The Effect of Packaging Type on The Shelf Life of Fresh Bread Premix Flour Based on Modified Flour

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Abstract. Ready-to-use flour products or premixes consist of several components of flour ingredients that are put together. This study aims to determine the quality of the effect of packaging type on the shelf life of the resulting premix flour. This study used modified rice, namely pre-cooked rice and germinated rice. The results showed that after the premix flour storage test, the shelf life of fresh bread premix flour stored using PP (Polypropylene) packaging at RH 65, 70, 75, and 80% was 0.6 years. While the product stored using HDPE (high-density polyethylene) packaging was 0.4 years at RH 65, 70, 75, and 80%. Meanwhile, white bread premix flour that uses aluminium foil packaging at the same RH, which is 65-80%, has a shelf life of 3.2 years. This is because the higher the RH of storage, the greater the pressure difference between the inside and outside of the packaging. The greater the difference in air pressure outside and inside the package, the greater the increase in the rate of diffusion of water vapor from the environment to the food product. This study shows that 65% RH is ideal for storing white bread premix flour because it has a longer shelf life.

1 Introduction

The development of consumer consumptive patterns towards instant products is increasing every year. In addition to being practical, instant products must be safe and nutritious [1]. One of the instant products that can answer the needs of consumers is modified rice flour-based fresh bread premix, which is an instant product with advantages in its functional value. The functional value of this product comes from the use of modified rice flour, namely germinated rice flour and pre-cooked rice flour, which are high in GABA (gamma-aminobutyric acid), B vitamins (B2, B6, B9), protein, fat, and iron [2]. With this premix flour, consumers will be facilitated in terms of time and cost in product processing. However, the problem that often occurs in flour products is that they easily absorb water from the air or are hygroscopic. Water vapor transfer in these products can cause unwanted changes

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and shorten the shelf life [3]. One of the technologies that can be applied to minimize this is packaging technology.

Packaging concerns are crucial and must be taken into account because packaging greatly affects the preservation of product quality and the efficient marketing of packaged goods [4] Increased water content, microbial activity, enzymes, air, and temperature are a few of the damaging causes that can be reduced by utilizing packaging technology [5] High-density polyethylene (HDPE), polypropylene (PP), and aluminium foil are the packaging materials that are frequently used for instant flour products [6]. This is because they have a comparatively lower permeability than other packaging materials.

The protective characteristics of the packaging are directly proportionate to the product's shelf life. Previous research has identified a modified rice flour-based fresh bread premix formula with the highest customer approval and nutritional content [2], however, the product's shelf life is unknown. One of the most significant pieces of information for consumers is the shelf life of food products. Extended Storage Studies (ESS) and Accelerated Shelf-life Testing (ASLT) can be used to determine the shelf life of food goods.

Accelerated Shelf-life Testing (ASLT) is becoming more popular due to its precision, speed, and low cost [7]. The ASLT method is separated into the Arrhenius model for high temperature and the Labuza model for critical moisture content. The ASLT method selects a model based on product characteristics, and because flour products are hygroscopic, the Labuza model with a critical moisture content approach is more appropriate for estimating shelf life [8].

According to the description above, this research is important because it will investigate the impact of different types of packaging on quality changes and analyze the estimation of the shelf life of modified rice flour-based fresh bread premix flour using the ASLT method with a critical moisture content approach.

2 Material and Method

2.1 Materials

The main ingredients of premix flour are modified rice flour (germinated and boiled rice), wheat flour, baker's yeast, skim milk powder, sugar, and salt. The analytical materials used are $Na_2B_2SO_4$, HgO, H_2SO_4, NaOH, HCl, and hexane.

2.2 Preparation of premix flour

The preparation of modified rice flour (boiled and germinated) refers to the previous procedure. The substituted flour consists of 20% boiled rice flour, 20% germinated rice flour, and 60% wheat flour. Then the additional ingredients used are 3% yeast, 20% skim milk powder, 30% sugar, and 3% salt. All ingredients were mixed well and passed a 100 mesh sieve in to obtain a homogeneous texture and mixture of premix flour.

2.3 Packaging and storage

Polypropylene (PP), high-density polyethylene (HDPE), and aluminium foil were used for packaging formulations (500 g/pack). Samples were stored in controlled room conditions at 30°C and 75% RH. Samples were evaluated for the initial total composition of the product, changes in proximate components, and overall acceptance of physical quality at regular intervals of 7 days for 28 days of storage.

2.4 Chemical Analysis

Analysis of Vitamin B2, B6, and B9 using [9], Iron [10], GABA content the spectrophotometric method [11], and Equilibrium moisture content (Me) [12].

2.5 Statistical Analysis

Quality change parameter data for comparison of packaging and shelf life, processed using the application of Statistical Product and Service Solution (SPSS 25) analysis. If the results are significantly different, it is continued with Duncan's test.

