International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

Consumer Acceptability, Storage and Dimensional Stability of the Formulated Congee as Canned and Pouched Disaster Food Product

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Abstract - *Ready to eat meals were invented by the military for long-term storage of complete meals for survival situations when there is no means for cooking. Ready to eat meals are very expensive, especially if preparing for a prolonged emergency. The potential of formulated adlai-glutinous rice and duck meat congee packaged in tin can and retort pouch to be a suitable emergency relief food during disaster was studied through evaluation of its storage stability and consumer acceptability. Accelerated shelf life test (ASLT) and sensory evaluation through consumer test were conducted. Results showed that canned and pouched samples did not differ significantly in terms of pH while inverse relationship was observed in color analysis due to electrochemical reaction. Based on the Q_{10} approach, it was found that the estimated shelf-life of the canned and pouched formulated congee were 165 and 315 days, respectively. On the other hand, consumer rating showed no significant difference between canned and pouched samples which both had, moderately acceptable evaluation. However, 75.2% of the panelists preferred retort pouch as the packaging material for the formulated congee. The study has shown that retort pouch was a better packaging material for the formulated congee than tin can in terms of shelf stability and consumer acceptability.*

Key Words: accelerated shelf-life, consumer acceptability, dimensional stability, formulated canned and pouched disaster food, storage stability

1. INTRODUCTION

The Philippines being part of the Pacific Rim it is considered as the pathway of seasonal typhoon which brings large amount of rainfall that causes flash flood likewise landslide and other forms of devastation. In addition there are also areas which are very prone to the occurrences of volcanic eruptions and experiencing periodic earthquakes. Thus, after a natural calamity happens, subsequent problem arises particularly in providing food as immediate disaster relief assistance. Food is usually distributed to the families at their homes or temporary shelters. However unavailability of water, electricity and fuel comes as a constraint for adequate cooking and reheating of food.

Ready to eat meals were invented by the military for long-term storage of complete meals for survival situations when there is no means for preparing or cooking food. The problem with ready to eat meals is that they are very expensive, especially if you are preparing for a prolonged emergency. This the reason why this project was conceptualized to develop Adlai (*Coix lacryma-joibi L.*) and locally cheaper meat (duck) product as the main ingredient for preparation of dishes as a canned and pouched disaster-based food product.

Adlai may be an indigenous and unfamiliar cereal grains grown in the Philippines but this plant could address the food requirement of Filipinos especially, during calamities. Some local tribes and farmers from Zamboanga del Sur have been planting and eating adlai just like same manner as rice. Adlai can be dish up as an alternative for rice-based food product. It is also used in making porridges, pastas and bread when ground into flour. Adlai seed can also be processed to make tea. According to farmers, its production was traditional yet sustainable, (Dela Cruz, 2011).There have also reports that it was being planted in some parts of the country however it has not yet been well documented and given priority until now. It is potentially suitable for use hence this crops resembles and tastes like rice. It contains higher food energy, carbohydrates, protein, fat and dietary fiber directly compared to rice and corn. Adlai is packed with other minerals also, such as: calcium, phosphorus, iron, niacin, thiamine, and riboflavin. Improvement on the utilization and consumption of these cereal grains will significantly contribute to the household food security and nutrition of the Filipino people.

On the other hand, the meat from duck (*Cairina moschata*) contains protein, fats, and minerals. It helps boost protein intake which supports the immune system as well as aid in the regulation of hormomes and enzymes for growth and maintain body tissues. The fat composition of duck meat is mostly unsaturated fat which has a function in lowering cholesterol level and as an antioxidant. Duck meat also increase minerals ingestion such as selenium and zinc, both of which play a role in enzyme function and activation needed for cellular metabolism. Zinc boost the immune system while selenium helps maintain the thyroid.

In this research, congee from adlai, glutinous rice and duck meat was formulated to develop a canned and pouched disaster food. Development of food product such as canned and pouched disaster-based meal could provide the immediate concern of distributing food rations during calamities. Even though adequate thermal processing is done on the product, it naturally undergoes deterioration and later on, spoilage. Therefore, it is important to determine the shelf life of the product or the length of time in which the product is safe for consumption. Moreover, the packaging of the product must be considered because it has the ability to control the shelf life of the product by preventing deteriorative reactions. Retort pouch and metal tin can is the type of packaging material most commonly used by the food processors. Both are shelf-stable pack that is a good barrier against oxygen and water (Man, 2002).

Part of the product development process is assessing the strength of packaging to withstand several hazards that it may encounter during processing, warehousing, transportation, and distribution (Brody, 2002). Seals of pouches can easily be disrupted during the processing of the food product especially during commercial sterilization in which retort pouches experience high pressure (Bernal, 2012). Furthermore, the storage condition is a critical factor for the strength of seals in pouches and lacquer quality of cans. In terms of transportation hazards, the formulated food product may undergo over-the-road truck transportation, rail transportation, and aircraft transportation. Throughout the course of distribution, packaged products are exposed to different stresses like shock, vibration, and compression. Cracks and pinholes could arise from the packaging due to the stated transportation hazards (Dunno, 2012). This could lead to decrease in product integrity, product loss and providing an appropriate environment for the onset of food deteriorative reactions. It is vital that the packaging material be evaluated in terms of its performance to respond on the various transportation hazards to ensure that the product arrives in good quality to intended consumers. The study aims to provide a comprehensive information about its storage stability, consumer acceptability, and develop appropriate packaging for disaster-based food.

