SPECIFICATION

A PROCESS FOR PRODUCING A READY-TO-EAT (RTE) PARBOILED ADLAI (*Coix-lacryma-jobi L.)*

TECHNICAL FIELD

The present utility model generally relates to food production processed but more particularly to a process for producing a ready-to-eat (RTE) parboiled adlai.

BACKGROUND OF THE UTILITY MODEL

Adlai (*Coix-lacryma-jobi L.*) plant, also known as Job's tear or Chinese pearl barley yield grains being referred to as adlai. Adlai is an alternative staple food for the popular padded rice (*Oryza sativa*) and corn (*Zea mays*) or maize. Adlai carries nutritional significance due to its low glycemic index and high protein contents compared to other crops. It is being compared to high valued crops like quinoa based on nutritional benefits but with lesser cost. As reported, adlai contains 50% starch, 14% protein and 6% fat (FAO, 2012). Adlai is underutilized because most Filipino consumers are not yet familiar with its various food applications and health benefits. The crop is being promoted by the Department of Agriculture (DA) as an alternative source of healthy staple food.

To familiarize Filipino consumers, the most popular rice-based products will be used as benchmark in the formulation of adlai-based products. Among the products identified is the parboiled Adlai. The developmental stage will focus on enhancing the acceptability of adlai-based products in terms of flavor/taste and texture. For adlai, the crop requires an appropriate processing and packaging technologies that will increase its commercial value and acceptability to Filipino consumers. Adlai has lesser acceptability compared with rice based on the previous studies conducted by Dela Torre (2018) and Mamucod et al. (2020). Researchers are continuously conducting research to use adlai as an alternative staple food not only because it could reduce the country's dependency on crops with high environmental impact like rice and corn but most importantly for its nutritional value. Currently, more farmers

are planting adlai and the demand for the crop is increasing. Adlai can be seen in the market in grit or grain form.

During the 2021 ENNS National Dissemination of DOST-FNRI, it was presented that 36.4% of Filipinos ages 20 and above have prevalence of impaired fasting glucose and another 8.1% with high fasting blood sugar. This accounts of about 30 million Filipinos based on the 68 million population of Filipinos under the age group. There is also 14.4% prevalence of elevated blood pressure among adults ages 20 to 59 and 33.4% to 60 years and above. Adlai will be an attractive product for these niche market as it has lower glycemic index compared to rice (Meng-Hsueh et al., 2010), and as compared earlier it has cheaper price than the imported quinoa. Adlai has also higher protein content when compared to rice and corn which are suitable to the work activities of military and police personnel which can be considered in addition to the target market.

Coupling the properties of adlai as good staple food with an appropriate packaging technology will be an effective approach to capture the niche market. Development of new adlai products using retort pouch packaging technology is one of the technologies to produce RTE meals which is expected to reach USD 2,023.2 million by 2028 (6Wresearch, 2023). This technology uses retort pouch that can withstand thermal processing, and retort chamber with counter pressure. Requirements for the technology are available in the country and feasible for companies to expand production to serve the niche market. The technology does not just promise product protection but as well as bringing adlai to be positioned in a competitive market. For total packaging solution, transport packaging as well as brand and label design should also be a consideration.

US20140370174 discloses the processing method of retort rice with the following steps: 1) Starting material rice - the water content of the starting material rice employed will be no greater than the normal i.e. less than 15%, preferably from 9 to 14%, more preferable from 9-13%, and even more preferably from 11 to 12%, 2) Pressurized heated steam treatment step-employing a pressure heating chamber, the starting material rice is treated for 1-5 minutes under pressurized heated steam

at a pressure of 0.7 to 0.38 MPa and temperature of 115 to 150°C. 3) Bag-filling - starting material passed through pressurized heated steam treatment, and is packed into retort pouch of bag form.

Depending on the type of rice, solid ingredients, and liquids such as water and seasoning, may be packed together into the pouch, mixed with starting material rice, and sealed, 4) Immersion and absorption - warming of retort pouch to 60 to 80°C with hot air, 5) Retorting sterilization - best treatment is performed at heat treatment conditions of the equivalent of 4 minutes in a state with the center of the food temperature of 120°C. The steps mentioned produced a product which is the retort rice.

