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STUDY ON THE EFFECT OF OXYGEN CONTENT ON CORN KERNELS QUALITY DURING HERMETIC STORAGE

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SUMMARY OF DOCTORAL THESIS

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A-INTRODUCTION

1. The necessery of the reseach subject

Today, the technology for preserving grains and vegetables in the world has a general tendency to gradually remove highly toxic preservative chemicals, replace them with less toxic ones, with their residue threshold reduced. or use clean, safe methods of storage. In which, the method of creating an oxygen-poor environment is selected to preserve food and grains that meet those requirements.

Research on quality degradation of corn kernels during preservation is always interested by the world and domestic scientists. The FOCOAR redox agent used to create oxygen-poor media is a good solution for kernels corn preservation.

However, it is necessary to quantify effect of oxygen content on corn kernel quality, thereby modeling and practical applications in storage is a problem posed in this thesis.

2. Purpuse and contents of the thesis

- Effect of oxygen content on kernel corn quality during airtight storage:
- Study on the effects of oxygen on the preservation quality of corn kernels, through sensory evaluation and changes in some nutritional components in 12 months of storage.
- Applying research results to practical preservation of commercial kernel corn and seed corn.

3. The scientific and practical significance of the thesis

The dissertation aims to develop a safe and effective kernel corn preservation solution with simple techniques that can be applied in practice. In particular, the oxygen-poor preservation method will overcome the disadvantages and replace, compete with the current local preservation methods.

- Evaluate the effect of oxygen on the quality of maize during preservation according to industry standard 10 TCN 513-2002. From there, building suitable storage conditions to minimize losses during storage.
- Determining the dependent correlation between the nutritional degradation of proteins, lipids, starch, and oxygen content over storage time. That is the scientific basis for building preservation models on a larger scale in reality
- Determining the advantages of oxygen-poor storage methods compared to to the chemical sauna method commonly used in Vietnam.

4. Summary of new thesis results

- The thesis assesses the effect of oxygen content on the quality of kernel corn during preservation qualitatively according to standards, especially through quantitative analysis during the preservation of 3 main nutrients, protein, lipids and starch.
- Determined the functional correlation between nutrient impairment (protein, lipid and starch) with storage time in the form of first-order kinetic equations, as a scientific basis for estimating performance and time proper storage.
- Applied the above experimental results or preserving commercial maize during 12 months; the obtained results meet the industry standard 10 TCN 513-2002 with preservation performance higher than 97%, and for preservation of maize seed - result meets National regulations QCVN on germination and quality of sapling.

Identified the superiority of the FOCOAR oxygen-poor preservation method compared to the most commonly used 56%

Qickphos fumigation method: the sensory quality and quantitative are superior, while storage doubled to 12 months; more technically easy to deploy, non-toxic to health and the environment.

5. Structure of the thesis

The thesis consists of 143 pages, divided into the following sections: Introduction 2 pages; 27 pages overview; 24 pages of experimental and research methods; results and discussion of 46 pages; Recommendation conclusion 2 pages; new thesis point 1 page; published list of works 1 page; references 10 pages (113 documents), Appendix 17 pages, 43 graphs, 24 tables.

B – MAIN CONTENT

CHAPTER 1: LITERATURE REVIEW

Learn about the composition and properties of corn kernels, the preservation environment of the factors affecting the quality of corn kernels, the methods of preserving in the country and the world ...

Learning about oxygen reducer applications in domestic and foreign storage.

CHAPTER 2: EXPERIMENT

2.1. Chemicals, equipment

2.2. Fabrication of minienvironment for storage in the laboratory

Create 6 minienvironments to preserve maize, including 5 minienvironments with oxygen content of 20.9%, 15%, 10%, 5%, <2%, stable for 12 months and 1 minienvironment use fumigation chemicals (sauna method) as the control experiment.

2.3. Evaluation of maize preservation quality

2.3.1. Quality assessment according to the industry standard 10 TCN 513-2002

Quality assessment through the criteria according to the industry standard 10 TCN 513-2002 on kernel corn - technical requirements and testing methods for kernel corn for commercial purposes.