2. MATERIALS AND METHODS

2.1 Materials

Adlai grains were procured from Southern Tagalog Integrated Agricultural Research Center located in Lipa City, Batangas while duck meat was bought from Victoria, Laguna. The 211x300 tin cans were ordered from General Metal Container Corporation in Novaliches, Quezon City. Likewise, retort stand-up pouches were acquired from San Miguel Yamamura Packaging Corporation. Other ingredients, spices and condiments used were obtained from grocery stores, supermarket and wet market in Los Baños, Laguna.

2.2 Methods

Preparation of Canned and Pouched Disaster Food Product. Several combination of ingredients, spices and condiments were prepared before achieving the final product formulation for adlai, glutenuos rice and duck congee. Product sensory characteristics and nutritional composition are the basis of the formulation.

Consumer Test. Affective test in the form of consumer testing was conducted to assess the degree of liking of average Filipino consumers of various age group to the newly developed product. One hundred twenty-five (125) untrained panelists were selected from nearby areas of UP Los Baños that belonged to a specific age group: school children (4-12 y/o), adolescents (13-19 y/o), young adults (20-35 y/o), adults (36-64 y/o), and elderly (>65). The samples were heated before serving, coded, and served to the panelists. A nine-point hedonic scale, ranging from 1 (extremely dislike) to 9 (extremely like) was used to assessed the tasters evaluation of color, aroma, flavor, texture, and aftertaste as well as determine the overall acceptability of the product and the panelists' chosen packaging material (can or pouch).

A spider web plot graphic presentation of all characteristics was used to illustrate the differences and similarities of the descriptive profiles of congee evaluated. This was accomplished by plotting the mean score for a given attribute on an axis that represents the 9-point hedonic scale used on the score sheet. Each axis extended from a center point and depicted a single attribute. The center point was equivalent to the low intensity origin of the hedonic scale, and the highest intensity was equivalent to the end of the axis.

Storage Study. The shelf life of ready-to-eat duck meat congee packaged in can and pouch was determined using temperature accelerated shelf life test (ASLT) (Fu and Labuza, 1997). The product was subjected to the following temperatures: 35, 45 and 55°C, with a target shelf-life of 12 months at 30°C. Three representative samples were selected for each incubation temperature according to its pre-determined schedule. In order to estimate the shelf life of the canned and pouched product the parameters evaluated were sensory characteristics and physicochemical properties such as pH, water activity, color, and consistency. The sampling time and frequency of assessment in each incubation temperature was based on Q_{10} value which was assumed to be 2.5 (Office of Technology Assessment, 1979). Microbial analyses (total plate count, yeast and mold count and thermophilic spores) were also conducted at 3 time points, beginning (time 0), mid and end of storage, for each temperature condition. Shelf life was estimated through data extrapolation from the Arrhenius plot wherein the equation of the line was obtained from the rate of reaction and the inverse of storage temperature.

Dimensional Stability Test for Package Formulated Disaster Food.

Bursting Strength. The methodology for the evaluation of bursting strength of retort pouches was based on American Society for Testing and Materials (ASTM) no. F2054 (2004). While the compression test was based on specifications, standards and testing methods for foodstuffs, implements, containers and packaging, toys and detergents, Japan External Trade Organization (2008). A sealed retort pouch containing the formulated congee was compress using an INSTRON 4411 to determining the peak compressive force that the retort pouches can withstand. The peak force needed to burst the pouched sample was recorded.

Lacquer Quality Test in Metal Cans. The lacquer quality testing for metal cans was based on International Organization for Standardization no. 1520 (2015). The quality of epoxy phenolic as lacquer for the cans used in the study was evaluated. The cans were filled with distilled water (test for lacquer taint), onion with distilled water (test for sulphur-resistance), 5% citric acid (test for acid-resistance). The samples were processed for 1 hour at 121°C in a pressure cooker. The cans filled with distilled water were incubated at 37°C for one week. On the other hand, the samples filled with onion and distilled water were placed at ambient temperature for one week. Lastly, the cans with 5% citric acid was inspected right after processing. The cans were examined for presence of taints and discontinuity.

Drop Test. The free fall drop test procedure of pouched and canned samples made use of the progressive drop test protocol based on ASTM 5276 (2004) and Indian Standard Institution 11057 (1984). The initial drop height for pouch was 48 inches while the can was dropped initially at 19 inches. The drop height was increased at intervals of 4 inches until failure was observed for both packaging materials. The pouch was considered broken when spillage of the contents occurs. On the other hand, failure of cans was attributed to formation of dents.

Experimental Design and Statistical Analysis. All laboratory analyses were expressed as mean values of at least triplicate determinations ± standard deviations. One-way analysis of variance was used to determine the significant differences of all data gathered. The least significant difference test was used to compare treatment means at 5% level of significance using Statistical Package for the Social Sciences (SPSS). An independent-sample t-test was done to compare the sensory characteristics, physicochemical compositions, and shelf life of canned and pouched samples. Completely staggered design was used in the stability study of formulated disaster food packaged in pouches and cans with sub-sampling and repetitions. Random samples were collected every sampling period. A regression analysis was run for each temperature treatment to estimate the shelf life of the product.