The objective of the utility model is to develop a process that will produce new product from adlai that can be commercially available for general population most specially to the niche market, people with prevalence of impaired fasting glucose and with high fasting blood sugar, elevated blood pressure, and working extraneous activities like military and police personnel. The products should have features of ready-to-eat, shelf stable and long product shelf life. With the above mentioned process, the process develop for ready to eat shelf stable parboiled adlai is different due to the following: 1) Starting material used in this new product and process is adlai grits and not rice, 2) Treatment used is parboiling of adlai grits in boiling water with anti-staling agent and did not use pressurized heated steam and definitely have different exposure time with the treatments, 3) Parboiled adlai after weighing at specified net weight and filled in retort pouch was already sealed and no addition of other solid and liquid ingredients mentioned in previous invention, 4) After sealing retort pouch containing parboiled adlai did not pass through immersion and absorption process, 5) The retort temperature used in new process is 118°C and not 120°C.

SUMMARY OF THE UTILITY MODEL

Disclosed is a process of producing new product using adlai grits. The product, parboiled adlai using adlai grits, was applied with retort pouch packaging technology to become ready-to-eat and shelf stable. The process was established using the

appropriate ratio of adlai grits and water, parboiling time, use of anti-staling agent, and retort processing parameters to produce the desired quality of the product. Product was packed in two types of high barrier retort pouch and applied with retort pouch packaging technology to achieve shelf life of 1 year or more at ambient storage condition 32±4°C).

The utility model aims to produce new product and process using adlai, an alternative staple food to rice and corn. With the application of retort pouch packaging technology, new product was developed for adlai with the feature of long product shelf life of 1 year or more at ambient temperature (32±4°C) using either vapor release Alox-PET/Nylon/ RCPP or PET/Aluminum/Nylon/CPP. The present utility model will offer a new kind of food in the market particularly to its niche market, 30 million men and women Filipinos ages 20 and above with prevalence to impaired fasting glucose and high fasting blood glucose (2018-2019 ENNS, DOST-FNRI; PSA, 2020).

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Fig. 1 is a flowchart of a process of producing RTE parboiled adlai.

DETAILED DESCRIPTION

Effect of retorting on parboiled adlai was determined to establish the pre-treatment of the product. Non-retorted and retorted parboiled adlai were subjected to sensory evaluation as shown in Table 1. The sensory evaluation results showed no significant differences between non-retorted and retorted parboiled adlai in terms of aroma and taste, but they were significantly different in appearance and texture. Based on the data gathered, non-retorted parboiled adlai has a lighter appearance and slightly harder texture compared to the retorted products. The softer texture of the retorted adlai can be attributed to the further heating of the product during retort processing. Although there were perceived differences, the overall acceptability of the two products was not significantly different. Both products are rated 'like very much' by the panelists.

Table 1. Sensory evaluation of non-retorted and retorted parboiled adlai

Sensory Attributes	Condition(s)	
	Non-retorted	Retorted
Appearance	5.79 ± 1.15 a	4.79 ± 1.52 b
Acceptability of Appearance	8.57 ± 0.62 a	7.50 ± 1.18 b
Aroma	8.00 ± 0.65 a	8.00 ± 0.93 a
Texture (adlai grits)	4.50 ± 0.82 a	3.93 ± 0.70 b
Acceptability of Texture	7.71 ± 0.59 a	8.07 ± 0.46 b
Taste	8.07 ± 0.59 a	8.21 ± 0.57 a
Overall Acceptability	8.00 ± 0.53 a	8.07 ± 0.80 a

Values are expressed as mean ± standard deviation. Means followed by the same letter within the row are not significantly different at p=0.05 (n=14)

Legend: **Appearance**: 1=extremely dark, 2= moderately dark, 3= slightly dark, 4=just right, 5= slightly light, 6= moderately light, 7=extremely light; **Acceptability of Appearance**: 9=Like extremely, 8=Like very much,7=like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately, 2= dislike very much, 1=dislike extremely; **Aroma:** 9=Like extremely, 8=Like very much,7=like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately, 2= dislike very much, 1=dislike extremely; **Texture:** 1=extremely soft, 2= moderately soft, 3= slightly soft, 4=just right, 5= slightly hard, 6= moderately hard, 7=extremely hard; **Texture Acceptability:** 9=Like extremely, 8=Like very much,7=like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately, 2= dislike very much, 1=dislike extremely; **Taste:** 9=Like extremely, 8=Like very much,7=like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately, 2= dislike very much, 1=dislike extremely; **Overall acceptability**:9=Like extremely, 8=Like very much,7=like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately, 2= dislike very much, 1=dislike extremely

Based on the initial results, pre-treatments for RTE parboiled aldai was established by conducting experiments on 1) effect of parboiling time, 2) effect of anti-staling agent, and 3) effect of retort temperature.

