33.7526	5.5217	57.8321	18.1031
Picnic	67.9503	32.0497	5.9460	47.2450	6.3694
Head	40.7468	59.2532	5.6955	24.7281	14.3327
Average	59.7701	40.2300	5.4251	50.1699	21.9764
Std. Dev	12.77779	12.77779	0.617023	19.52111	18.73254

radie is reduinate rinary did redaitd	Table 4.	Proximate	Analysis	results
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Microbiological Quality

'Unsold lechon' are markedly high in bacterial counts because they are displayed all day in stalls without refrigeration and are handled constantly during weighing when sold in kilos. As shown in Table 5 and Figure 3 all unsold '*Lechon*' samples from different stall owners have high microbial loads including pathogenic microorganisms. The results were expected since '*Lechon*' are displayed for prolonged periods from early morning until night. Temperature abuse repeated handling, and environmental conditions played vital roles in the proliferation of these microbes.

Table 5. Summary	of the	Microbial	Results
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Parts No. &	Sample/	APC	Coliform	E. coli	S. aureus	Molds	Yeast
Name	Stall No.	(cfu/g)	(cfu/g)	(cfu/g)	(cfu/g)	(cfu/g)	(cfu/g)
	1	520,000	120,000	<1,100	<1,600	1,700	59,000
01 Ham/Leg	2	3,700,000	920,000	<800	<12,000	5,800	8,900
	3	TNTC	liquified	liquified	<850	1,100	7,700
	Mean	2,110,000	520,000	<950	<14,450	2,867	25,200
	1	130,000	25,000	<12,000	870,000	<9,000	13,000
03 Butt	2	1,200,000	95,000	<11,000	570,000	<1,000	<10,000
Shoulder	3	2,300,000	160,000	<12,000	1,200,000	<1,500	<1,500
	Mean	1,210,000	93,333	<11,667	880,000	<3,833	<8,167
	1	900,000	30,000	<10,000	590,000	<1,000	3,300
05 Picnic	2	3,000,000	670,000	<60,000	820,000	<3,700	39,000
	3	770,000	35,000	<4,000	340,000	<1,700	<5,000
	Mean	1,556,667	245,000	<24,667	583,333	<2,133	<15,767

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Table 5. Summary of the Microbial Results (continuation)									
	1	450,000	56,000	2,800	52,000	<370	13,000		
06 Head	2	8,800,000	1,600,000	<100	3,800,000	3,500	9,600		
	3	1,800,000	1,600,000	TNTC	3,800	1,800	120,000		
	Mean	3,683,333	1,085,333	<1,450	1,285,267	<1,890	47,533		

Note: specific stall owner is anonymous to maintain confidentiality

Concerns stirred on the safety of 'unsold lechon' as raw material due to the high levels of *S. aureus* and Coliform, where enterotoxin production is expected. When the toxin is performed before processing, there is a high probability of foodborne illnesses. In addition, toxins have very structured and rigid membranes that are difficult to penetrate even at high temperatures. This means that despite exposure to high retort temperatures, toxins are still not inactivated.



Fig. 3. Samples of Microbial results: (a) Aerobic Plate Count PC; (b) Staphylococcus aureus; (c) Coliform and Escherichia coli; (d) Molds and Yeast Count; (e) Listeria spp. on Chromogenic and Esculin based agars; and (f) Motility test, Catalase Test and Gram Staining

Detection of toxin analysis was considered; however, equipment and other materials were not available, hence, a time series evaluation was performed instead. Microbial analysis was done four (4) times within the day at intervals from 9:00 AM to 4:00 PM. This then allowed the determination of the allowable time of collection at which samples are deemed safe and toxin-free. Table 6 summarizes the results of the analysis conducted.