3. RESULTS AND DISCUSSIONS

Consumer Acceptability. One hundred twenty-five (125) consumer panelists, 81 females and 44 males, were taken as respondents to evaluate the acceptability of canned and pouched adlai-glutinous rice and duck meat congee. They were selected in a randomly stratified way using age group as the stratum [children (4-12 y/o), adolescents (13-19 y/o), young adults (20-35 y/o), adults (36-65), and elderly (>65)]. The judges assessed the samples based on color, aroma, flavor, aroma, aftertaste, and general acceptability. In addition, the panelists were asked to evaluate their personal acceptance between the two packaging materials of the developed product.

At $p \leq 0.05$, Table 1 showed that canned and pouched samples were not significantly different based on all attributes of the sensory evaluation determined by different age groups in affective testing. Based on the R values, the two packaged products' general acceptability was found out to be strongly dependent on almost all the parameters, especially the aftertaste, except for the packaging. The latter showed non-significant correlation to general acceptability because they did not highly consider the type of packaging in their overall product acceptability. Moreover, most of the respondents claimed that they cannot differentiate their evaluation of the two packaging unless there was printed advertisements and product information plastered on it.

Table-1: Mean (±SD) and R-values of sensory attributes in correlation to the general acceptability of canned (A) and pouched (B) disaster food product.

PARAMETER	SENSORY SCORES[A]		R VALUES	
	A	B	A	B
Color	6.82±1.32	6.92±1.21	0.498	0.573
Aroma	6.61±1.68	6.69±1.51	0.708	0.659
Flavor	6.71±1.65	6.76±1.80	0.767	0.792
Texture	6.39±1.78	6.53±1.72	0.709	0.796
Aftertaste	6.43±1.75	6.46±1.75	0.810	0.811
General Acceptability	6.76±1.62	6.75±1.59	1.00	1.00
Packaging Material	6.76±1.62	6.75±1.59	0.154	0.036

[A] Mean scores bearing same superscript in the same column are not significantly different at $p \leq 0.05$.
Range of scores: 1= Extremely unacceptable, 9 = Extremely acceptable
Range of R values: Strong: 1.0-0.5; moderate: 0.3-0.5; weak: 0.1-0.3; weak: -0.1-0.1: none or very weak

Figure-1: Spider plot of consumer's evaluation on canned and pouched adlai- glutinous rice and duck meat congee based on age groups.

On the other hand, Figure 1 illustrates the average evaluation of each age groups per sensory attribute. In canned packaging, adults and elderly had the highest average score in general acceptability (7.8 and 7.6 respectively), while the adolescents had the lowest average of 6. This was also true for all the specific attributes with the adults and elderly having an average rating range of 7-8 whilst adolescents had 5-6. As shown in figure 1, the canned samples results were comparatively similar to the samples packaged in pouches. Based on the consumer test, 78.4% of the panelists accepted treatment A (congee in can) while 80.6% of them liked treatment B (congee in pouch). In terms of the packaging material, most of the age groups had a unanimous preference for retort pouch over metal cans. Out of 125 panelist, 94 preferred retort pouch as packaging material for adlai-glutinous rice and duck meat congee.

Storage Stability. Chemical, microbial, and physico-chemical tests are used alternatively in the determination of the storage stability of different food products. In this research, accelerated shelf life testing was conducted in which the main concept was to analyze the shelf life of food products via the use of accelerated storage conditions and to predict the real shelf life of the product using Arrhenius equation and Q10 approach. The study measured several parameters: water activity, consistency, pH, color, and sensory evaluation as the deteriorating quality attribute. These parameters was used to predict shelf-life of the adlai-glutinous rice and duck meat congee.

Water Activity. During storage period, it was determined that the water activity of adlai glutinous rice and duck meat congee packaged in can and pouch increased prominently. Water activity value was determined as 0.918 at time 0. At the end of storage, the average value was found as 0.95±0.01. Within present research, it was proven that at different temperature conditions, changes in water activity were significant (p= 0.002 to p=0.006) with respect to the storage time. Moreover, the calculated r^2 of the different linear regression plots which was more than 0.80 indicated that variation in the change in water activity was explained by the increase in storage time.

The crystalline state as compared to the amorphous one has a higher water activity value. Rahman (2007) stated that the structure of crystalline starch does not allow water molecules to access the starch's gel junction zone, thus bounding water only to the surface of the granule. This causes reduction of energy of water, thereby decreasing the humidity of the food as compared to the pure water. Another contributing factor to the increase in water activity is conversion of amorphous starch granules to its crystalline state because of the onset of retrogradation. Starch granules that has undergone heating then retrogradation are mostly likely to be converted from its amorphous state into its water-impenetrable crystalline state. As storage time increases, so does retrogradation. This was supported by the study of Dong Hyun and Keun Taik (2012) on the quality changes of ready-to-eat ginseng chicken porridge packaged in retort pouches during storage at 25°C in which the retrogradation value of the sample increased significantly with prolonged storage. Using the findings of Dong Hyun and Keun Taik, retrogradation occurred in the adlai-glutinous rice and duck meat congee during the shelf life monitoring; as retrogradation proceeds, exudation of water starts to occur. The released water and some of the surrounding water molecules could be adsorbed to the surface of starch granules.