1. Effect of parboiling time

The data presented in Table 2 shows that adlai parboiled in water (1:8 ratio) has increasing weight reported as percent yield while the time of cooking lengthens.

Prolonged heating time causes more absorption of water in cooking adlai. Similar with the study conducted by Hadipematu et. al (2022) in Ciherang variety of rice.

While looking at the percent yield of parboiled adlai, the sensory quality of the product was also considered. The results of the sensory evaluation in Table 3 showed no significant differences among the products in all sensory attributes except for texture. The shorter parboiling time resulted in a firmer and 'just right' texture of parboiled adlai. Too much water absorption causes the grits to swell and become mushy. There is no significant difference in texture between parboiled adlai cooked in 16 and 18 minutes, and both are significantly different from those cooked in 20 minutes. Although, in terms of overall acceptability, there was no significant difference among the three treatments, panelists rated each product processed in different parboiling times' very much'.

Parboiled adlai with different parboiling times was also subjected to physico-chemical analysis. The results for pH, water activity, and color showed no significant differences.

Based on the series of experiments conducted, while there is more yield in the 20-minute cooking time, the 16-minute one provided firmer quality, particularly when the batch size was increased. The 16-minute cooking time is also more economical considering production time and energy. In the succeeding experiment in the development of parboiled adlai, the 16-minute cooking time prior to retorting was used.

Table 2. Percent yield of parboiled adlai at different cooking times.

Cooking Time (minutes)	Parboiled Adlai Yield (%)	Temperature reach during cooking (°C)
16	252	98.0
18	255	99.5
20	272	99.8

Table 3. Sensory evaluation of parboiled adlai at different cooking times

Sensory Attributes	Cooking Time (minutes)		
	16	18	20
Appearance	4.27 ± 1.11 a	4.13 ± 1.15 a	4.20 ± 1.22 a
Acceptability of Appearance	7.33 ± 0.88 a	7.33 ± 0.88 a	7.33 ± 0.59 a
Aroma	7.67 ± 0.98 a	7.60 ± 1.18 a	7.53 ± 0.90 a
Texture (adlai grits)	4.13 ± 0.52 a	4.20 ± 0.41 a	3.67 ± 0.59 b
Acceptability of Texture	7.73 ± 1.04 a	7.87 ± 0.77 a	7.53 ± 0.91 a
Taste	8.00 ± 0.85 a	8.13 ± 0.80 a	8.07 ± 0.85 a
Overall Acceptability	7.73 ± 0.97 a	7.80 ± 0.80 a	7.40 ± 0.62 a

Values are expressed as mean ± standard deviation. Means followed by the same letter within row are not significantly different at p=0.05 (*n*=14)

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2. Effect of anti-staling agent

addition of an anti-staling agent at different concentrations did not affect the yield of parboiled adlai, as shown in Table 4.

The different concentrations of anti-staling added to parboiled adlai have no significant differences in sensory attributes and acceptability in terms of appearance, aroma, texture, and taste as shown in Table 5. For physico-chemical properties presented in Table 6, all parameters have no significant differences except in pH. The increased concentration of food stabilizer caused a decrease in the pH of parboiled adlai but still falls under the category of low acid food. Food with a pH value >4.6 and water activity >0.85 are covered by the Low-acid Canned Foods (LACF) Regulation of the USFDA (1997).

Since there were no significant differences in sensory properties, and the category of the food still remains low-acid food, a 6% concentration of anti-staling agent was applied to parboiled adlai.

Table 4. Percent yield of parboiled adlai at different anti-staling agent concentration.