	Table 6. Summary of Time Series Analysis Result								
	Stall		Coliforn	n (cfu/g)		Staph	ylococcus	<i>aureus</i> (cfu	ı/g)
Part	No.	9:00	12:00	2:00	4:00	9:00	12:00	2:00	4:00
		AM	PM	PM	PM	AM	PM	PM	PM
01	1	$52x10^{2}$	96x10 <sup>3</sup>	$16x10^{4}$	$21 \times 10^{5}$	$61x10^4$	$11 \times 10^{5}$	$18 \times 10^{5}$	TNTC
Ham	2	$80x10^{3}$	$96x10^{3}$	$12x10^{4}$	TNTC	96x10 <sup>4</sup>	$10x10^{5}$	15x10 <sup>5</sup>	TNTC
	3		46x10 <sup>4</sup>	$60x10^4$	TNTC		$71x10^{4}$	26x10 <sup>5</sup>	TNTC
06	1		$80x10^{3}$	$76 \times 10^4$	$21 \times 10^{5}$		$20x10^{5}$	26x10 <sup>5</sup>	TNTC
Head	2	$24x10^{3}$	$11x10^{4}$	$47x10^{4}$	TNTC	$44x10^{4}$	$14x10^{5}$	$41 \times 10^{5}$	TNTC
	3	$52x10^{2}$	$79x10^{2}$	$14x10^{3}$	$84x10^{3}$	$84x10^{4}$	$11x10^{5}$	$18 \times 10^{5}$	21x10 <sup>5</sup>
03	1	$32x10^{2}$	$71x10^{2}$	$46x10^{3}$	$10x10^{5}$	96x10 <sup>3</sup>	$17x10^{4}$	$12x10^{5}$	23x10 <sup>5</sup>
Butt	2	$51x10^{2}$	$11x10^{3}$	$62x10^{3}$	$24x10^{5}$	$11x10^{3}$	$11x10^{4}$	$84x10^{4}$	TNTC
	3	$45 \times 10^2$	66x10 <sup>4</sup>	$69x10^{4}$	TNTC	$11x10^{4}$	55x10 <sup>5</sup>	$90x10^{5}$	TNTC
05	1	$23x10^{2}$	$10x10^{4}$	$11x10^{5}$	TNTC	$45x10^{3}$	$11x10^{5}$	$71 \times 10^{5}$	TNTC
Picnic	2	$40x10^{3}$	$70x10^{3}$	$70x10^{4}$	53x10 <sup>5</sup>	$90x10^{2}$	$52x10^{4}$	$84x10^{4}$	TNTC
	3	81x10 <sup>2</sup>	86x10 <sup>2</sup>	96x10 <sup>3</sup>	26x10 <sup>5</sup>	55x10 <sup>3</sup>	$12x10^{4}$	$72x10^{4}$	TNTC

According to FDA Circular No. 2013-010, at levels  $>10^5$  cfu/g of pathogens, toxins are produced at detectable levels. Thus, based on the results of the time series evaluation, samples must be collected before 4 pm to avoid producing pre-formed toxins before processing. Moreover, it can be noticed that some samples have low counts for both microorganisms, which suggests that with safe food handling practices and protocols lower microbial load is possible.

In the freeze-thaw cycle performed, Figure 4, Log10 mean *E. coli* counts for butt shoulder steadily declined until the 4th day which then increased on the 5th day together with the ham and picnic parts of the unsold *Lechon*. However, the lowest log value for picnic and ham was on the 2nd day and 3rd day, respectively. The highest *E. coli* count for the head part was on the 4th day and had a steep decline towards the 5th day.



Fig. 4. Log10 values of Escherichia coli count from Day 1 to Day 5

46 https://irjstem.com The butt shoulder had the highest log mean counts of *Staphylococcus aureus* (Figure 5), among all parts. It continuously increased until reaching the peak log count of 7.19 cfu/g by the 3rd day. On the other hand, counts for the head and picnic parts on the same day are the lowest but increased towards the 5th day. Only microbial counts of the ham part declined on the 2nd day, which then steadily increased up to the 5th day.



Fig. 5. Log10 values of Staphylococcus aureus count from Day 1 to Day 5

To determine the significant differences in the number of both microbial indicators throughout the cycle and also the daily differences between parts, log10 mean values were analyzed using a One-Way Analysis of Variance. Multiple comparisons using Tukey HSD were also performed post-hoc and also to determine which day(s) gave a significant increase or decrease in values.