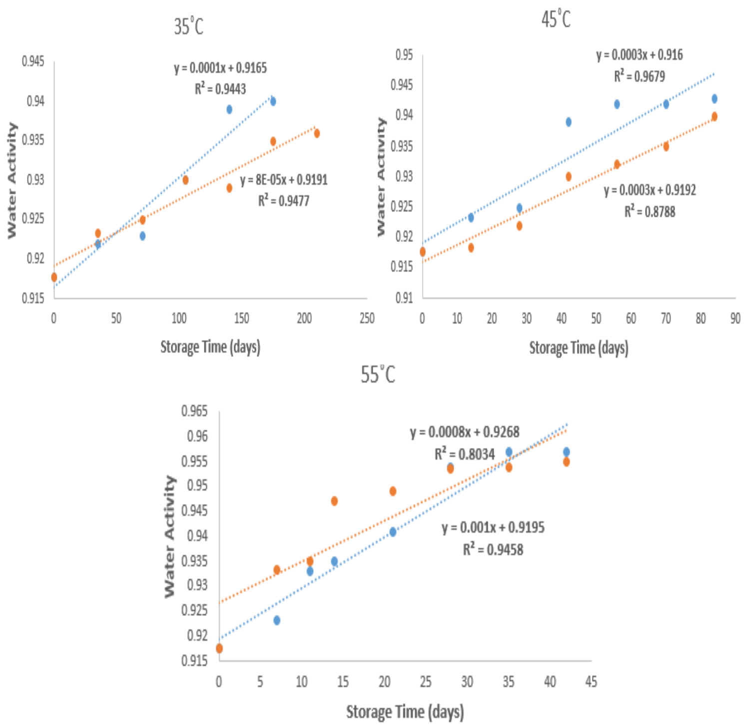

Figure-2: Changes in water activity during storage of adlai-glutinous rice and duck meat congee packaged in can (●) and pouch (♦) at different storage temperature (35, 45, and 55°C).

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

Consistency. The consistency of the formulated disaster food product increases (Figure 3) because of the increase in water content due to exudation of water from the crystallized food components. It can be attributed to the rate of retrogradation and formation of amylose-lipid complex. The increase in consistency was related to the previous discussion in which water exudates from the crystallized food components. This creates additional moisture to the product allowing for easier flow of the congee.

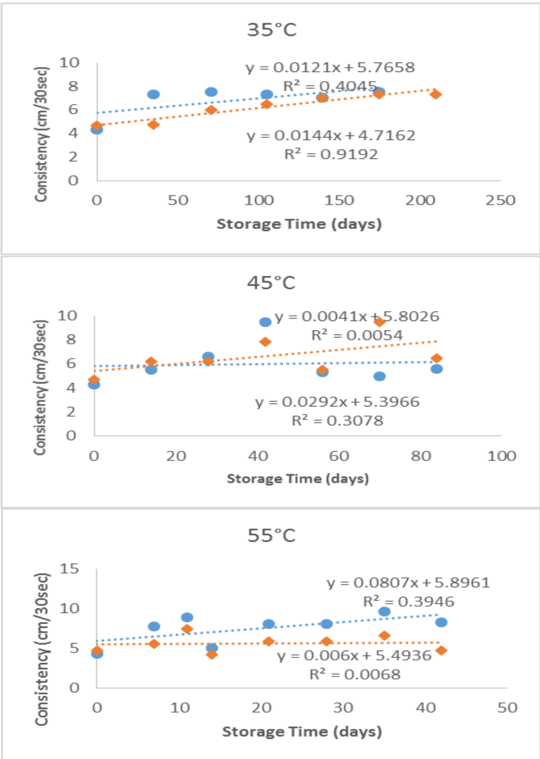

Figure-3: Changes in consistency during storage of adlai-glutinous rice and duck meat congee packaged in can (●) and pouch (♦) at different storage temperature (35, 45, and 55°C).

pH. One of the factors that determines the quality of a product exposed in various conditions is pH. Moreover, this factor can vary depending on other parameters that are present in the internal and external environment of a processed food product. The changes in pH of adlai-duck meat congee packaged in can and pouch as a result of storage at different temperature treatments, the effect of packaging itself, and the presence of microorganisms.

The initial pH of the product was approximately 6 which was categorized as low acid. At the end of storage, the pH showed a decrease trend and reached to a value of below 5 for both can and pouch. The changes in the pH of the samples during storage at 45°C and 55°C were shown to be linearly dependent with time ($p = 0.002$ to $p = 0.014$). Moreover, the high r^2 which ranged from 0.7931 to 0.9203 of various linear regression lines at different kinetic orders indicated that variation in the change in pH was explained by the increase in storage time.

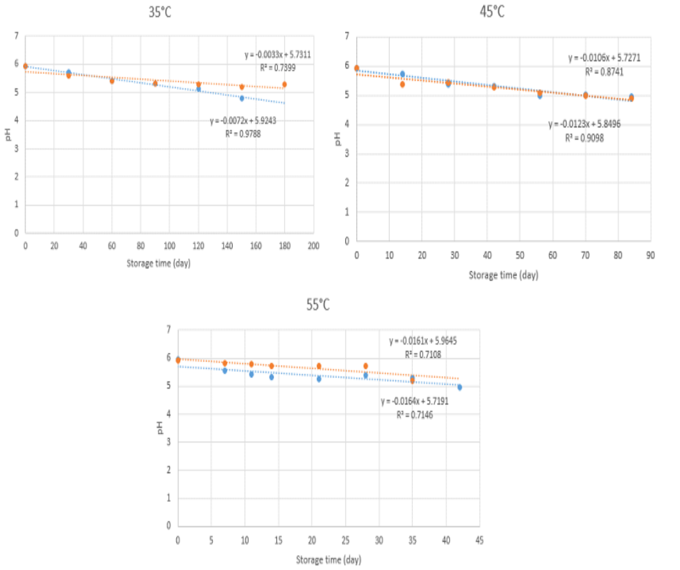

Figure-4: Changes in pH for canned (●) and pouched (●) adlai-glutinous rice and duck meat congee during shelf-life monitoring stored at different temperature (53°C, 45°C and 55°C).

