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Estimation of vegetable leather shelf life from a combination of beluntas leaves (*Pluchea indica* L.) and seaweed (*Eucheuma cottonii*) with various types of packaging using the ASLT (accelerated shelf life testing) method of the arrhenius model

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Abstract. Beluntas leaves vegetable leather is a new processed product, so its shelf life is currently unknown. This research utilised the ASLT (*Accelerated Shelf Life Test*) Arrhenius model to assess the shelf life of vegetable leather in three different forms of packaging, including aluminum foil, combination (aluminum foil-polyethylene), and polypropylene. The research includes two replications and a descriptive design. Three different types of packing were used to store vegetable leather for a month at oven temperatures of 30°C, 35°C, and 40°C (28 days). Every week, on days 0, 7, 14, 21, and 28, observations were made about the moisture content and sensory factors (texture, color, and aroma). The shelf life of vegetable leather was calculated using the parameter data using the Arrhenius model ASLT method with Microsoft Excel 2010. The results indicated that vegetable leather beluntas leaves packaged in aluminum foil had a shelf life of 179.53 days (5 months, 27 days), while in combination packaging (aluminum foil-polyethylene), they had a shelf life of 44.20 days (1 month, 13 days). In polypropylene packaging, the product had a shelf life of 35.94 days (1 month and four days) according to order 1 of the Arrhenius model ASLT method.

1. Introduction

The Beluntas plant (*Pluchea indica* L.) belongs to the Asteraceae family. Clinically recognized as a plant used to treat numerous health conditions, such as diarrhea, body odor, rheumatism, laxative fever, stomach pain, and inflammation. Beluntas leaves contain 2.02 percent tannin, 3.18 percent alkaloids, 1.09 percent flavonoids, 3.06 percent saponins, and 0.38 percent essential oils. Relatively few beluntas leaves are processed [1]. The leaves of Beluntas can be turned into plant-based foods, specifically vegetable leather . Vegetable leather is a product made from dried vegetables that is chewy in texture and consumed as a snack in the form of strips or flexible sheets [2].

Vegetables with a high fiber content are utilized in the production of vegetable leather . The crude fiber content of beluntas leaves is very high, at 14.77 - 15.80 % [3]. The production of vegetable leather necessitates a binder to provide a flexible and supple texture that is resistant to breaking. To do this, *Eucheuma cottonii* seaweed containing hydrocolloid chemicals was added as a binder. 54-73 % of the hydrocolloid chemicals in *Eucheuma cottonii* are carrageenan [4]. The shelf life of vegetable leather beluntas leaves must be determined because it is a newly processed product. The vegetable leather utilized in this study is vegetable leather made from beluntas leaves processed at a ratio of 30% beluntas leaves to 70% seaweed.

Packaging is one approach to maintain and extend the shelf life of a product. For the storage of vegetable leather, the optimal packaging has not yet been determined. The use of unsuitable packaging materials will result in a decline in product quality within a certain time frame. The amount of water in a food product has a significant impact on its level of acceptance. The texture of vegetable leather is firm and rigid/plastic because to the lower water content [5]. The best way to shield vegetable leather beluntas leaves from impurities, stop nutrient loss, and increase shelf life is through packaging. Each type of packaging has a distinct resistance to maintaining the quality of food goods because it has a different permeability to gas and water vapor [6]. Three packaging types polypropylene plastic, aluminum foil, and a mix of the two can be utilized to increase the shelf life of products (polyethylene-aluminum foil plastic).

The densities for aluminum foil, PE (LDPE), and PP packing were 1,0580 g/m3, 0,9081 g/m3, and, correspondingly, 0.9177 g/m3 [7]. The permeability of the packaging material to gas and water vapor decreases with increasing density value. When a food product is consumed, it has had its shelf life, which is the amount of time since it was produced. The product's look, taste, aroma, texture, and nutritional value all indicate that it is in good condition [8]. The Accelerated Shelf Life Testing (ASLT) method can be used to determine a product's shelf life by applying environmental characteristics that can hasten the process of a food product's useable quality. The ASLT method employs the Arrhenius equation, which applies kinetic theory and frequently employs zero or first order for food products [9]. According to the zero-order reaction model, enzymatic degradation, non-enzymatic browning processes, and fat oxidation reactions are the types of food deterioration. Fresh fruits and vegetables, certain frozen foods, dry grains, and dry dairy products are examples of foods that can cause allergic reactions (eg increased rancidity in snacks, dry foods and frozen foods). The first order reaction includes the following types of food spoilage: (1) rancidity (e.g., in salad oil and dried vegetables); (2) growth of microorganisms (e.g., in fish and meat and death of microorganisms due to heat treatment); (3) production of off-flavor by microbes; (4) vitamin loss in canned and dried foods; and (5) loss of protein quality (dry foods). Vegetable leather may adhere to a zero-order or first-order reaction paradigm based on this assertion. Using the Accelerated Shelf Life Test (ASLT) method of the Arrhenius model, the purpose of this study is to estimate the shelf life of vegetable leather packaged in polypropylene, aluminum foil, and a combination (PE – aluminum foil).