2.3.2. Quality evaluation through the identification of several ingredients in the corn kernels

Using several methods of determining the particle composition:

- The definition of protein quantity follows the DUMAS method
- Determination of total fat by Randall extraction
- Determination of starch content by Lane-Eynon method

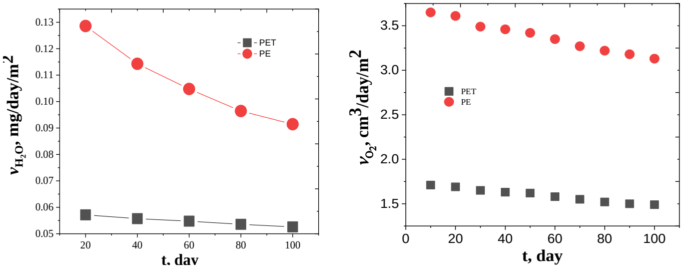
- Determination of water content in corn kernels

CHAPTER 3: RESULT AND DISCUSSION

3.1. Poor oxygen preservation in minienvironments

3.1.1. Tightness of PET, PE preservative films

From the mass of water, oxygen permeates the membrane in a unit area over time and is shown graphically in Figures 3.1.a and 3.1b.



(3.1a) ***(3.1b)***

Figure 3.1. *Variation of water vapor and oxygen permeability rate over time*

- ***Water vapor permeability:***

After 100 days, PET film has an average permeability rate of 0.053 mg / day / m2 and PE of 0.091 mg / day / m2..

If stored in a 15.78 liter flask using PE and PET films (at 25°C, the internal relative humidity (RH) is 70%, the saturated air humidity is 23g / m3 [101]) then The percentage of water seeped into c in PET and PE bottles is 2.5% and 4.3%, respectively.

This result is small with the error of the automatic humidity temperature measuring system (5%). This suggests that 365 days of steam penetration is negligible or that the storage device guarantees good tightness for 12 months of storage.

- Oxygen permeability:

After 100 days for bottles using PET film, the oxygen content increased to 0.33%, the average oxygen permeability rate was 1.49 $cm^3/day/m^2$ and the bottle used PE film, the oxygen permeability was 0.69. %, the rate of oxygen silencing is 3.13 $cm^3/day/m^2$. That is, PE film has an oxygen permeability rate 2.1 times higher than that of PET film.

The above results show that, if kept for 365 days, the content of oxygen penetrated into the PET bottle is 1.2% and PE 2.5%. To limit this error, set up an automatic warning MSI system when the content changes by ± 0.2% and calculate the amount of FOCOAR just enough to reduce oxygen replenishment to increase every 3 months.

3.1.2. Effect of FOCOAR reducing agent in PET minienvironments

3.1.2.1. Effect of reducing agent content FOCOAR on oxygen content

Reducing oxygen with a predetermined amount (4g, 8g ...) in the flask until the oxygen content is stable, based on the measured oxygen content over time ($x_{O_2(i)}$), calculate the content of bi oxygen degradation. (x_{O_2}, %) and volume of oxygen reduced. From there, build a standard curve between the oxygen mass and reduced oxygen content, figure 3.2.

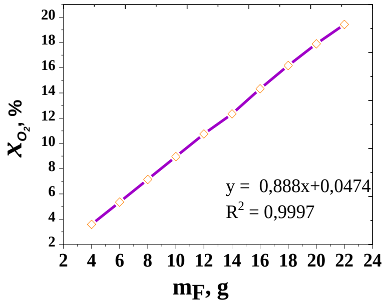


Figure 3.2. *A calibration curve relating the FOCOAR mass to the reduced oxygen*

Based on the graph equation, we have a relationship between the amount of reduced FOCOAR and the reduced oxygen (x_{O_2}) :

$$x_{O_2} = 0{,}888m_F + 0{,}0474$$

The above equation is significant in calculating the amount of reducing agent required to reduce oxygen to the desired content.

3.1.2.2. Redox rate in the minienvironments

Investigating the variation of oxygen content, from 20.9%, over time in 2 minienvironments, PET1 (without corn) and PET2 (containing 10kg of kernel corn).