The pH values are accounted thru the amount of hydrogen ions (H^+) in a solution (Newton, 2007). Likewise, it is essential to determine the amount of dissociated acids in the samples as the product ages because this parameter greatly affects the sensory evaluation of panelists as well as shelf life of the adlai-glutinous rice and duck meat congee. Considering the packaging, the pH results showed that at all accelerated temperatures, canned and pouched congee's pH did not show any difference at $p \leq 0.05$ (Figure 4). Typically, as temperature increases, molecular vibrations also increases inhibiting the formation of hydrogen bonds, increasing the number of observable and free H^+ ion molarity and decreasing the pH value (researchgate.net). Moreover, time-temperature interaction exhibits rapid pH decrease (Pope and Gould, 1973). Thus, the longer storage time, the longer the exposure to the accelerated temperatures means constant molecular vibrations with increasing protein deterioration releasing free ions, such as glutamic acid, aspartic acid, lysine and methionine (Aronal et al., 2012) in duck, that will decrease the pH.

Color. Table 2 shows significant difference between the two packaging materials in terms of color of the packed disaster food product. This can be due to variety of possible deterioration mechanisms, i.e. package-food interactions (lacquer failure), Maillard reaction, residual oxygen, and severe heat treatment. Since tin can is a heat-labile material, one possible color deterioration mechanism is internal corrosion/lacquer failure due to foods with high content of sulfur containing amino acids. It was a result of uncommon aggressive reaction between can and its food components (Bev et al., 2003). This type of deterioration in canned foods is an electrochemical reaction depending mostly on pH and type of food, presence of oxidants, storage temperature and time, and air in the headspace which critically create limiting factors on the shelf life of canned products, such as affecting its organoleptic properties, i.e. color (JEFCA, 2000; Mannheim and Passy, 1982). Moreover, this can integrity problem, in the literature reports, is said to be one of the most common observations in processed canned foods due to appearance of black stains on both the internal surface of the can body and occasionally on the product surface. According to Oldring and Nehring (2007), the can lacquer of this study, epoxy-phenolic, has less resistance to sulfur-containing products as compared to other lacquers and when in contact with high sulfide content levels, it reduces its capacity to protect the base metal. Duck meat, in general, contains glutamic acid, aspartic acid, lysine, and methionine (sulfur-containing amino acids) at significant levels, with highest concentrations present in the breasts and thighs (Aronal et al., 2012). With that, dissolution of lacquer takes place and the occurrence of sulfur blackening/staining was due to production of tin sulfides and tin oxides, formed by decomposition of food with sulfide compounds (H_2S or other products containing thiol (-SH) group) to the tin layer of the metal can (Cicek, 2017) which occurs in products having pH over 5.

Table-2: Mean (±SD) Delta L* values of canned (A) and pouched (B) adlai-glutinous rice and duck meat congee at different storage temperatures.

TEMPERATURE (°C)	TREATMENT	
	A	B
35	3.117±2.027[a]	7.456±2.077[b]
45	1.762±2.615[a]	9.111±2.455[b]
55	5.197±2.026[a]	8.560±2.227[b]

Means values with different letters in the same row per storage temperature are significantly different from each other at p≤0.05.

Delta L* represents a lightness difference between sampling data and baseline data (Can-50.429; Pouch-46.675).

Adlai-glutinous rice and duck meat congee having a duck ingredient may have experienced this type of degradation and the dark and brown precipitates observed at the top of the sample after opening the can were the by-product of the reaction of sulfur to the iron and tin content (FeS and SnS precipitate). One way to prevent these freed and loosely bounded sulfur compounds is to use zinc oxide, which can absorb the compounds during thermal processing (Oldring and Nehring, 2007).

The intrinsic darkening of the samples inside the can material can be caused by maillard reaction. It is a type of non-enzymatic browning that is initiated by the condensation of the carbonyl group of reducing sugars with the free amino groups and/or proteins. Likewise, this chemical process produces brown color (melanoidins) in foods without the participation of enzymes (Bharate, 2014). The dark-brown appearance of the product was caused by thermal application and long-term storage of the food containing reducing sugars. Hence, color can be determined as the primary characteristic of maillard reaction.

As for the adlai-glutinous rice and duck meat congee, the duck component has a very high lysine content (9.21±0.38 per 100 g protein of duck meat) (Aronal et al., 2012). This lysine can react with the reducing sugar brought about by the adlai component. Adlai has a high amount of carbohydrate content which will be degraded upon exposure to high thermal application. Ho et al. (2008) stated that at high temperatures, hydrolysis of carbohydrates happens and it releases reducing sugars and these monosaccharides will then react to the free amino acids exuded by the duck meat yielding brown pigments or melanoidins. This brown color in the samples had provided undesirable perception and therefore resulted to failing remarks from the trained panelists in the canned samples. Possible presence of residual oxygen must have accelerated the degree of corrosion as iron will automatically react with oxygen yielding iron oxide (FeO) compounds which are also black precipitates (Ranken, 1984).