Based on the results (Tables 7 - 8), tests for differences in the viable mean counts of *Escherichia coli* and *Staphylococcus aureus* per part from day1 to day5 freeze-thaw cycle and daily differences between parts were found to be significantly different at 99% level of significance (p-value < 0.001).

	part of unsold <i>techon</i> Day't to Day's neeze-thaw cycle								
	Microbe	Head	Butt	Picnic	Ham				
			Shoulder						
F-value	E.coli	483.620***	548.580***	973.143***	433.872***				
_	S. aureus	37.605**	1228.325***	432.833***	239.101***				
p-value	E.coli	0.000	0.000	0.000	0.000				
	S. aureus	0.001	0.000	0.000	0.000				
		1.1.1.1	0.0011 1.0.1						

Table 7. Summary of ANOVA F-value for Escherichia coli and Staphylococcus aureus count perpart of unsold lechon Day1 to Day5 freeze-thaw cycle

Note: \*\*\* - significant 0.001 level of significance

Results of the performed posthoc test (Table 9), indicated a significant increase which was also the peak values, on Day 3 to Day 4 for the head part, and Day 4 to Day 5 for the butt and ham parts. Meanwhile, a significant decrease was found to be on Day 4 to Day 5 for the head part, Day 2 to Day 3 for the ham part, and Day 1 to Day 4 for the butt shoulder. The picnic part d a fluctuating log10 values for *E. coli* counts.

Table 8. Summary of ANOVA F-value for Escherichia coli and Staphylococcus aureus count perA day between parts of unsold Lechon

	Microbe	Day 1	Day 2	Day 3	Day 4	Day 5			
F-value	E.coli	647.150***	5375.504***	194.651***	343.381***	542.873***			
-	S. aureus	1268.545***	1510.032***	6348.861***	555.300***	396.745***			

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p-value	E.coli	0.000	0.000	0.000	0.000	0.000
	S. aureus	0.000	0.000	0.000	0.000	0.000

Note: \*\*\* - significant 0.001 level of significance

# Table 9. Tukey HSD Multiple Comparison for Escherichia coli count between parts of unsoldlechon following Day1 to Day5 freeze-thaw cycle

		Fre	eze-Thaw Cycle		
Part	Day1	Day2	Day3	Day4	Day5
	(+ 0.022 log cfu/g) (+	0.013 log cfu/g) (+	$0.036 \log cfu/g)$ (+	0.052 log cfu/g) (+	0.110 log cfu/g)
Head ( <u>+</u> 0.098 log cfu/g)	5.380211 <sup>cx</sup>	4.792392 <sup>bz</sup>	5.255273 <sup>cy</sup>	6.113943 <sup>dz</sup>	2.176091 <sup>az</sup>
Butt Shoulder ( <u>+</u> 0.035 log cfu/g)	6.041393 <sup>cx</sup>	5.230449 <sup>bw</sup>	4.662758 <sup>ax</sup>	4.591065 <sup>ax</sup>	5.361728 <sup>bx</sup>
Picnic ( <u>+</u> 0.031 log cfu/g)	6.176091 <sup>ey</sup>	4.414973 <sup>ax</sup>	5.30103 <sup>cy</sup>	4.80618 <sup>bx</sup>	5.518514 <sup>dx</sup>
Ham (+0.040 log cfu/g)	5.462398 <sup>bz</sup>	5.934498 <sup>cy</sup>	4.643453 <sup>ax</sup>	5.414973 <sup>by</sup>	6.20412 <sup>dy</sup>

Note: Means followed by different letters indicate differences by Tukey HSD test at a 0.05 level of significance. Values under each heading correspond to its mean standard errors (a-e) - per part throughout the cycle (row). (w-z) - between parts within a day of the cycle (column)

The result of the posthoc test (Table 10) for the viable mean log counts of *Staphylococcus aureus*, indicated a significant increase which was also the peak values on both Day 1 to Day 2 and Day 3 to Day 4 for the head part, Day 1 to Day 3 for the butt part, Day 1 to 2 for the ham part, and Day 3 to Day 5 for the picnic part. On the other hand, significantly decreased microbial counts were found to be on Day 2 to 3 for the head part, Day 3 to Day 4 for the butt shoulder part, and Day 1 to Day 2 for the ham part. Low microbial counts which were not significant from each other were noted on Day 1 to Day 3 for the picnic part.