2. Materials and methods

This study utilized beluntas leaves (*Pluchea Indica* L.) from Kotabumi, North Lampung; E. cottonii seaweed from Way Urang Village, Kalianda District, South Lampung; and salt as a supplement. This study employed as packaging materials polypropylene (PP) plastic packaging with a thickness of 0.07 mm, aluminum foil with a thickness of 0.06 mm, and a combination (polyethylene-aluminum foil) with thicknesses of 0.03 mm and 0.06 mm. The Aladin Jaya store in Bandar Lampung is one of the distributors of various types of packaging.

Vegetable leather was packaged in polypropylene, aluminum foil, and a combination (polyethylene-aluminum foil) and stored at 30^{o}C, 35^{o}C, and 40^{o}C with two replications. The research used descriptive technique with three storage temperature treatments and two replications. Storage of vegetable leather is performed for 28 days. The moisture content and sensory tests (color, aroma, and texture of vegetable leather) were evaluated once each week on days 0, 7, 14, 21, and 28 and compared to controls. The collected test results are used to calculate the shelf life of vegetable leather by applying the ASLT (Accelerated Shelf Life Testing) Arrhenius model in Microsoft Excel 2010 with the test data. The obtained test results were applied to the ASLT (Accelerated Shelf Life Testing) Arrhenius model in Microsoft Excel 2010 to calculate the shelf life of vegetable leather.[10].

2.1. Research Implementation

The research implementation consists of various stages, including the production of vegetable leather, the storage of vegetable leather , the analysis and observation of vegetable leather , and the estimation of the shelf life of vegetable leather leaves beluntas. The segments 1-10 of beluntas leaves utilized were sourced. The utilized seaweed was dry *Eucheuma cottonii* seaweed. Beluntas leaves and seaweed are combined in a ratio of 30%:70%. The combined weight of beluntas leaves and seaweed is 150 grams, plus 1.5 grams of salt and one liter of water. Before being processed, beluntas leaves are cleaned with clean water and blanched for 5 minutes under steam. In the meanwhile, *E. cottonii* seaweed was soaked for 1.5 hours in water and rinsed thoroughly. Both components are blended for 5 minutes at medium speed in a blender until they become smooth. In addition, the slurry is printed onto sheets measuring 20x20 cm. The sheets of vegetable leather were then air-dried at room temperature for four days. The vegetable leather was taken from the mold after drying and then baked at 60°C for 15 minutes.

The created vegetable leather samples are next packaged in polypropylene plastic packaging, aluminum foil, and a combination (PE-aluminum foil), and then stored at 30^{o}C, 35^{o}C, and 40^{o}C for 28 days using three ovens for each storage temperature. At each storage temperature and packaging type, eight packets of 50 g each were manufactured.