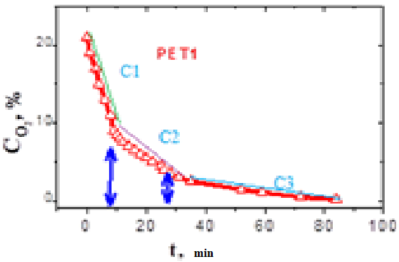


Figure 3.3. *Variation of oxygen content over time in the minienvironment PET1*

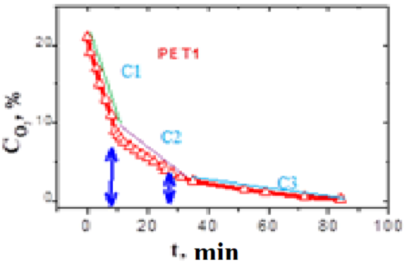


Figure 3.4. *Variation of oxygen content over time in the minienvironment PET2*

The reduction rate of FOCOAR in the minienvironment of PET1 in 84 minutes averaged 0.25%/min and the minienvironment of PET2 in 1100 minutes was 0.019%/min. It can be seen that the PET2 minienvironmen containing kernel corn has hindered the diffusion of oxygen to the surface of the reducing agent, resulting in a slower reduction of oxygen content than PET1. The reason for the conversion of each phase to another oxidation is due to the metal passivation in the oxidized Focoar redox to reduce atmospheric oxygen in the minienvironmen using PET film.

3.1.2.3. Effect of redox on storage microclimate

Microenvironment was investigated in a 15.78 liter flask containing 10 kg of corn, at 13% moisture, 73% of the initial air humidity, using 30 grams of redox, maintaining the initial temperature of 27.1.°C by air conditioner. The temperature and humidity in the experimental flask were measured automatically in 1800 minutes, obtained the graph as shown in figure 3.5.

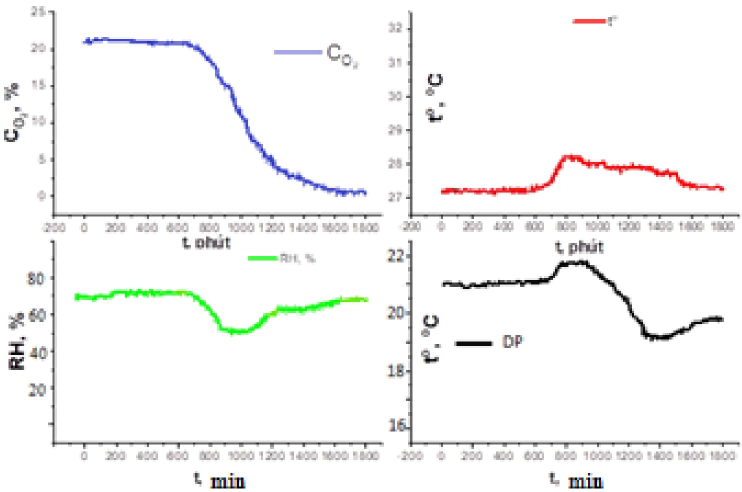


***Figure 3.5.** Variation of humidity, temperature and dew point in minienvironment in 30 hours*

When the reducing agent Focoar was active, at the time from 730 to 1362 minutes, the oxygen content decreased rapidly, leading to the increase in the temperature in the microenvironment from 27.1 ^{o}C to 28.6 ^{o}C, then gradually decreasing to 27^{o}C, at the same time The humidity in the air decreased from 70.0% to 51.5%. The dew point temperature has a maximum increase of 25,19℃, at 770 minutes, because at this time the redox reaction occurs quickly, increasing the temperature, but there is no dew condensation on the surface of the storage film.

The above experiment showed that when FOCOAR reducing agent works more or less, it affects the microclimate of storage warehouse. However, the redox process occurs quickly with a small amplitude, so the impact level is negligible [14].

3.2. Preserving kernel corn

3.2.1. Effect of oxygen on kernel corn quality

The experiments of preserving corn grain in 5 minienvironment with oxygen content respectively <2%, 5%, 10%, 15%, 20.9% are denoted W2, W5, W10, W15, W21 respectively; and preserving the sterilized fumigation, denoted by XH, as a control. The results were compared with the agricultural sector standard 10 TCN 513-2002 on kernel corn.

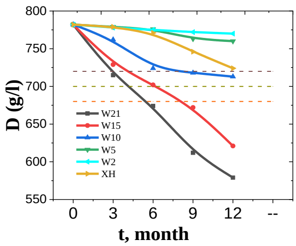


Figure 3.6. *Variation of particle density (specific gravity) over time in minienvironment*

The density of kernel corn depends on the oxygen content and storage time, the lower the oxygen content, the less will be loss of density (Figure 3.7). The two micro-mediums W2 and W5 with particle weight both reach grade 1 (> 720g / l), there is no significant difference between these two minienvironment.