Tonowing Day1 to Day5 freeze-thaw cycle							
	Freeze-Thaw Cycle						
Part	Day1	Day2	Day3	Day4	Day5		
	(+ 0.028 log cfu/g)	(+ 0.043 log cfu/g)	(+ 0.023 log cfu/g)	(+ 0.039 log cfu/g)	(+ 0.044 log cfu/g)		
Head							
( <u>+</u> 0.038 log cfu/g)	4.544068ay	4.90309bz	4.568202ay	4.869232bz	4.763428bz		
Butt Shoulder							
$(\pm 0.022 \log cfu/g)$	5.973128ax	7.093422cx	7.20412dx	6.30103bx	6.255273bx		
Picnic							
$(\pm 0.038 \log cfu/g)$	4.643453ay	4.7075702ay	4.579784ay	5.447158by	5.80618cy		
Ham							
(+0.044 log cfu/g)	5.579784cz	4.5910646ay	4.80618bz	4.959041bz	5.681241cy		

Table 10. Tukey HSD Multiple Comparison for Staphylococcus aureuscount between partsfollowing Day1 to Day5 freeze-thaw cycle

Note: Means followed by different letters indicate difference by Tukey HSD test at a 0.05 level of significance. Values under each heading correspond to its mean standard errors (a-e) - per part throughout the cycle (row). (w-z) - between parts within a day of the cycle (column)

The log values of the microbial indicators were fluctuating throughout the freeze-thaw cycles giving no clear indication of when the samples would still be microbiologically safe. These may be attributed to: the microbial growth curve of each pathogen; cell rupturing or injury due to the formation of large ice crystals; the revival of microorganisms due to the availability of moisture during thawing; pH changes; homogeneity of solid samples; and physical characteristics of the different parts of the "*Lechon*".

In this regard, it is suggested that the raw materials are to be processed immediately. However, if this is not possible, the unsold "*Lechon*" is to be stored not more than 48 hours constantly at  $\leq -18^{\circ}$ C.

#### **Organoleptic Properties**

### Training and selection of sensory evaluators

Out of the (38) screened and trained candidate panelists, only (13) passed to be part of the discrimination and descriptive tests. These assessors got a 100% score on the Basic Taste Recognition Test. The decision for the selection is mainly due to the savory nature of the product to be developed and meatiness is generally attributed to umami taste. Other assessors are included as panel members for the effective tests of the products to be developed.

### Triangle Test

A summary of the number of detected differences between fresh and frozen different parts of typically 'unsold *Lechon*' is presented in Table 11, while the summary of confidence interval calculations is shown in Table 12.

Table 11. Summary of Number of detected and undetected differences between	fresh and fro	ozen unsol	ld
Lechon using Triangle Test.			

Responses			n=25	
F	Leg	Shoulder	Picnic	Ham
Detected	14	13	10	13
Not detected	11	12	15	12
α-risk level	$\alpha = 0.05$	$\alpha = 0.05$	"no difference"	$\alpha = 0.05$

Confidence interval calculations, on the proportion of the population that can distinguish the samples.

- $p_c(proportion \ correct) = \frac{x}{n}$
- $\hat{p}_d(proportion \ distinguished) = 1.5 \ p_c 0.5$
- $s_d(standard \ deviation \ of \ \hat{p}_d) = 1.5 \sqrt{p_c(1-p_c)/n}$
- upper confidence limit =  $\hat{p}_d + z_\alpha s_d$
- lower confidence limit =  $\hat{p}_d z_\alpha s_d$

Where  $z_{\alpha} = 1.64$  for a 95% confidence interval

	01 0011100110			
Confidence interval calculations	Leg	Shoulder	Picnic	Ham
p <sub>c</sub> (proportion correct)	0.56	0.52	0.40	0.52
$\hat{p}_d = (proportion \ distinguished)$	0.34	0.28	0.10	0.28
$s_d = standard \ deviation$	0.1489	0.1499	0.1470	0.1499
95% upper confidence limit	0.58	0.53	0.34	0.53
95% lower confidence limit	0.10	0.03	-0.14	0.03

Table 12.	Summarv	of Confidence	Interval	Calculations
1 4010 12.	Summury	or confidence	morvar	Culculutons

Only the picnic sample with a lower 95% confidence limit = -0.15, indicating no perceptible difference between the samples, unlike the leg, shoulder, and ham samples.

Quantitative Descriptive Analysis (QDA®)

Of the (13) invited panel members for the QDA, ten (10) participated in the training and term generation while nine (9) in the descriptive evaluation. There were equal numbers of males and females among the ten (10) recruits, with an age range of 20 to 32. Demographics were not anticipated to affect their evaluation since training was conducted. In the lexicon development activity, generated descriptors that best describe the raw material per category were identified (Tables 13) and defined (Table 14).