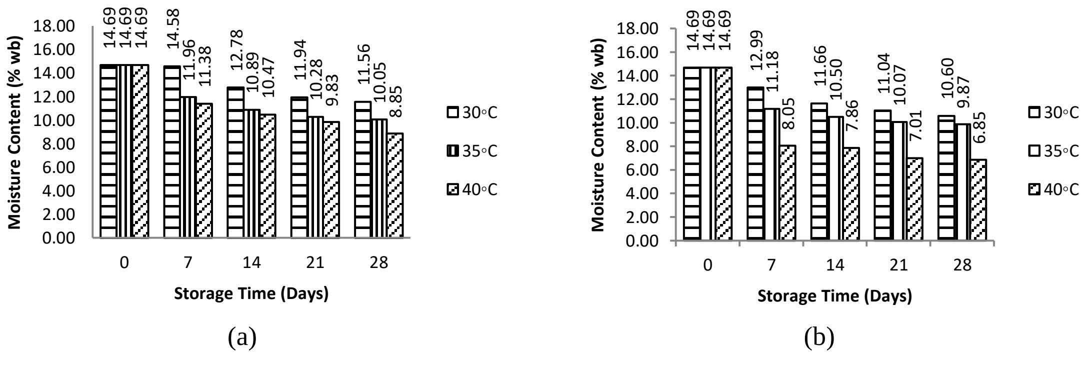
2.2. Observation

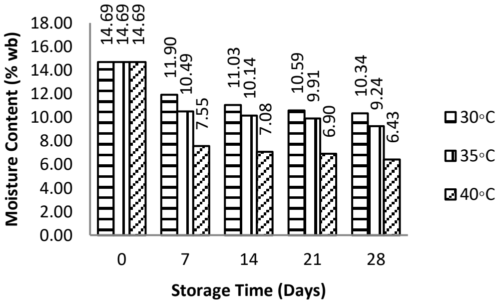
Throughout a period of 28 days, vegetable leather was observed once per week, on days 0, 7, 14, 21, and 28. The moisture content [11] and sensory (color, aroma, and texture) characteristics of vegetable leather were evaluated. The sensory test used the scoring method with 20 trained panelists. The results were subsequently evaluated to establish the shelf life of vegetable leather after moisture content and sensory tests (color, aroma, and texture) were conducted. The ASLT method (accelerated storage) combined with the Arrhenius approach is the technique used to estimate shelf life (reaction kinetics). Analysis of the determination of the shelf life of vegetable leather utilizing the Arrhenius model acceleration method simulation in Microsoft Excel 2010 Program Line and Scatter [10].

3. Results and Discussion

3.1. Water content

The figure 1 shows the histogram of the relationship between the amount of time (days) and amount of moisture (% wb) that vegetable leather on aluminum foil, combined polyethylene and polypropylene packaging was stored at 30^0 C, 35^0 C, and 40^0 C.





(c)

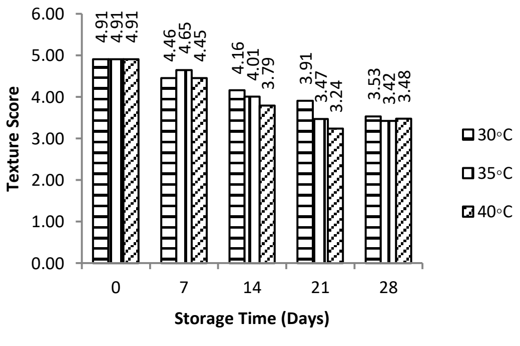
Figure 1. Changes in vegetable leather 's moisture content during storage: (a) aluminum foil packaging, (b) combination packaging, and (c) polypropylene packaging.

The moisture content of vegetable leather beluntas leaves and *Eucheuma Cottonii* seaweed generally decreases when packaged in aluminum foil, combination (aluminum-polyethylene), and polypropylene and stored at 30^0C, 35^0C, and 40^0C (oven) temperatures for 28 days. Temperature and storage time cause the water content of vegetable leather to evaporate, resulting in a decrease in the water content of vegetable leather. Because high temperature and air velocity accelerate the evaporation process on the surface and within the particles due to the different vapor pressures of the liquid [12], the higher the storage temperature, the lower the moisture content of a product. In addition, different types of packaging lead to varying water content reductions. This is due to the fact that the permeability of the three packing types differs.

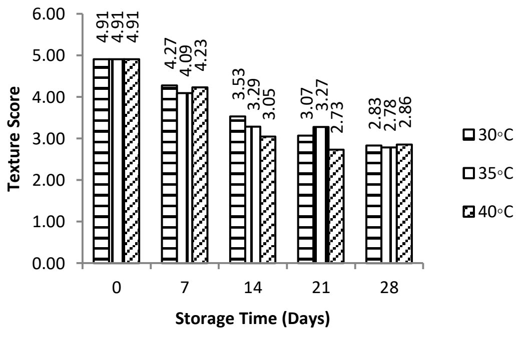
In comparison to the other two methods of packaging, aluminum foil has a lower permeability to water vapor (0.1773 g/m^2/24 hours) and a lower permeability to O_2 (0.3 cc/m^2/24 hours) [13]. In contrast, polypropylene packaging has a higher permeability to water vapor and gas than aluminum foil, which has a permeability of 0.185 g/m^2/24 hours and 3.2 ml cc/m^2/24 hours, respectively. This is because polyethylene packaging in combination packaging has a higher permeability to water vapor and gas, which is 800 cc/sec. cm^2, cmHg and 55 cc/sec. cm^2, cmHg [14]. Based on this, aluminum foil packaging inhibits vegetable leather 's water vapor evaporation during storage more than the other two packaging choices.