For minienvironment W10 is ranked 1st in the first 6 months and 2nd in 12 months. The density in the W15 minienvironment is only grade 2 (> 700 g / liter) under 6 months and class 1 (> 720 g / liter) under 3 months of storage.

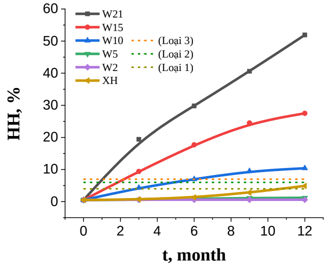


Figure 3.7. *Total number of damaged (HH) particles over time in minienvironment*

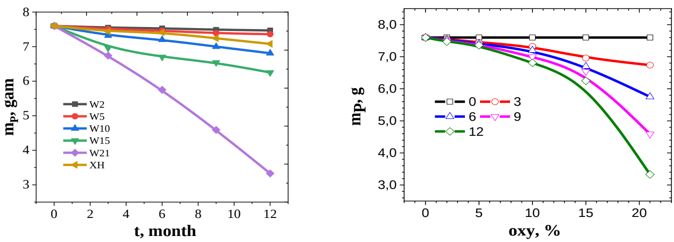
After 12 months of storage, the number of damaged seeds (total) in minienvironment W2 and W5 was much lower than the agricultural industry standard (grade 1).

The lower the oxygen content, the lower the spoilage of corn kernels, the best results are stored at <2%..

3.2.2. Effects of oxygen on certain nutrients in corn kernels

3.2.2.1. The effect of oxygen on the degradation. of protein content

Protein content was analyzed by Dumas method before (a gram) and after 3, 6, 9, 12 months (a gram) of storage. The preservation effectiveness for kernel corn protein in 5 micro-media (W2, W5, W10, W15, W21) was evaluated with the control samples by fumigation (XH) method.



(3.8b) (3.8a)

Figure 3.8. *Variation of protein content with time (a) and with oxygen content (b) in the minienvironment*

The degree of protein degradation depends on the oxygen content of the most optimal oxygen content to maintain the protein content of kernel corn, with an efficiency of over 98.29%, <2%, long shelf life. up to 12 months.

Preservation of corn protein by oxygen-poor method at ≤5% oxygen content is higher quality than the fumigation method..

• ***Establish the kinetic expressions of protein degradation over time at different oxygen contents***

Based on protein content data plotted $\ln \frac{a}{a - x_i}$ over time, Figure 3.9.

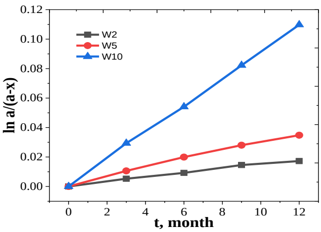


Figure 3.9. *Kinetic curve of kernel corn protein degradation. over time in minienvironment*

We get 3 equations:

W2: $Y_1 = 0{,}0015x$

W5: $Y_2 = 0{,}003x$

W10: $Y_3 = 0{,}009x$

Replace the coefficient of the angle (or constant speed) of the line Y1 as kp1 = 0.0015; Y2 is kp2 = 0.003 Y3 is kp3 = 0.009 in the kinetic equation of degree 1, we get:

$$\ln \frac{7,60}{7,60 - x_1} = 0,0015.t \qquad \text{(III.1)}$$

$$\ln \frac{7,60}{7,60 - x_2} = 0,003.t \qquad \text{(III.2)}$$

$$\ln \frac{7,60}{7,60 - x_3} = 0,009.t \qquad \text{(III.3)}$$

Corresponding to the formulas III.1, III.2, III.3 are 3 equations of the W2, W5, W10 minienvironment describing the protein decline over time.

From Equations III.1, III.2 and III.3 establish the correlation between protein preservation performance and time in W2, W5, W10 minienvironment, respectively::

$$H_{P1} = e^{-0,0015.t}.100\% \qquad \text{(III.4)}$$

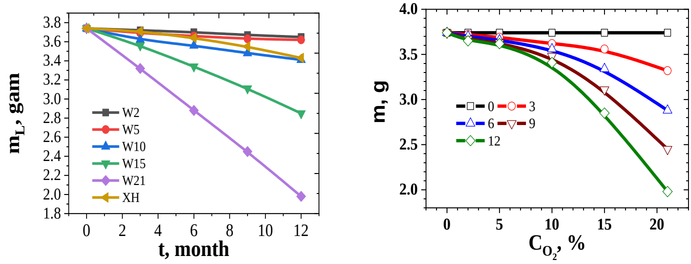
$$H_{P2} = e^{-0,003.t}.100\% \qquad \text{(III.5)}$$

$$H_{P3} = e^{-0,009.t}.100\% \qquad \text{(III.6)}$$

From 3 equations that are significant in modeling the quality of protein preservation, helping to control the quality of protein preservation over time.