Appearance	Aroma	Taste/Flavor	Mouthfeel	Residual
Fatty	Distinct Lechon	Distinct Lechon		
Crispy (skin)	Aroma	Taste/Flavor	Crunchy (skin)	Greasy
Reddish (skin)	Aromatic	Salty	Tender (meat)	Spicy
Doneness	Smoky	Meaty	Juicy (meat)	aftertaste
		Spicy		

	Tuble 11. Definitions of each descriptor		
Attribute	Consensus Definition		
Fatty	Fat to lean ratio where the least intensity is the leanest while the highest intensity is the fattiest		
Crispy (skin)	In terms of visual brittle texture observation		
Reddish (skin)	The least intensity is red-orange while the preferable color of <i>Lechon</i> skin is brownish-red (highest intensity)		
Doneness	degree of cookness of the meat (bloody to well-done)		
Distinct Lechon Aroma	since meat has several organic volatile compounds, this collective term is used		
Aromatic	in terms of the herbs and spices used (pepper, garlic, bay leaves, lemongrass, star anis, etc.)		
Smoky	the infusion of smoke from roasting		
Distinct Lechon Taste/Flavor	collective term for the taste from the volatile compounds of the meat, smoke, herbs, and spices used		
Salty	degree of saltiness of the meat (4% is considered salty)		
Meaty	amino acids volatile compounds in meat + umami		
Spicy	taste from herbs and spices used		
Crunchy (skin)	crisp noise will be perceived when bitten		
Tender(meat)	the softness of the meat pieces, easy to chew		
Juicy (meat)	fluid exuded from the meat upon chewing		
Greasy	oily feel on the lips when expectorating		
Spicy aftertaste	herbs and spices that linger during expectorating		

ANOVA was employed on the mean sensory ratings of the different parts of both frozen and freshly unsold *Lechon* (Tables 15 and 16). Crispiness, reddishness, crunchiness, and juiciness attributes of the freshly unsold '*Lechon*' were significant at different parts which suggests that the nearness of the Lechon while rotating under the ember contributes to the different color variations, crunchiness, and locking-in of moisture of the meat.

Table 15. Mean panelists' ratings1 showing significant differences between groups (Fresh)						
Attributes	Butt	Head	Ham	Picnic		
Fatty	$6.85 \pm 4.52$	$5.33 \pm 3.25$	$6.24 \pm 4.22$	$6.16 \pm 4.22$		
Crispy	$6.04^{\rm a}\pm4.48$	$5.92^{a} \pm 3.37$	$4.33^{ab}\pm2.82$	$3.13^{b} \pm 1.99$		
Reddish	$7.21^{ab}\pm3.62$	$9.41^{a} \pm 3.58$	$8.84^{\mathrm{a}}\pm3.75$	$5.74^{b}\pm3.92$		
Doneness	$10.48 \pm 2.68$	$10.82\pm2.53$	$9.85\pm2.82$	$10.06\pm3.26$		
Distinct Lechon	$8.72\pm2.04$	$8.57\pm2.65$	$7.56 \pm 2.42$	$8.17\pm2.71$		
Aroma						
Aromatic	$5.85\pm2.18$	$5.52\pm2.80$	$4.50\pm1.87$	$5.27 \pm 2.67$		
Smoky	$7.10\pm2.20$	$7.10\pm3.03$	$6.59 \pm 2.70$	$5.94 \pm 2.78$		
Distinct Lechon	$8.21 \pm 2.08$	$7.93 \pm 2.98$	$7.35\pm2.52$	$7.75\pm2.71$		
Taste/Flavor						
Salty	$4.95\pm2.13$	$5.18\pm2.65$	$5.01\pm2.58$	$5.80 \pm 2.82$		
Meaty	$9.41 \pm 2.81$	$8.08\pm3.14$	$7.95\pm2.16$	$8.71 \pm 2.47$		
Spicy	$5.03 \pm 2.80$	$6.05 \pm 10.15$	$3.97 \pm 2.17$	$5.32\pm2.82$		
Crunchy	$5.47^{\mathrm{ac}} \pm 4.16$	$4.43^{\mathrm{a}}\pm2.88$	$4.09^{a} \pm 3.19$	$2.71^{ab} \pm 2.14$		
Tender	$7.82 \pm 2.45$	$8.40\pm2.97$	$6.54 \pm 2.54$	$8.13\pm2.65$		
Juicy	$7.50^{\mathrm{a}} \pm 2.67$	$7.84^{ab} \pm 2.60$	$5.91^{\mathrm{ac}} \pm 2.45$	$7.35^{\mathrm{a}}\pm2.44$		
Greasy	$6.30\pm3.37$	$6.52\pm2.63$	$4.61 \pm 2.55$	$5.49 \pm 2.53$		
Spicy After taste	$3.96 \pm 1.78$	$4.53\pm2.28$	$3.59\pm2.21$	$4.91 \pm 2.67$		