In addition, color dictates the severity of heat treatment and can be utilized to determine the quality deterioration from heat exposure (Lozano and Ibarz, 1997; Shin and Bhowmik, 1995). This statement was proven true as seen in the samples inside the can packaging material. The part of congee that is in contact and exposed to the tin can showed considerable dark appearance as compared to that of those parts in the center. This may be due to longer processing time of canned samples compared to pouched counterpart. Thus, this samples closely in contact with the metal barrier of the tin can changes the overall chromatic property of the product in the said packaging and significantly widened the two treatment's color measurements by the color meter.

Lacquer failure, maillard reaction, residual oxygen and heat treatment greatly affected the samples in can which resulted in a significant deviation of chromatic data between the two packaging in the analysis. This can be due to retort pouches being non-corrosives and have no any inner coatings that can react to the product; thus, during storage, no unwanted precipitates can form. And since retort pouches have thin specifications, its thermal processing to reach the critical point was less than those of can which prevents overcooking; thus, it produces better color than those samples on can (Richardson, 2008). Coles et al. (2003) and Kilcast and Subramaniam (2000) confirmed that retort pouches' flat shape reduces processing time and thus heat exposure which provides opportunity to process heat-sensitive products, which are not suitable for conventional cylindrical canned processing.

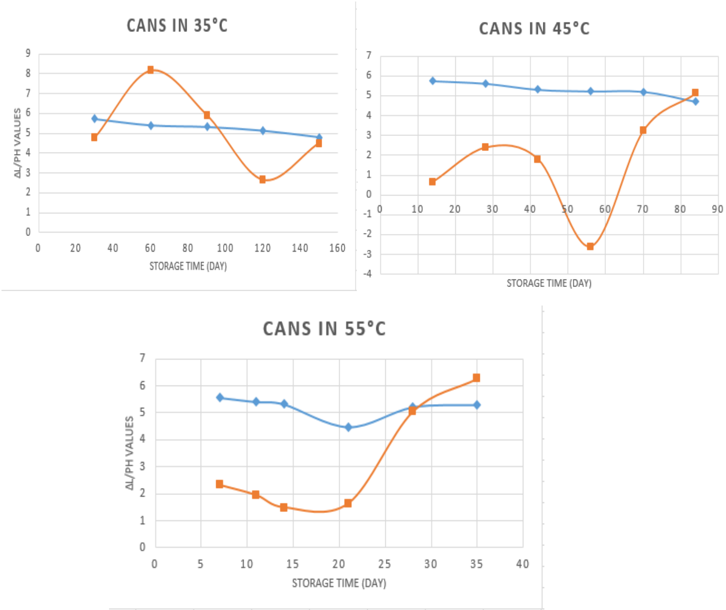

Figure-5: Changes in the ΔL (■) and pH (♦) of canned congee during shelf life monitoring stored at different temperature (35, 45, and 55°C).

The ΔL's obtained for every sampling at different accelerated temperatures of in canned and pouched samples was theoretically and practically precise shown in Figure 5. The ΔL's for pouches were higher than those of cans which mean that they turned out to be much lighter throughout the ASLT period. The ΔL of canned and pouched samples positively increased in values after every analysis period which indicated that the samples became lighter than the control L value. The increase in lightness of the products were due to reduction of maillard reaction. Maillard reaction happens at increasing temperature and increasing pH, and is scientifically defined as pH sensitive. Thus, the extent of color formation from the reaction increases with increasing pH. Maillard reaction proceeded given that there is presence of high temperature and almost neutral pH value (Owusu-Appenten, 2004). The temperature was constant but the pH of the samples continually decreases. Thus, maillard reaction gradually lessens due to linear decrease of pH which analytically observed in the increasing color.

Microbial Analysis. Tables 3, 4, and 5 shows the results of microbial analysis during shelf life study. At the storage temperatures of 35°C, 45°C, and 55°C, there were no coliforms and thermophilic spore formers detected on canned and pouched adlai-glutinous rice and duck meat congee. According to the FDA Circular No. 2013-010, the coliform level and APC level of ready-to-eat foods should not exceed 10^2 cfu/g and 10^4 cfu/g, respectively. In the study, the coliform and APC counts for both the canned and pouched adlai-glutinous rice and duck meat congee were within the allowable limits for ready-to-eat foods. Based on the results, <10 to no growth was observed in canned and pouched samples stored at 35°C, 45°C, and 55°C. Therefore, both samples were microbiologically acceptable as there were no any significant microbiological changes that happened in the products during storage. Moreover, the number of detected coliforms and APC were within the allowable limits. There were also no thermophilic sporeformers detected which proved that the time and temperature employed in the thermal processing of the product was effective to destroy the pathogenic microorganisms.

Table-3: Aerobic plate, coliform, and thermophilic spore-form counts of canned (A) and pouched (B) adlai-glutinous rice and duck meat congee at 35°C.

SAMPLE	DAY	AEROBIC PLATE COUNT (cfu/ml)	COLIFORM (cfu/ml)	THERMOPHILIC SPOREFORM COUNT
A	0	<10	ND	ND
	105	ND	ND	ND
	210	ND	ND	ND
B	0	ND	ND	ND
	105	ND	ND	ND
	210	ND	ND	ND

ND = not detected/ no growth

Table-4: Aerobic plate, coliform, and thermophilic spore-form counts of canned (A) and pouched (B) adlai-glutinous rice and duck meat congee at 45°C.

SAMPLE	DAY	AEROBIC PLATE COUNT (cfu/ml)	COLIFORM (cfu/ml)	THERMOPHILIC SPOREFORM COUNT
A	0	<10	ND	ND
	42	<10	ND	ND
	71	<10	ND	ND
B	0	ND	ND	ND
	42	<10	ND	ND
	71	<10	ND	ND

ND = not detected/ no growth

Table-5: Aerobic plate, coliform, and thermophilic sporeform counts of canned (A) and pouched (B) adlai-glutinous rice and duck meat congee at 55°C.