3.2. Sensory Test

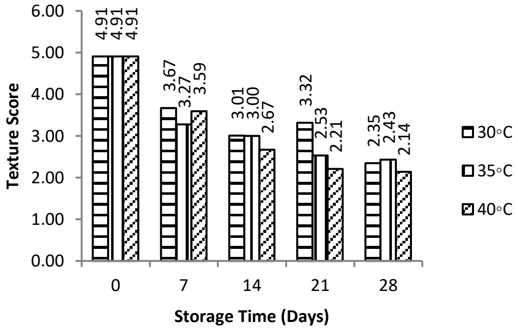
3.2.1. Texture. The figure 2 depicts the histogram of the association between storage time (days) and the texture of vegetable leather on aluminum foil, combination (alufo-PE), and polypropylene packaging held at 30^0 C, 35^0 C, and 40^0 C.



(a)



(b)



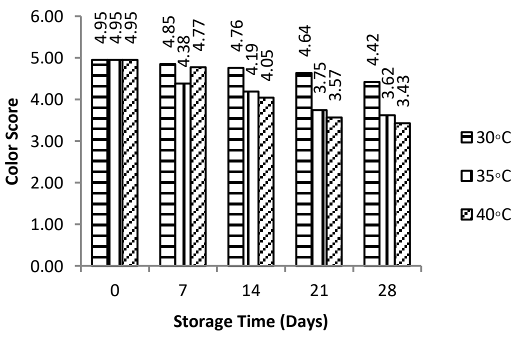
(c)

Figure 2. Changes in vegetable leather 's texture score during storage: (a) aluminum foil packaging, (b) combination packaging, and (c) polypropylene packaging.

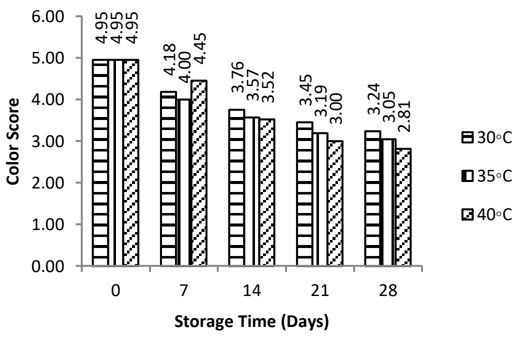
The texture score of vegetable leather beluntas leaves when packaged in aluminum foil, combination (aluminum-polyethylene), and polypropylene and stored at 30^0C, 35^0C, and 40^0C temperatures for 28 days tended to decrease. The resulting texture becomes less dense as storage time and temperature increase. Especially at higher temperatures, the texture becomes less dense (not plastic and readily smashed). The water content of the product influences the depreciation of product texture. The lower the water content, the more the texture of vegetable leather becomes non-plastic and brittle when rolled [15].

As a result of the utilization of three distinct methods of packaging, the texture's value was diminished differently. Compared to combination packaging and polypropylene, aluminum foil packaging has a smaller textural value reduction. This is because aluminum foil packaging has a lower permeability to water vapor and gas. Low water vapor permeability helps limit vegetable leather water evaporation and avoid texture deterioration. The expected texture of vegetable leather is similar to that of nori. As a coating or wrapper for sushi, nori has a texture that is predominantly crunchy but not easily broken [16].

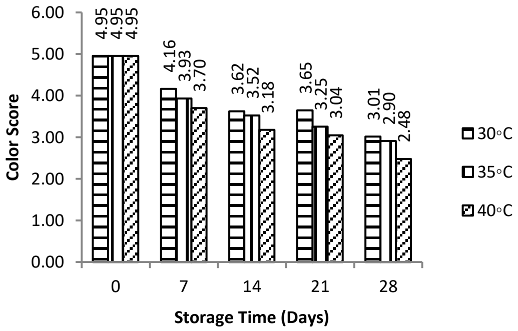
3.2.2. Color. The figure 3 depicts the histogram of the association between storage time (days) and vegetable leather color for aluminum foil packaging, combination (alufo-PE), and polypropylene stored at 30^0 C, 35^0 C, and 40^0 C.