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<sup>1</sup>Mean ratings of different parts of Lechon (N=108) ANOVA and Tukey post hoc was applied to obtain differences in means  $abc_{-}$  different letters represent a significant difference at p<0.05

Table	16. Mean	panelists'	ratings1	showing	significant	differences	between	groups (	(Frozen)	
1	10.1.1.		100011901	0110				Drompo (		

	<b>1</b>	8 8 8		
Attributes	Butt	Head	Ham	Picnic
Fatty	$6.09\pm3.30$	$7.33 \pm 3.59$	$6.65 \pm 4.87$	$6.32\pm3.73$
Crispy	$5.17^{\mathrm{a}}\pm4.18$	$4.83^{ab}\pm3.54$	$2.86^{b}\pm2.34$	$5.11^{a} \pm 3.15$
Reddish	$8.17^{\rm a}\pm3.38$	$9.24^{ab}\pm3.53$	$6.35^{ac}\pm3.65$	$7.33^{a}\pm4.18$
Doneness	$10.11\pm2.96$	$11.16\pm3.03$	$10.58\pm3.25$	$11.04\pm3.12$
Distinct Lechon	$8.24\pm3.34$	$9.29\pm3.03$	$7.96 \pm 2.82$	$8.82\pm3.16$
Aroma				
Aromatic	$5.18 \pm 2.44$	$6.56\pm3.24$	$5.33 \pm 3.03$	$5.88 \pm 3.12$
Smoky	$6.28 \pm 2.63$	$7.16\pm2.81$	$5.99 \pm 2.66$	$6.70\pm3.38$
Distinct Lechon	$8.81 \pm 2.83$	$8.13\pm3.04$	$7.50\pm2.91$	$9.25\pm2.22$
Taste/Flavor				
Salty	$5.66^{\mathrm{a}}\pm2.49$	$4.96^{ab} \pm 2.12$	$4.47^{ab}\pm2.66$	$6.86^{\circ} \pm 2.89$
Meaty	$9.83 \pm 2.48$	$8.64 \pm 2.96$	$10.00\pm2.50$	$9.90 \pm 2.64$
Spicy	$5.44 \pm 2.79$	$4.63\pm2.44$	3.98±2.15	$6.41 \pm 3.03$
Crunchy	$4.81^{ab}\pm3.88$	$2.78^{a} \pm 1.82$	$2.68^{a}\pm1.66$	$5.65^{b}\pm3.79$
Tender	$8.09 \pm 2.59$	$9.53 \pm 2.54$	$7.63\pm3.50$	$8.19\pm2.78$
Juicy	$7.3296 \pm 2.47$	$7.33 \pm 2.70$	$6.68\pm2.66$	$8.21 \pm 2.39$
Greasy	$6.10^{a} \pm 3.00$	$7.18^{a}\pm3.92$	$3.80^{\text{b}} \pm 2.21$	$6.16^a\pm2.57$
Spicy After taste	$4.91^{ab} \pm 2.36$	$4.10^{a} \pm 2.02$	$3.95^{a} \pm 2.17$	$5.96^{\rm b} \pm 3.25$

<sup>1</sup>Mean ratings of different parts of Lechon (N=108) ANOVA and Tukey post hoc was applied to obtain differences in means

 $abc_{-}$  different letters represent significant differences at p<0.05

51 https://irjstem.com On the other hand, mean sensory ratings of frozen unsold '*Lechon*' showed significance for crispiness, reddishness, saltiness, spiciness, greasiness, and spicy aftertaste attributes of the raw material. All significant parameters may be due to the melting of ice crystals after thawing, releasing the organic volatile compounds and bound waters. Spider Plots show the sensory profile of the raw material in triplicate measurements (Figures 6 and 7), indicating in a graphical view that the fresh sample has somewhat similar mean values for all the parts, unlike the frozen material where mean values noticeably vary.