SAMPLE	DAY	AEROBIC PLATE COUNT (cfu/ml)	COLIFORM (cfu/ml)	THERMOPHILIC SPOREFORM COUNT (cfu/ml)
A	0	<10	ND	ND
	14	<10	ND	ND
	27	<10	ND	ND
B	0	ND	ND	ND
	14	<10	ND	ND
	27	<10	ND	ND

ND = not detected/ no growth

Sensory Evaluation. As observed on the periodic sensory assessment at 55°C, the sensory evaluation for canned and pouched samples stopped before its possible last sampling point due to the development of off-odor. As for the sensory testing at 35°C, canned adlai-glutinous rice and duck meat congee ended earlier than the pouched samples because of the poor condition of the metal tin can. As discussed earlier, black deposits were found on the canned samples making it unfit for consumption. This was supported by Manheim and Passy (1982) in which they stated that internal corrosion in can affects the sensory properties of the product such as color, flavor, and texture. While, at the end sampling day for 45°C, neither like nor dislike descriptive score value for sensory evaluation was verdict.

Shelf Life Estimate. The shelf life was obtained using two methods: Arrhenius equation at first-order reaction and Q_{10} approach, as shown in Table 6. The most applicable model for estimating the shelf life of adlai-glutinous rice and duck meat congee packaged in can and pouch was the Q_{10} approach. Reason for this is that the study was only in its preliminary stage, the chosen approach is a general approach integrating the effects and cut-off points of all the deterioration parameters: water activity and pH have yet to establish their standards, hence, their cut-off points (COPs) are still to be verified.

The shelf life of both packaging ended earlier than the estimated shelf life which is 365 days. The possible reason for this was the early ending of shelf life testing on the basis of the development of off-odor. The formation of sour odor in the food product could be connected to the increasing off-flavor of adlai duck-meat congee. As mentioned earlier, the observed trend in the off-flavor parameter was due to the build-up of oxidative secondary by-products such as 2,4-decadienal and 2-furfurylthiol. Both are types of unsaturated volatile aldehyde that contributes to the production of "cardboard" flavor and "sour" flavor of the duck meat; as well as, the development of unpleasant odor (Jayasena et al., 2014). Accumulation of sulfide compounds due to the continual degradation of proteins can also contributed to the formation of off-odor to the product. Hydrogen sulfide, one of the products of protein degradation, is an organic volatile compound that is associated with rotten egg odor. Furthermore, hydrogen sulfide could react with aldehydes, ketones and furans to form sulfur derivatives that can also cause off-odor to the product (Kazeniac, 1989). The two methods of estimating shelf-life generated the same results that the canned samples have lower shelf life than the pouched samples. Since most of the rate of change in the measured deteriorating attributes of adlai-glutinous rice and duck meat congee was not significantly different when packaged in can and pouch, the contributing factor for the difference in the shelf life of canned and pouched samples was the development of off-odor in the sensory evaluation part and formation of the black deposits in the can body.

Table-6: Shelf life estimation of formulated disaster food packaged in can (A) and pouch (B) using Arrhenius equation and Q_{10} approach.

TREATMENT	ESTIMATED SHELF-LIFE (Days)		
	Arrhenius Equation[1]	Arrhenius Equation[2]	Q_{10} Approach
A	419	456	165
B	655	538	315

A= canned sample; B= pouched sample
[1] Based on water activity, estimated at first order reaction
[2] Based on pH, estimated at first order reaction

Dimensional Test for Packaging

Burst Strength. The seals of the retort pouches were tested for burst strength using the burst testing method. This was executed in order to determine the ability of a hermetically sealed package to resist pressure differential. The pouch samples were subjected for two days in different conditions: dry, frozen (-10˚C), and submerged in water. This was done to simulate the possible scenarios that may happen during storage and warehousing. The effect of extreme temperature on the pouch is evident on the weakening of its seal strength. Table 7 presents the pressure that the pouch's seal can withstand after subjecting to three different storage conditions.

Table-7: Burst pressure of retort pouches subjected in three different storage conditions.

STORAGE CONDITION	PRESSURE (psig)
Dry	20.046 ± 0.33
Frozen*	18.166 ± 0.66
Soaked in water	18.806 ± 1.57

*Samples stored at -10˚C

Based on one way ANOVA, there was no significant difference (p>0.05) on the bursting strength of pouch when subjected to three different storage conditions. Ideally, significant differences in the burst pressure should be achieved because the properties of laminates, especially the sealant layer, change depending on the temperature and humidity of storage. The lowering of the strength of pouch seal is attributed to the weakening of the sealant layer. The utilized retort pouch in this study uses cast polypropylene (CPP) as its sealant layer. When the retort pouch is subjected to low temperatures or frozen conditions, CPP weakens due to the transition from the rubbery to glass state. CPP has a glass transition temperature near the refrigeration storage conditions (O°C). When it achieves its glass transition state, the seal becomes brittle allowing the seal to burst even at low pressures. Dry conditions have minimal effects on the sealant layer because CPP is resistant against stress cracking. As for the water-soaked condition, its heat seal part of the pouch wherein time exposure to this storage condition could weaken seal integrity (Dunno, 2014). Factor for the non-significance of bursting pressure among the three different storage conditions was the insufficient retort pouch samples. Moreover, the effect of storage conditions could not have been achieved within the span of 2 days and must be subjected to an extended storage time of one week.