3 Result and Discussion

3.1 Vitamins B2, B6 and B9

Significant differences were observed in the composition of vitamins B2, B6, and B9 in white bread premix flour between the initial and final grades. The type of packaging had a notable impact on the final vitamin B2 and B6 content ($P<0.01$), while it had no significant effect on the content of B9 ($P>0.05$). Specifically, when premixed flour was stored in HDPE packaging, it showed the most substantial reduction in vitamin B2 and B6, with a decrease of 37% and 95%, respectively. For premixed flour in PP packaging, vitamin B2 decreased by 17%, and vitamin B6 decreased by 93%. In contrast, aluminium foil packaging resulted in the least decline in vitamin B2 and B9, with reductions of 12% and 92%, respectively. Regarding the B9 content, all three packaging types experienced a similar decrease of 44% each.

Table 1. Results of the final quality study of white bread premix flour

Parameters	Packaging			Units
	PP	HDPE	Alufo	
Vitamin B2	0.46[a]	0.35[b]	0.49[c]	mg/ 100g
Vitamin B6	0.20[a]	0.14[b]	0.24[a]	mg/ 100g
Vitamin B9	130.45[a]	130.33[a]	130.66[a]	mg/ 100g
Iron (Fe)	3.89[a]	3.31[b]	4.33[c]	mg/ 100g
GABA	55.63[a]	42.57[b]	58.46[a]	mg/ kg

Source: Research Result, 2022

Aluminium foil packaging is clearly more successful in preserving vitamin retention in white bread premix flour. This conclusion was previously published [13] suggesting that when packaging has a significant permeability to oxygen and water vapor, optimizing vitamin retention becomes difficult. This shows that vitamins B2, B6, and B9 are likewise susceptible to oxidizing chemicals [14]. The generation of reactive oxygen species such as hydroxyl radicals can lead to vitamin B oxidation in general, resulting in the degradation of vitamin B2, B6, and B9 in flour.

Using packaging with low permeability values to block the transfer of oxygen and water vapor is an effective way to preserve the vitamin content in premix flour [15] observed that the overall vitamin content in enriched wheat is preserved up to 90% throughout 3 months of storage at temperatures below 25°C utilizing PET/aluminium packaging.

3.2 Iron

During the storage of premixed flour, significant iron loss might occur. Even when packaged in aluminium foil packaging with a very low permeability value to oxygen and water vapor, around 23% of iron is destroyed once it reaches its critical point. The iron content of samples wrapped in PP packaging was around 31%. When the flour samples were placed in HDPE packaging, which has a greater oxygen and water vapor permeability value than PP and aluminium foil packaging, iron degradation increased by up to 41.31%.

Packaging has a substantial impact on iron retention due to its protection against oxygen and molecular moisture, which might favour direct or indirect oxidation via the activation of free radicals generated during lipid oxidation or enzymatic breakdown, respectively. Active free radicals produced by lipid oxidation or enzymatic breakdown process [13]. Iron breakdown begins with an increase in FA when it oxidizes and generates free fatty acids (FFA) via lipolytic processes, resulting in greater interaction of enzymes contained in the flour with their substrate [16]. The most influential effect on the iron degradation pathway is the exposure of flour to air and moisture.

3.3 GABA

GABA content in fresh bread premix flour may degrade after storage. The final GABA content was significantly affected (P0.01) by the packing utilized. According to the package, the initial GABA content in premix flour was 62.28 mg/kg and reduced by 6-31% when it reached the crucial point. Aluminium foil wrapping retained GABA content more effectively than PP and HDPE packaging. The GABA content of premix flour samples held in aluminium foil packaging deteriorated by 6.13%. The GABA content of the sample in PP packaging decreased by 10.67%, while the sample in HDPE packaging degraded by 31.64%.

A proposed mechanism for GABA degradation during storage is structural disintegration, which results in the loss of water molecules and the creation of gamma butyrolactam [17]. Enzymes involved in GABA production and degradation have been reported to be active during storage [18]. GABA content decreased as storage time and temperature increased, which was attributable to its breakdown enzymes [19]. These findings imply that white bread premix flour should be stored at a low temperature for a short period to avoid GABA breakdown.

3.4 Shelf-life Calculation

Based on Table 2, Table 3, and Table 4, it is known that the shelf life of fresh bread premix flour depends on the RH of storage and the type of packaging used. The shelf life of fresh bread premix flour stored using PP packaging at RH 70, 75, 80, and 85% were 1.7, 1.3, 1.1, and 0.9 years respectively. While products stored using HDPE packaging were 1.0, 0.8, 0.7, and 0.6 years at RH 70, 75, 80, and 85% respectively. Meanwhile, fresh bread premix flour using aluminium foil packaging at the same RH of 70-85% had a shelf life of 7.4, 5.8, 4.8, and 4.2 years respectively. The results showed that the tendency to increase the RH of the storage place was inversely proportional to the shelf life of fresh bread premix flour. This is a result of the higher the RH of storage, the greater the pressure difference between the inside and outside of the packaging. The greater the difference in air pressure outside and inside the package, proportional to the increase in the diffusion rate of water vapor from the environment to food products [20]. The results showed 70% RH as the ideal condition for storage of white bread premix flour because it has a longer shelf life.