Fig. 6. Sensory Profiles of frozen unsold 'Lechon' (four parts). Zero (0) at the center of the web indicates the least detection, with each spoke representing the intensity scale (outward-high)



Fig. 7. Sensory Profiles of fresh unsold 'Lechon' (four parts). Zero (0) at the center of the web indicates the least detection, with each spoke representing the intensity scale (outward-high)

In the Principal Component Analysis (PCA), five (5) components represented 71.25% of the variability between the different parts of freshly unsold '*Lechon*' raw material. The groupings: PC1 – 30.80% (salty, spicy, spicy aftertaste); PC2 – 14.30% (distinct *Lechon* aroma and taste, meaty, doneness); PC3 – 10.77% (crispy, reddish, and crunchy); PC4 – 9.35% (tender, juicy, greasy); and PC 5 – 6.03% (fatty, aromatic, smoky) are illustrated in Figure 8:



Figure 8. 2D representation of the Principal Component Analysis of fresh unsold Lechon (PC1-red; PC2-yellow; PC3-green; PC4-blue and PC5-violet)

Meanwhile, the frozen sample grouped six (6) components which represented 74.42% of the variability between the typically unsold parts of '*Lechon*' material. The factors: PC1 – 31.20% (salty, spicy, spicy aftertaste); PC2 – 12.84% (doneness, distinct *Lechon* aroma and taste, meaty); PC3 – 9.45% (tender, juicy, greasy); PC4 – 7.98% (crispy, crunchy); PC5 – 7.00% (fatty, aromatic); and PC6 – 5.94% (reddish, smoky) are illustrated in Figure 9.



Fig. 9. 2D representation of the Principal Component Analysis of frozen unsold Lechon (PC1-red; PC2-yellow; PC3-green; PC4-blue green; PC5-blue PC6-violet)

The most important descriptors characterizing the raw materials were their saltiness, spiciness, and spicy aftertaste. Since both the frozen and fresh samples returned the same set of essential descriptors, it would imply that concerning sensory descriptions, either fresh or frozen unsold *Lechon* can be used as raw material without any pre-treatments and can be used in product development interchangeably. This is in terms of their sensorial properties only, other factors such as microbial profile must be primarily considered.

Market Assessment

The respondents' demographic profile presented in Table 17 indicates that of the three hundred (300) respondents surveyed, 59% consists of the highest frequency distribution were consumers of age ranging from 20-30 years old. Moreover, 151 were male and about 149 were female. The majority that accounts for about 65% of the distribution was "Single". Monthly income of about 79% had incomes from below Php 10,481.00 – Php 41,923.00.

Table 17. Distribution of the Respondents' Demographic Frome				
Socio-demographic Profile	Frequency	Percentage		
Age				
20 – 30 years old	178	59.33		
31 - 40 years old	65	21.67		
41 - 50 years old	37	12.33		
51 – 60 years old	20	6.67		
sex				
Male	151	50.33		
Female	149	49.67		
civil Status				
Single	194	64.67		
Married	101	33.67		
Widow	5	1.67		
Ionthly Income				
Not Available	49	16.33		
below P 10, 481.00	88	29.33		
P 10, 482.00 - P 20, 961.00	64	21.33		
P 20, 962.00 - P 41, 923.00	86	28.67		
P 41, 924.00 - P 73, 366.00	13	4.33		
Total	300	100.00		

Table 18 shows that all respondents consume *Lechon* of which about 79% reported consumption from once a month to very seldom due to availability of budget and some health issues and concerns.

Consumption Pattern	Frequency	Percentage
1. Consumption of Lechon		
Yes	300	100.00
No	(175)	(7)
2. How often		
Everyday	5	1.67
Very Often	14	4.67
Once a Week	43	14.33
Very Seldom	120	40.00
Once a Month	118	39.33
Total	300	100.00

The summary of the product preference patterns is shown in Table 19. For both proposed retorted products for reprocessed unsold *Lechon*, over 77% thought that the idea was good or excellent. Also, the majority: preferred glass jars as the packaging material; indicated their willingness to buy at Php 40-50 per 150 grams; and thought that the whole household would consume the products. More importantly, it was also shown that about 64% preferred Lechon Paksiw de Leyte over the Humba de Leyte.