(a)



(b)



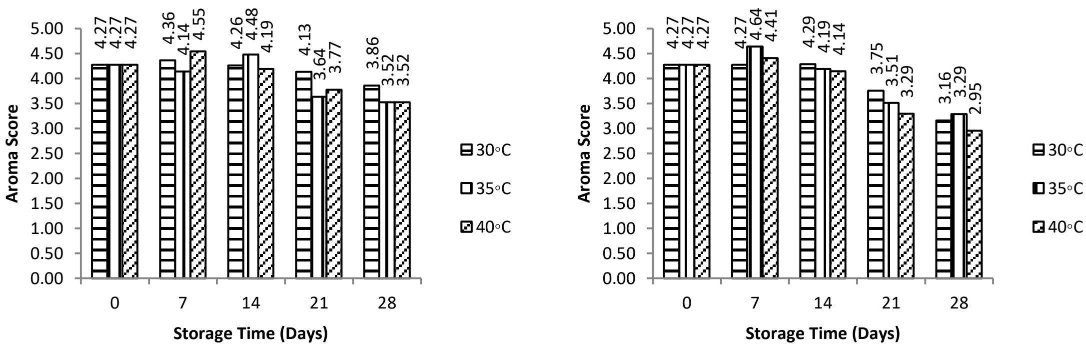
(c)

Figure 3. Changes in vegetable leather color score during storage: a) aluminum foil packaging, (b) combination packaging, (c) polypropylene packaging

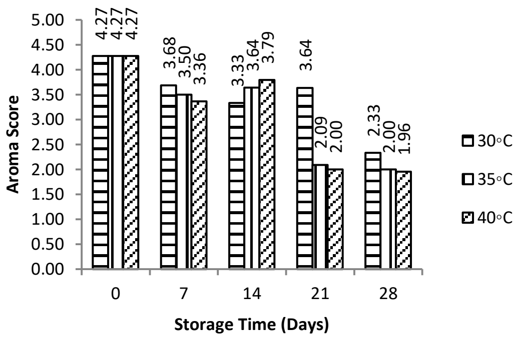
Vegetable leather Beluntas leaves and *Eucheuma cottonii* seaweed packaged with three various types of packing and stored at 30^0C, 35^0C, and 40^0C for 28 days tend to lose color. Particularly at higher temperatures, the color begins to progressively fade and a brownish color also appears. It is believed that the color shift of vegetable leather is induced by non-enzymatic browning reactions such as the chlorophyll degradation. The conversion of chlorophyll to pheophytin is accelerated at temperatures exceeding 40ºC [7]. In the presence of heat, the protein coupled to lipoprotein and chlorophyll will become denatured. This denatured state can enable the release of Mg ions from chlorophyll, which are then replaced by H ions, resulting in the formation of brown pheophytin and feoforbid.

Compared to combination packaging and polypropylene, there is a smaller drop in color value with aluminum foil packaging. This occurs because this packaging is more resistant to heat, minimizing the chlorophyll degradation caused by high temperatures during storage. Changes in water content can also cause variations in color. The lower the water content, the greater the production of vegetable leather chocolate. The presence of water can reflect light, making the object appear brighter [17].

3.2.3. Aroma. The figure 4 illustrates the histogram of the relationship between the amount of time (days) spent in storage and the aroma of vegetable leather stored on aluminum foil packaging, combination (alufo-PE), and polypropylene at temperatures of 30^0 C, 35^0 C, and 40^0 C.



(a) (b)



(c)

Figure 4. Changes in the aroma score of vegetable leather during storage a) aluminum foil packaging, (b) combination packaging, (c) polypropylene packaging

The aroma is evaluated hedonistically based on the level of preference of the panelists. The aroma value of vegetable leather wrapped with three various forms of packing and stored at 30°C, 35°C, and 40°C for 28 days tends to diminish. Especially when the temperature rises, the aroma becomes increasingly unpleasant. The aroma of vegetable leather is derived from the beluntas leaves and *E. Cottonii* seaweed used in its production. However, the aroma of the beluntas leaves is more prominent because the beluntas leaves contain thiopenes, an aromatic chemical responsible for the plant's foul stench [18].

The evaporation of volatile chemicals in the product can lead to a decline in the panelists' evaluation of aroma [15]. In addition, the aroma tends to diminish during storage due to the product's contact with oxygen, which triggers an oxidation reaction and disrupts the product's aroma. According to the result of the research, aluminum foil packaging can avoid a lesser reduction in scent scores than combination packaging and polypropylene. This is associated with the packaging's permeability. The lower the permeability, the lower the evaporation process of volatile chemicals caused by the storage process at high temperatures, and the less likely it is that the oxidation process will occur, which can result in variations in the aroma of vegetable leather. In the meanwhile, this form of plastic packaging is also translucent. The combination of oxygen and light can speed the oxidation process. Light is an accelerator against rancidity.

3.3. Shelf Life Estimation

The criteria for the selection of quality parameters to calculate the shelf life of a product are the quality parameters whose quality degrades most rapidly during storage, as indicated by the coefficient k or the correlation coefficient with the greatest value (R^2) [10]. Tables 1, 2, and 3 outline the criteria for a variety of these experimental characteristics using three distinct packing techniques.