Aluminium foil packaging is considered more capable of protecting fresh bread premix flour than PP and HDPE packaging, which is indicated by the results of the study that the shelf life is longer at 7.4 years. The same thing has been reported by Agustia et al. [21] that instant towel flour packaged using aluminium foil has the longest shelf life, reaching 8.5 years. This is due to the permeability value of aluminium foil packaging, namely 0.0061 g $H_2O/day/m^2$.mmHg which is lower than PP and HDPE packaging and is more in accordance with the conditions of the type of material being packaged.

Table 2. Shelf life estimation data of white bread premix flour using PP packaging

Parameters	Units	RH			
		70%	75%	80%	85%
Initial moisture content (Mi)	g H_2O/g solid	0.051	0.051	0.051	0.051
Critical moisture content (Mc)	g H_2O/g solid	0.0775	0.0775	0.0775	0.0775
Slope of the curve (b)		0.1016	0.1016	0.1016	0.1016
Packaging permeability (k/x)	g H_2O/day/m2(mmHg)	0.0542	0.0542	0.0542	0.0542
Equilibrium moisture content (Me)	g H_2O/g solid	0.088	0.093	0.098	0.103
Dry weight of product (Ws)	g	487.5	487.5	487.5	487.5
Packaging area (A)	m^2	0.06	0.06	0.06	0.06
Saturated water vapor pressure (P0)	mmHg	31.824	31.824	31.824	31.824
	Day	612	481	399	341
Shelf life	Month	20.4	16.0	13.3	11.4
	Years	1.7	1. 3	1.1	0.9

Source: Research Result, 2022

Table 3. Shelf life estimation data of fresh bread premix flour using HDPE packaging

Parameters	Units	RH			
		70%	75%	80%	85%
Initial moisture content (Mi)	g H_2O/g solid	0.051	0.051	0.051	0.051
Critical moisture content (Mc)	g H_2O/g solid	0.0876	0.0876	0.0876	0.0876
Slope of the curve (b)		0.1444	0.1444	0.1444	0.1444
Packaging permeability (k/x)	g H_2O/day/m2.mmHg	0.131	0.131	0.131	0.131
Equilibrium moisture content (Me)	g H_2O/g solid	0.109	0.116	0.123	0.138
Dry weight of product (Ws)	g	487.5	487.5	487.5	487.5
Packaging area (A)	m^2	0.06	0.06	0.06	0.06
Saturated water vapor pressure (P0)	mmHg	31.824	31.824	31.824	31.824
	Day	369	305	260	202
Shelf life	Month	12.3	10.2	8.7	6.7
	Years	1.0	0.8	0.7	0.6

Source: Research Result, 2022

The permeability value of the packaging is inversely proportional to the shelf life, as a result, clumping of fresh bread premix flour in PP and HDPE packaging is easier to occur than aluminium foil packaging. Low water vapor permeability is useful in maintaining the shelf life of a product because the rate of water vapor transmission in the packaging can be limited. The low permeability of the packaging can also maintain the hygroscopic properties of the fresh bread premix flour and affect its quality due to the entry of water vapor from outside the packaging. This is evident in the observation of equilibrium moisture content and critical moisture content in this study, where fresh bread premix flour packaged using aluminium foil packaging takes a longer time to reach. A product will have a longer shelf life if the time to reach critical moisture content lasts longer [22].

Table 4. Shelf Life Estimation Data of Fresh Bread Premix Flour Using Aluminium Foil Packaging

Parameters	**Units**	**RH**			
		70%	75%	80%	85%
Initial moisture content (Mi)	g H_2O/g solid	0.051	0.051	0.051	0.051
Critical moisture content (Mc)	g H_2O/g solid	0.0646	0.0646	0.0646	0.0646
Slope of the curve (b)		0.0413	0.0413	0.0413	0.0413
Packaging permeability (k/x)	g H_2O/hari/m2.mmHg	0.0061	0.0061	0.0061	0.0061
Equilibrium moisture content (Me)	g H_2O/g solid	0.068	0.070	0.072	0.075
Dry weight of product (Ws)	g	487.5	487.5	487.5	487.5
Packaging area (A)	m^2	0.06	0.06	0.06	0.06
Saturated water vapor pressure (P0)	mmHg	31.824	31.824	31.824	31.824
	Day	2662	2092	1739	1494
Shelf life	Month	88.7	69.7	58.0	49.8
	Years	7.4	5.8	4.8	4.2

Source: Research Result, 2022

4 Conclusion

Fresh bread premix flour packed in aluminium foil retained its quality better than flour packed in PP (Polypropylene) or HDPE (High-Density Polyethylene) packaging. Each package's results for the shelf life of premixed bread flour at RH 70, 75, 80, and 85% and temperature 30°C varied. Fresh bread premix flour has a shelf life of 1.7, 1.3, 1.1, and 0.9 years in PP packaging, 1.0, 0.8, 0.7, and 0.6 years in HDPE packaging, and 7.4, 5.8, 4.8, and 4.2 years in aluminium foil packaging, depending on the relative humidity of storage. Aluminium foil packaging is superior to polypropylene (PP) and high-density polyethylene (HDPE) packaging.

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