Table 19. Product Preference Pattern				
Product Preference Pattern	Frequency	Percentage		
1. Idea of Processing Lechon Paksiw				
Excellent	147	49.00		
Good	86	28.67		
Average	52	17.33		
Below Average	15	5.00		
2. Product Packaging				
Canned (Glass Jar)	186	62.00		
Canned (Retort Pouch)	88	29.33		
Canned (Tin Can)	55	18.33		
3. Household consumer				
Whole household	169	56.33		
Adults	109	36.33		
Children	22	7.33		
4. Product price per 150 grams				
30	69	23.00		
40	113	37.67		
50	114	38.00		
others	4	1.33		
5. Frequency of buying the product				
1-2 times a week	43	14.33		
Twice a Month	111	37.00		
Once a Month	131	43.67		
Others	15	5.00		
6. Idea of Developing <i>Humba de Leyte</i>				
Excellent	158	52.67		
Good	75	25.00		
Average	56	18.67		
Below Average	11	3.67		
7. Product Packaging				
Canned (Glass Jar)	171	57.00		
Canned (Retort Pouch)	91	30.33		
Canned (Tin Can)	52	17.33		
8. Household consumer				
Whole household	179	59.67		
Adults	100	33.33		
Children	21	7.00		

 Table 19. Product Preference Pattern (continuation)

Product Preference Pattern	Frequency	Percentage
9. Product price per 150 grams		
30	73	24.33
40	116	38.67
50	108	36.00
Others	3	1.00
10. Frequency of buying the product		
1-2 times a week	80	26.67
Twice a Month	41	13.67
Once a Month	162	54.00
Others	17	5.67
11. Product Preferred		
Lechon Paksiw de Leyte	191	63.67
Humba de Leyte	109	36.33
Total	300	100.00

In calculating the market potential based on the market assessment, a summary of the frequency of purchase and product volume are summarized in Table 20:

Frequency	150 grams of Lechon Paksiw de Leyte Consumption in Kilos
1-2 times a week (x4) 80 respondents	48 (80 x 4 x 0.15)
Twice a Month (x2) 41respondents	12.3 (41 x 2 x 0.15)
Once a Month 162 respondents	24.3 (162 x 0.15)
Monthly Total	84.6
Yearly total (x 12 months)	1,015.20
No. of household purchasing (Table III)	169
Volume in kilos / household / annum	6.01
Calculations:	
Volume in kilo	$s / househol / annum = \frac{1,105.20}{169}$

Table 20. Summary of frequency of purchase and product volume

= 6.01 kilos

#### CONCLUSION AND RECOMMENDATION

'Unsold *Lechon*' of each of the 32 members of the Tacloban City Litson Industry Association (TACLIYA) reached 20 kilos daily with a maximum of 70 kilos of a culled pig. Typically, unsold *Lechon* parts are the Head, Ham, Butt, and Picnic Shoulder. Concerns about Good Manufacturing Practices as well as Sanitation Standard Operating Procedures were highlighted. Continuous interventions are ongoing in terms of waste disposal, storage facility, personal hygiene, equipment, pest control, product handling, and other Physico-Chemical characteristics such as Aw and pH generally depend on the part of the pork meat due to its different muscle structures. 'Unsold lechon' have near-neutral pH, high water activities, and moisture contents, which increase susceptibility to microbial proliferation. Crude Protein and Crude Fat content depends also on the part of the meat suggesting being a variable in the retort product development.

High microbial load is expected from the raw material due to temperature abuse of prolonged display on stalls, repeated handling, and others. For the product development phase, 'unsold *Lechon*' must be collected before 4:00 pm to avoid toxin production, especially if there's no improvement or changes in the members' practices. Storage of collected raw materials must not exceed 48 hours under  $<-12^{\circ}$ C.

In distinguishing the difference between the freshly 'unsold *Lechon*' from the frozen sample, only the picnic part can be detected. Therefore, must be used as fresh and if not possible, must be thawed properly. The most important descriptors for the raw material are the saltiness, spiciness, and spicy aftertaste for both frozen and fresh, indicating not being a variable in terms of its sensorial descriptive property. *Lechon Paksiw de Leyte* was preferred over *Humba de Leyte* as the product to be developed through reworking unsold *Lechon*. The market potential of the product in Volume in kilos per household per annum is 6.01Kg.

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