Concentration (%)	Cooking time of adlai (minutes)	Parboiled Adlai Yield (%)
6	16	230.0
8	16	230.0
10	16	238.5

Table 5. Sensory evaluation of parboiled adlai at different anti-staling concentrations

Sensory Attributes	Concentration of anti-staling agent (%)		
	6	**8**	**10**
Appearance	4.40 ± 1.13 a	3.60 ± 1.11 a	4.20 ± 1.11 a
Acceptability of Appearance	7.53 ± 0.97 a	7.07 ± 1.29 a	7.40 ± 1.04 a
Aroma	7.87 ± 0.60 a	7.60 ± 0.63 a	7.73 ± 0.73 a
Texture (adlai grits)	4.40 ± 0.51 a	4.40 ± 0.51 a	4.33 ± 0.75 a
Acceptability of Texture	7.87 ± 0.55 a	7.80 ± 0.60 a	7.93 ± 0.49 a
Taste	7.87 ± 0.80 a	7.80 ± 0.80 a	7.87 ± 1.21 a
Overall Acceptability	7.93 ± 0.64 a	7.40 ± 0.66 a	7.87 ± 0.86 a

Values are expressed as mean ± standard deviation. Means followed by the same letter within row are not significantly different at p=0.05 (*n*=15)

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Table 6. Physicochemical analysis of parboiled Adlai at different levels of anti-staling agent

Parameter	Concentration of anti-staling agent (%)		
	6	**8**	**10**
pH	5.72 ± 0.05 a	5.10 ± 0.10 b	4.75 ± 0.64 c
Water activity	0.996 ± 0.001 a	0.995 ± 0.001 a	0.993 ± 0.001 a
Color			
L	66.8 ± 0.52 a	66.7 ± 0.64 a	67.2 ± 0.20 a
a	1.5 ± 0.03 a	1.3 ± 0.16 a	1.4 ± 0.28 a
b	8.5 ± 0.62 a	8.2 ± 0.27 a	8.2 ± 1.09 a

Means followed by the same letter within row are not significantly different at p=0.05, for pH and aw, n=6, for color n=8.

3. Effect of retort temperature

Table 7 shows the results of sensory evaluation of parboiled adlai retort processed at 118°C and 121°C. For sensory evaluation, there were significant differences in terms of appearance, texture, and overall acceptability. Sensory panelists observed that products retort processed at 118°C has lighter appearance, 'just right' texture, and higher overall acceptability compared to those processed at 121°C.

Table 7. Sensory evaluation of 118°C and 121°C processing temperature.

Sensory Attributes	Condition(s)	
	118°C	121°C
Appearance	4.47 ± 1.12 a	3.73 ± 1.16 b
Acceptability of Appearance	7.60 ± 0.99 a	7.07 ± 0.96 b
Aroma	7.40 ± 0.91 a	7.60 ± 0.74 a
Texture (adlai grits)	3.87 ± 0.64 a	4.73 ± 0.46 b
Acceptability of Texture	7.13 ± 0.64 a	7.00 ± 0.83 a
Taste	7.80 ± 0.77 a	8.00 ± 0.65 a
Overall Acceptability	7.40 ± 0.83 a	7.00 ± 1.20 b

Values are expressed as mean ± standard deviation. Means followed by the same letter within row are not significantly different at p=0.05 (n=15)

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Established pre-treatment for parboiled adlai was used in the final formulation of RTE parboiled adlai as shown in Fig. 1. Retort pouches are sealed and processed in a retort chamber with counter pressure. Using a toll packer's retort chamber with capacity of 1152 pouches (120 mm x 205 mm retort pouches), the process schedule was established at 22 minutes at 118°C. The reference microorganism used is *C. Botulinum*. Table 8 shows the heating parameters and results of commercial sterility tests validating the process schedule established for RTE parboiled adlai.

Table 8. Heating parameters for RTE parboiled adlai in retort pouch (200 g).

No. trial (s)	Heating parameters	
	jh	fh
1	1.61	11.70
2	1.53	11.98
3	1.41	11.03
4	1.59	12.55
5	1.66	12.50

Parboiled adlai in two types of packaging produced using the established process schedule was evaluated for sensory evaluation and physicochemical analysis shown in Tables 9 and 10 respectively. Table 11 shows the evaluation of Alox-PET/Nylon/RCPP with vapor release and PET/Aluminum/Nylon/CPP processed with parboiled adlai.

Based on the sensory evaluation results, no significant differences between the two products were observed for all attributes except for overall acceptability. Parboiled adlai packed in vapor release (Alox-PET/Nylon/RCPP) has a higher overall acceptability compared to product packed in foil pouch (PET/Aluminum/Nylon/CPP).