3.2.2.2. Effect of oxygen content on lipid degradation. in corn kernels

Lipid content (mL) was analyzed according to Randall extraction method. Analyzes were performed before (b) and after 3, 6, 9, 12 months (b - yi) storage. Evaluation of preservation quality for kernel corn lipids in 5 minienvironment (W2, W5, W10, W15, W21) and control for preservation by fumigation method (XH).



(3.10a) (3.10b)

Figure 3.10. *Change of lipid content over time (3.10a) and by oxygen content (3.10b) in minienvironment*

Thus, to preserve corn kernels (at W = 13%, RH = 65-70%, to = 25 ± 2 ° C), oxygen is the main cause affecting lipid degradation.. The deep degradation. in oxygen content prolongs storage time and maintains lipid content in seeds.

The above results showed that the most suitable oxygen content range to maintain lipid content, efficiency reached over 97.59%, is <2%, and prolong the storage time to 12 months. Compared with the fumigation (XH) method, the 5% oxygen content method is more effective.

- ***Set up the kinetic expression of corn kernels for lipid degradation. over time in different oxygen content minienvironment***

Similar to the study of protein degradation. kinetics of corn kernels, lipid degradation. kinetics was investigated with analytical results with oxygen contents at 0, 3, 6, 9 and 12 months.

From the results of lipid content in 12 months, calculated $\ln \dfrac{b}{b - y_i}$ at the time of 3, 6, 9, 12 months, the results are deficient in figure 3.11.

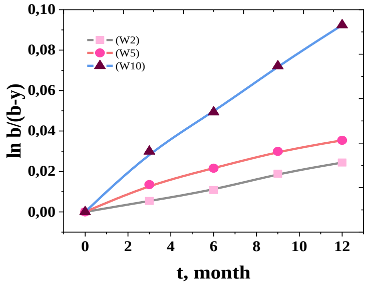


Figure 3.11. *kinetics of time-based lipid degradation. of corn in the minienvironment*

Linear fitting is 3 equations:

W2: $Y_1' = 0{,}002x'$

W5: $Y_2' = 0{,}0032x'$

W10: $Y_3' = 0{,}0079x'$

Replace the slope (or speed constant) of the Y'1 line as kpL1 = 0.0014; Y'2 is kL2 = 0.0027 Y'3 is kL3 = 0.009 in the first-order kinetic equation, we get 3 equations with 3 different oxygen contents

$$\ln\frac{3,74}{3,74 - y_1} = 0{,}0020.t \qquad \text{(III.7)}$$

$$\ln\frac{3,74}{3,74 - y_2} = 0{,}0032.t \qquad \text{(III.8)}$$

$$\ln\frac{3,74}{3,74 - y_3} = 0{,}0079.t \qquad \text{(III.9)}$$

The above equation shows that the degree of lipid degradation. depends on the speed constant of minienvironment, the lower the oxygen content minienvironment, the smaller the rate constant. This shows that the rate of lipid degradation. depends on the content of stored oxygen.

- ***Set up the expression of lipid preservation performance of corn kernels over time in different minienvironment with different oxygen content***

Similarly, set up the storage performance calculation expression for the 3 W2, W5, W10 minienvironments respectively:

$$H_{L1} = e^{-0,020.t}.100\% \qquad (III.10)$$

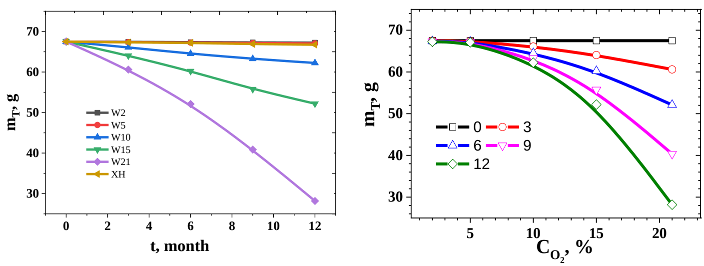
$$H_{L2} = e^{-0,032.t}.100\% \qquad (III.11)$$

$$H_{L3} = e^{-0,0079.t}.100\% \qquad (III.12)$$

Based on equations (III.10) - (III.12) it is possible to predict lipid preservation efficiency over time. This helps to control the quality of lipid preservation well.