Table 1. Graph depicting the relationship between aluminum foil packaging quality criteria and storage temperature

Parameters Quality	Information/ Shelf life	Temper -ature (°C)	Order 0			Order 1		
			Slope (k)	Intercept (b)	Correlation (R^2)	Slope (k)	Intercept (b)	Correlation (R^2)
Moisture Content		30	-0.127	14.889	0.9275	-0.0097	2.7042	0.9342
		35	-0.1564	13.765	0.838	-0.013	2.6209	0.8709
		40	-0.1889	13.691	0.8743	-0.0166	2.6188	0.918
	average ∑		-0.1574	14.1150	**0.8799**	-0.0131	2.6480	**0.9077**
	1/T Relationship Plot		-3766.1	10.3680	0.9996	-5097.5	12.194	0.9982
Texture		30	-0.0471	4.8534	0.9902	-0.0113	15,668	0.9927
		35	-0.0594	4.9211	0.9484	-0.0145	15,896	0.95
		40	-0.0583	4.7901	0.8638	-0.0144	15,976	0.8551
	average ∑		-0.0549	4.8549	**0.9341**	-0.0134	15846.66 67	**0.9326**
	1/T Relationship Plot		-2035.9	3.7041	0.6934	-2312.1	3.1891	0.7369
Color		30	-0.0183	4.9810	0.9688	-0.0039	1.6066	0.9626
		35	-0.0472	4.8397	0.956	-0.0112	1.5805	0.9675
		40	-0.0608	5.0056	0.9512	-0.0147	1.6185	0.9559
	average ∑		-0.0421	4.9421	**0.9587**	-0.0099	1.6019	**0.9620**
	1/T Relationship Plot		- 11422. 0	33.8060	0.9053	- 12632. 0000	36.2380	0.9061
Aroma		30	-0.0151	4.3900	0.7238	-0.0037	1.4806	0.7206
		35	-0.0285	4.4087	0.5884	-0.0073	1.4871	0.6114
		40	-0.0324	4.5151	0.7718	-0.0082	1.5117	0.7832
	average ∑		-0.0253	4.4379	**0.6947**	-0.0064	1.4931	**0.7051**
	1/T Relationship Plot		-7266.0	19.8680	0.8781	-7575.5	19.4930	0.8634
	average ∑				**0.8674**			**0.8764**

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Table 2. On combination packaging, plot the relationship between quality metrics and storage temperature.

Parameters Quality	Information/ Shelf life	Temper -ature (^oC)	Order 0			Order 1		
			Slope (k)	Intercept (b)	Correlation (R^2)	Slope (k)	Intercept (b)	Correlation (R^2)
Moisture Content		30	-0.1449	14.224	0.9341	-0.0117	2.6572	0.9504
		35	-0.1536	13.412	0.7363	-0.0129	2.5903	0.7723
		40	-0.2388	12.237	0.6487	-0.0238	2.4742	0.7063
	average ∑		-0.1791	13.2910	**0.7730**	-0.0161	2.5739	**0.8097**
	1/T Relationship Plot		-4717.9	13.5750	0.8292	-6707.5	17.602	0.8442
Texture		30	-0.0766	4.7955	0.9683	-0.0205	1.5800	0.9846
		35	-0.0725	4.6828	0.9169	-0.0194	1.5515	0.9405
		40	-0.0801	4.6745	0.8453	-0.0217	1.5442	0.8507
	average ∑		-0.0764	4.7176	**0.9102**	-0.0205	1.5586	**0.9253**
	1/T Relationship Plot		-415.8	-1.2225	0.1927	-530.9	-2.1628	0.2496
Color		30	-0.0594	4.7491	0.9369	-0.0149	1.5622	0.9637
		35	-0.0661	4.6775	0.9089	-0.0171	1.5464	0.9432
		40	-0.0819	4.8965	0.9571	-0.0218	1.6027	0.9696
	average ∑		-0.0691	4.7744	**0.9343**	-0.0179	1.5704	**0.9588**
	1/T Relationship Plot		-3040.5	7.1927	0.9605	-3603.4	7.6677	0.9722
Aroma		30	-0.0392	4.4981	0.7654	-0.0105	1.5133	0.7547
		35	-0.0443	4.5991	0.7606	-0.0115	1.5336	0.7764
		40	-0.0537	4.5654	0.8367	-0.0147	1.5326	0.8362
	average ∑		-0.0457	4.5542	**0.7876**	-0.0122	1.5265	**0.7891**
	1/T Relationship Plot		-2981.1	6.5871	0.9813	-3182.9	5.9219	0.9296
	average ∑				**0.8513**			**0.8707**