Appearance	4.47 ± 1.29 a	4.47 ± 1.60 a
Acceptability of Appearance	8.00 ± 0.76 a	7.93 ± 0.46 a
Aroma	7.93 ± 0.70 a	7.93 ± 0.59 a
Texture (adlai grits)	4.40 ± 1.35 a	4.47 ± 1.30 a
Texture acceptability	7.87 ± 0.92 a	7.87 ± 0.92 a
Taste	8.00 ± 0.53 a	8.00 ± 0.65 a
Overall acceptability	7.86 ± 0.53 a	7.64 ± 0.93 b

Table 9. Sensory evaluation of established processing time for RTE parboiled adlai processed in Aiox-PET/Nylon/RCPP with vapour release and PET/Aluminum/Nylon/CPP

Values are expressed as mean ± standard deviation. Means followed by the same letter within row are not significantly different at p=0.05 (*n*=15)

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Table 10. Physico-chemical tests of established processing time for RTE parboiled adlai (200 g) processed in Aiox-PET/Nylon/RCPP with vapour release and PET/Aluminum/Nylon/CPP

Parameter	Retortable pouches	
	Alox-PET/Nylon/RCPP	PET/Aluminum/Nylon/CPP
pH	6.43 ± 0.05 a	6.45 ± 0.01 a
Water activity	1.000 ± 0.002 a	0.996 ± 0.001a
Color		
L	69.83 ± 0.56 a	69.36 ± 0.63 b
a	2.06 ± 0.33 a	2.17 ± 0.19 b
b	9.70 ± 1.08 a	10.26 ± 0.08 a

Means followed by the same letter within row are not significantly different at p=0.05, for pH and aw, n=6, for color n=8.

Table 11. Evaluation of retortable pouches using the established processing time for RTE parboiled adlai (200 g).

	Retortable pouches	
Parameters/Properties	Alox-PET/Nylon/ RCPP	PET/Aluminum/ Nylon/CPP
Seal strength, N/15mm Manufacturer's seal Toll packer's seal	 64.869 63.774	 64.458 45.489
Oxygen Transmission Rate, cc/m²-day	49.0	0.9099
Water Vapor Transmission Rate, g/m²-day	1.42	0.254
Ability to withstand 118°C	Can withstand retort processing time &temperature	Can withstand retort processing time &temperature
Visual inspection for change in appearance and flex crack	No delamination & no change in color of pouches	No delamination & no change in color of pouches

The RTE parboiled adlai is a new product using the commodity being promoted by Department of Agriculture as an alternative staple food to rice and corn. Adlai is a good alternative ingredient as research in modern medicine has confirmed its beneficial effects on health, including the ability to regulate blood sugar, blood lipids, blood pressure to improve gastrointestinal physiology and reproductive endocrine hormones (Hsia et al., 2007). Establishment of the process to create new product from adlai will help the Food Industry to cater the need of niche market, 30 million men and women Filipinos ages 20 and above with prevalence to impaired fasting glucose and high fasting blood glucose (2018-2019 ENNS, DOST-FNRI; PSA, 2020). Military and police with population of 151,000 (Global firework, 2023) and 207,642 respectively (PSA, 2021) are also potential markets

Coupling the properties of adlai as good staple food with an appropriate packaging technology will be an effective approach to capture the niche market. Development of new adlai products using retort pouch packaging technology is one of the technologies to produce RTE meals which is expected to reach USD 2,023.2 million by 2028 (6Wresearch, 2023). This technology uses retort pouch that can withstand thermal processing, and retort chamber with counter pressure. Requirements for the technology are available in the country and feasible for companies to expand production to serve the niche market. The technology does not just promise product protection but as well as bringing adlai to be positioned in a competitive market. For total packaging solution, transport packaging as well as brand and label design should also be a consideration.

Recapping the utility model, the process for producing ready-to-eat (RTE) and shelf stable parboiled adlai which can be grits or any forms of adlai as raw material, comprises the steps of:

a.) Parboiling of adlai in water with adlai and water ratio of 1:6 to 1:10 and anti-staling agent in the amount by percent of 6 to 10% by weight of adlai for 16 to 20 minutes;

b.) Filling parboiled adlai weighing 200 grams in a retort pouch;

c.) Sealing of the retort pouch; and

d.) Retorting the parboiled adlai in the retort pouch at 118°C to achieve condition with sterility value of 4 minutes.

The 6-10% of anti-staling agent based on solids is added to maintain soft texture or parboiled adlai after retorting and during storage.