3.3.2.3. Effect of oxygen content on corn starch degradation.

The starch content was analyzed by Lane-Eynon method (Appendix I.3). The starch content before storage is c gam and after 3, 6, 9, 12 months is c - z_i gram, in 5 minienvironment (W2, W5, W10, W15, W21) has different oxygen contents. minienvironment preserved by fumigation (XH) method as a control.



(12a) (12b)

Hình 3.1. *Variation of starch degradation. of corn kernels according to oxygen content (3.12a) and time in the minienvironments (3.12b)*

The results in Figure 3.12 show that the decrease in starch increases over time (Figure 3.12a) and the degree of lipid degradation. depends on the oxygen content, the lower the oxygen content, the lower the failure level. degradation. of starch.

Thus, to preserve kernel corn under conditions: W = 13%, RH = 65-70%, t° = 25 ± 2°C, the oxygen content is the main cause affecting starch degradation.. The optimal oxygen content range to ensure starch quality is 2%, with a storage time of up to 12 months with an efficiency of over 99.35%.

**** Set up the starch degradation. kinetics of corn in the minienvironments (3.12b)***

Based on the starch content calculated $\ln \frac{c}{c - z_i}$ at the time of 3, 6, 9, 12 months, the results are shown in figure 3.13.

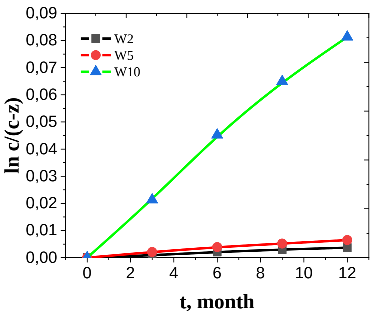


Figure 3.12. *Kinetic curves reduced the starch degradation. of corn kernels over time in the minienvironments*

/2: $Y_1'' = 0{,}0003x''$

/5: $Y_2'' = 0{,}0006x''$

/10: $Y_3'' = 0{,}007x''$

Replace the angle coefficient (or speed constant) that the Y_1'' line is $k_{T1} = 0.0003$; Y_2'' is $k_{T2} = 0.0006$ Y_3'' is $k_{T3} = 0.007$ and graph equation we get 3 kinetic equations of order 1, times corresponding to 3 minienvironments W2, W5, W10:

$$\ln \frac{67,5}{67,5 - z_1} = 0,0003.t \qquad (III.13)$$

$$\ln \frac{3,74}{3,74 - z_2} = 0,0006.t \qquad (III.14)$$

$$\ln \frac{3,74}{3,74 - z_3} = 0,007.t \qquad (III.15)$$

The kinetic equation describes the degradation of starch over time, indicating that the degree of nutritional decline depends on the rate constant of each ward, the lower the oxygen content, the lower the rate constant. This shows that the rate of starch degradation depends on the content of stored oxygen.

• ***Establish expression of starch preservation performance of corn kernels over time minienvironments***

Similarly, from III.13, III.14, III15 establish the relationship between starch preservation efficiency and time with 3 minienvironments W2, W5, W10 respectively:

$$H_{T1} = e^{-0,0003.t}.100\%$$

$$H_{T2} = e^{-0,0006.t}.100\%$$

$$H_{T3} = e^{-0,007.t}.100\%$$

Based on these equations, it is possible to predict starch preservation performance over time, helping to control the quality of starch preservation better and more actively.