Table 3. A graph showing how quality factors and storage temperature relate to polypropylene packing

Parameters Quality	Information/ Shelf life	Temper -ature (^oC)	Order 0			Order 1		
			Slope (k)	Intercept (b)	Correlation ($R^{2)}$	Slope (k)	Intercept (b)	Correlation ($R^{2)}$
Moisture Content		30	-0.1431	13.713	0.8013	-0.0117	2.6159	0.8336
		35	-0.1639	13.190	0.6989	-0.014	2.571	0.7386
		40	-0.2454	11.963	0.6132	-0.0249	2.4401	0.6652
	average ∑		-0.1841	12.9553	**0.7045**	-0.0169	2.5423	**0.7458**
	1/T Relationship Plot		-5100.9	14.8450	0.919	-7142	19.056	0.9107
Texture		30	-0.0782	4.5442	0.8304	-0.0225	1.5240	0.8485
		35	-0.0815	4.3689	0.812	-0.0238	1.4712	0.8772
		40	-0.0989	4.4879	0.8846	-0.0307	1.5103	0.9315
	average ∑		-0.0862	4.4670	**0.8423**	-0.0257	1.5018	**0.8857**
	1/T Relationship Plot		-2219.2	4.7500	0.8710	-2936.7	5.8643	0.8742
Color		30	-0.0628	4.7591	0.918	-0.0161	1.5673	0.9318
		35	-0.0682	4.6693	0.9169	-0.018	1.5465	0.9549
		40	-0.0801	4.5924	0.8967	-0.0226	1.5331	0.9404
	average ∑		-0.0704	4.6736	**0.9105**	-0.0189	1.5490	**0.9424**
	1/T Relationship Plot		-2303.4	4.8207	0.9631	-3210.0	6.4453	0.9588
Aroma		30	-0.0561	4.2354	0.7601	-0.0175	1.4640	0.7285
		35	-0.0851	4.2913	0.8748	-0.029	1.4921	0.8616
		40	-0.0856	4.2758	0.8103	-0.0297	1.4888	0.8079
	average ∑		-0.0756	4.2675	**0.8151**	-0.0254	1.4816	**0.7993**
	1/T Relationship Plot		-4028.1	10.4800	0.7648	-5040.7	12.6680	0.7914
	average ∑				**0.8181**			**0.8433**

Following the first order reaction model, the rate of change of vegetable leather packed in three distinct forms of packaging, namely aluminum foil, combination (alufo-PE), and polypropylene (PP), Because the average value of the correlation coefficient (R^2) for the rate of decline in vegetable leather quality is more than order 0. Vegetable leather wrapped in aluminum foil, combination, and polypropylene have the highest R^2 value for order one's color parameter, according to the data in the table. To determine the shelf life of beluntas vegetable leather leaves, the results of a shelf life calculation based on the color parameter are used. Given that 30^{o}C is close to room temperature, it is at this temperature that the shelf life of vegetable leather is determined.

Comparing aluminum foil packaging to combination packaging, the former has a longer shelf life. This is because aluminum foil packaging has lower water vapor and gas permeability and greater heat and light resistance than plastic packaging. Table 4 displays the results of calculations used to determine the shelf life of vegetable leather beluntas leaves stored in reaction order 1 at 30°C, 35°C, and 40°C and packaged in three distinct packaging materials: aluminum foil, combination, and polypropylene (PP).

Table 4. The shelf life of beluntas vegetable leather leaves is based on order 1 quality degradation factors and various storage conditions (30°C, 35°C, and 40°C)

Packaging	Temperature	Shelf Life of vegetable leather beluntas leaves			
		Moisture Content (Day)	Testur (Day)	Color (Day)	Aroma (Day)
Aluminum Foil	30°C	83.13	62.68	**179.53**	205.32
	35°C	63.27	55.37	**91.25**	136.82
	40°C	48.57	49.12	**47.39**	92.37
Combination (alufo-PE)	30°C	66.75	32.23	**44.20**	72.89
	35°C	46.60	31.33	**36.44**	61.46
	40°C	32.91	30.48	**30.23**	52.11
Polypropylene	30°C	63.28	21.94	**35.94**	24.45
	35°C	43.16	18.75	**30.26**	18.66
	40°C	29.80	16.10	**25.62**	14.37

4. Conclusion

The shelf life of vegetable leather from beluntas leaves and seaweed *Eucheuma cottonii* determined based on order 1 color parameters at 30°C. Vegetable leather packaged in aluminum foil had a shelf life of 179.53 days (5 months, 27 days), while in combination packaging (aluminum foil-polyethylene), they had a shelf life of 44.20 days (1 month, 13 days). In polypropylene packaging, the product had a shelf life of 35.94 days (1 month and four days).