Bursting strength is important due to its application on processing and transportation. In terms of processing, commercial sterilization can delaminate pouch if the packaging has a low value of bursting strength. A good retort pouch should withstand pressures of 20 psig (Yam, 2009). From the data gathered (Table 7), it was observed that the burst pressure data of the incubated pouches were within the range of standard 20 psig.

For the transportation aspect, the main concern is air transportation. A study made by Singh et al. (2009) showed that the highest pressure equivalent altitude observed for all domestic and international air shipments was 6,400 ft. The pressure equivalent of this height is 3.333 psig; this means that the pouch should withstand the pressure differential at that level. The recorded burst pressure of retort pouches stored in three different conditions were compared with 3.333 psig. It was found that retort pouches subjected to extreme conditions can still be transported via air shipping. As discussed earlier, the CPP layer is resistant against environment stress cracking.

Burst test can also expose the weak points in the packaging. Even though the utilized retort pouch has a high bursting strength value, adjustments are still needed for continual improvement of retort pouch. The weak point in the over-all seal of the pouch was determined to be the side seals. Due to leaks found on the sides of pouch in all samples.

Compression Force. Pouched samples also undergone compression testing to simulate stacking forces during storage and distribution. Using the Instron 4411, the pouches were subjected to compression using 50 kg/force. It was found that the adlai-duck meat congee packaged in pouches can withstand compressive forces of 296 N (30.17 kg_f). Based on Canadian Food Inspection Agency as stated by Test Techno Consultants (2016), for a retort pouch to be categorized as good it should withstand a force equivalent to 30 kg_f for 60mm internal seal length.

Lacquer Quality. The tin cans used in this study were tested for its lacquer quality. The can packaging was coated with a single layer of epoxy-phenolic lacquer; the can coating was evaluated for lacquer taints, acid-resistance, and sulphide-resistance. The results showed that the epoxy-phenolic lacquer was acid- and sulfur-resistant. Furthermore, lacquer taints were not detected after incubation. Lacquer taints is a type of defect in can that is caused by the interaction of food material with the base metal (Page et. al., 2003). The findings indicated that the can was fully coated with epoxy-phenolic and did not show any signs of discontinuity. No enamel thinning was exhibited even after thermal processing. In addition, the observations from the lacquer quality study coincides with the theoretical properties of the epoxy-phenolic: less resistant to sulfur, acid-resistant as it is normally used for acidic beverages and has a very good pack resistance (Oldring and Nehring, 2007).

Drop Test. Progressive drop test method was done on pouched and canned samples to determine the critical drop height that may cause failure on the packaging. Table 8 shows the comparison of the critical drop height of pouched and canned samples. Canned samples have significantly lower critical drop height and number of drops than pouched samples ($p \leq 0.05$). The difference in drop height was due to the variation in the material used in manufacturing can and pouch. Metal is the main material used in making cans. Metals are easily deformed because of the defects present in the metal crystal. Defects such as dislocations occur due to a defective bonding. Movement of dislocations happens whenever stress is induced to the metal; this initiates bending and later on, deformation. When higher stress such as dropping from a certain height is applied to the metal, permanent deformation occurs. This type of deformation is called plastic deformation (Morris, 2007).

Table-8: Average drop height and number of drops of canned and pouched adlai-duck meat congee.

Packaging	Average Drop Height (inch)	Number of Drops (from initial height)
A	29.00 ±2.83	4
B	72.00 ±5.66	7

A= canned sample; B= pouched sample

Pouch, on the other hand, is made up of polymeric chains of carbon, hydrogen, nitrogen and oxygen atoms. Polymers exhibit a time-dependent behaviour which implies that stress is a function of time. The material will deform slowly with time when constant stress is applied. This was observed in the pouched adlai-duck meat congee when dropped from a particular height. Unlike the metal tin can, permanent dents did not occur in the pouched samples. Stress due to free fall drop steadily built up in the films of the pouch and when it exceeded the maximum stress it can endure, the seal burst and cracks in the plastic films occurred (Emri et al., 2010).

4. CONCLUSIONS

The study formulated a congee from adlai, glutinous rice and duck meat as disaster food product packaged in cans and pouches. The integration of duck meat and fusion of adlai grains with glutinous rice in one of the popular Filipino dishes, particularly *congee*, can be the start of popularizing the use of this underutilize meat and grains in the food industry. This study showed that the thermally-processed canned and pouched adlai glutinous rice and duck meat congee were safe for consumption during emergency feeding situations. Based on the shelf life study, the canned and pouched disaster food product could be stored for 165 and 315 days, respectively at ambient temperature. The Q10 shelf life estimation was the most applicable method for the study because of the lack of critical value of water activity. Moreover, retort pouch was the appropriate packaging material to contain the formulated congee due to its good barrier characteristics, same as metal tin cans, and its high package durability, as it can withstand several hazards that it may encounter during processing, warehousing, transportation, and distribution.

ACKNOWLEDGEMENT

This work was part of the research projects, supported by the OVCRE UPLB through UPLB basic research. Also greatly acknowledge and extend heartfelt appreciation to the individuals and institutions whose more ways than one have bring this into completion: To the reviewer/ evaluator for the impressive and splendid ideas and information you shared as well as for the valuable comments, suggestions and recommendation. And to the OVCRE staff for their monitoring and assistance.

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