5. References

[1] Muta'ali R dan Purwani K I 2015 Pengaruh ekstrak daun beluntas *(Pluchea indica)* terhadap mortalitas dan perkembangan larva *Spodoptera litura F J. Sains dan Seni ITS* **4** 55-58

[2] Handayani L 2014 Indeks glikemik dan beban glikemik vegetable leather brokoli (*Brassica oleracea Var Italica)* dengan substitusi inulin *J. of Nutrition College* **3**783-790

[3] Rukmiasih 2011 Penurunan bau amis (off-odor) daging itik lokal dengan pemberian daun beluntas (*Pluchea indica L.*) dalam pakan dan dampaknya terhadap performa Institut Pertanian Bogor Bogor

[4] Anggadiredja T J, Zatnika A, Purwoto H dan Istini S 2011 *Rumput Laut* Penebar Swadaya Jakarta

[5] Rahmanto S A, Parnanto N H R dan Nursiwi A 2014 Pendugaan umur simpan fruit leather nangka (*Arrtocarpus heterophyllus*) dengan penambahan gum arab menggunakan metode Accelerated Shelf Life Test (ASLT) model Arrhenius *J. Teknosains Pangan* **3** 35-43

[6] Indraswati D 2017 *Pengemasan Makanan* Forum Ilmiah Kesehatan Ponorogo p 24

[7] Sembiring B S dan Hidayat T 2012 Perubahan mutu lada hijau kering selama penyimpanan pada tiga macam kemasan dan tingkatan suhu *J. Littri* **18** 115-124

[8] Swadana A W dan Yuwono S S 2014 Pendugaan umur simpan minuman berperisa apel menggunakan metode accelerated shelf life testing (ASLT) dengan pendekatan arrhenius *J. Pangan dan Agroindustri* **2** 203-213

[9] Hariyadi P 2019 *Masa Simpan dan Batas Kadaluwarsa Produk Pangan : Pendugaan, Pengelolaan dan Penandaannya* PT Gramedia Pustaka Utama Jakarta pp 18-27

[10] Kusnandar F D R, Adawiyah dan Fitria M 2010 Pendugaan umur simpan produk biskuit dengan metode akselerasi berdasarkan pendekatan kadar air kritis *J. Teknologi dan Industri Pangan* **21** 117-122

[11] AOAC (Official Methods of Analysis) 2019 Association of Official Analitycal Chemist (AOAC) Washington DC USA p 49

[12] Djaeni M A, Prasetyaningrum dan Mahayana A 2012 Pengeringan karaginan dari rumput laut *Eucheuma cottonii* pada spray dryer menggunakan udara yang didehumidifikasi dengan zeolit alam tinjauan kualitas produk dan efisiensi energi *Momentum* **8** 28- 34
[13] Budiyanto M P 2012 Pengaruh jenis kemasan dan kondisi penyimpanan terhadap mutu dan umur simpan produk keju lunak rendah lemak. Institut Pertanian Bogor Bogor
[14] Arpah M 2007 *Penentuan Kadaluwarsa Produk Pangan* Program Studi Ilmu Pangan Institut Pertanian Bogor Bogor pp 86-88
[15] Hasany M R, Afrianto E dan Pratama R I 2017 Pendugaan umur simpan menggunakan metode accelerated shelf life test (ASLT) model arrhenius pada fruit nori *J. Perikanan Kelautan* **8** 48-55
[16] Liviawaty E, Namira S and Afrianto E 2021 Shelf life of nori from *Gracilaria Sp*. with aluminium foil packaging based on the Accelerated Shelf Life Test method *International Journal of Quantitative Research and Modeling* **2** 1-10
[17] Haryati T E, Feronika H dan Ahmadi Kgs 2015 Pendugaan umur simpan menggunakan metode accelerated shelf-life testing (ASLT) dengan pendekatan arrhenius pada produk tape ketan hitam khas mojokerto hasil sterilisasi *J. Pangan dan Agroindustri* **3** 156-165
[18] Ibrahim S R M, Abdallah H M, Elhalawany A M and Mohamed G A 2016 Naturally occurring thiophenes: isolation, purification, structural elucidation, and evaluation of bioactivities *Phytochem Rev* **15** 197-220