3.3. Application for local preservation of corn

3.3.1. Application for commercial kernel corn *preservation*

Choose the optimal conditions for storing corn commercial:

t°	RH, %	W, %	Oxi, %
25°C±2	65-70%	13,4%	<2%

Table 3.1. *Results of evaluating a number of kernel corn quality indicators*

VMT	W (%)	HH (%)	Seed worms (%)	D (g/lit)	grain other color (%)	smell	Oxygen content (%)
N0	**13,4 %**	**0,63**	**0,43**	**755**	**0,52**	**aroma**	**0,1**
After 12 months of storage							
N1	12,9	0,72	0,69	740	0,82	aroma	0,3
N2	12,8	0,88	0,73	737	0,78	aroma	0,2
N3	13,1	0,79	0,75	742	0,77	aroma	0,8
N4	12,7	0,81	0,69	732	0,86	aroma	0,6
N5	12,8	0,91	0,81	736	0,69	aroma	0,4
N6	13,0	0,83	0,73	744	0,78	aroma	0,9
N7	12,8	0,82	0,77	734	0,79	aroma	0,8
N8	12,9	0,75	0,72	745	0,67	aroma	0,3
N9	12,6	0,91	0,89	727	0,87	aroma	0,5
N10	12,8	0,88	0,73	735	0,86	aroma	0,6
TB	12,8	0,83	0,75	737	0,79	-	0,54
Change	decrease 0,6 %	increase 0,17	increase 0,32	decrease 0,18 g/lít	decrease 0,27%	constant	decrease 0,44%

During 12 months of preserving in minienvironments, the oxygen content was kept stable below 2%, the kernel corn remained aromatic, the moisture decreased by 0.6%, the rate of color changing kernel corn increased by 0.27 on average %, maize pests and diseases increase 0.32% on average, harmful kernel corn (total) increase 0.17% on average, average grain weight decreases 0.18g / liter. Comparing these criteria with the 10TCN 513-2002 standard on commercial maize shows that the above criteria have all met and exceeded quality standards.

Table 3.2. *Content of protein, lipid, starch after 12 months*

Time	sample	H_{pi},%	H_{Li},%	H_{Ti},%
After 12 months	N1	98,22	97,32	99,66
	N2	97,95	97,76	99,66
	N3	98,63	97,99	98,98
	N4	98,08	97,76	99,83
	N5	98,63	97,54	99,49
	N6	98,08	97,76	99,32
	N7	97,95	97,76	99,15
	N8	97,12	97,32	99,66
	N9	98,22	96,42	99,32
	N10	97,95	97,32	99,49
average		**98,08**	**97,49**	**99,42**

After 12 months of storage: The average protein content of kernel corn was 7.16 grams, achieving storage efficiency of 98.08%, repeatability 0.029. The average lipid content reached 4.36g / 100g, storage efficiency 97.49%, with repeatability 2.029. Average starch content reached 58.56g / 100g, storage efficiency of 99.42%.

Comparison between the performance evaluation results under actual conditions with the efficiency formula at oxygen content <2% drawn from experiments on protein, lipid, starch preservation: actually preserved protein was 0.14% lower. 0.13% lower lipid, 0.22% lower starch.

The above results show that the equation obtained from experiments in the laboratory to predict the preservation performance for the protein, lipid and starch content in 12 months is reliable. The experimental formula is suitable even with other maize varieties (DK8868) and the temperature changes according to the local climatic conditions (<30 ° C).

3.3.2. Application in corn seed preservation

3.3.2.1. Sensory evaluation

Corn kernels were preserved for 12 months, assessed for 3 months according to three criteria (sensory index): 1- Round shape, no cracks, no pests (this criterion is denoted d) 2) the color of the kernel is not dull (this criterion is c), 3) a good gloss (symbol b). All three criteria (dcb) are rated on three levels: good (dcb), acceptable (d-c-b-) and bad (- -).

Table 3.3. Sensory evaluation of kernel corn ***for 12 months of storage***

No	sample	t, month	Kernel corn moisture W, %			
			11,7		13,2	
			20.9%	< 2%	20.9%	< 2%
1	S0	0	dcb	dcb	dcb	dcb
2	S3	3	dcb-	dcb	dc-b-	dcb
3	S6	6	d-c-b-	dcb	d- - -	dcb
4	S9	9	d-c- -	dcb	- - -	dcb-
5	S12	12	d- - -	dcb	- - -	dc-b-

According to sensory evaluation results, G11-2 sample has good sensory evaluation quality (dcb): After 12 months of storage, in general, round grains have no cracks, no pests and diseases. The G13-2 model has good storage quality for 6 months, after which the quality gradually decreases in luster and dull color at 9-12 months. In addition, the 2 samples G11-20 and G13-20 had good sensory evaluation quality in the first 3 months, then gradually decreased, especially G13-20 did not meet any criteria in September and December.

3.3.2.2. Effect of oxygen content and preservation time on germination ability of seed corn

After 12 months of storage, the GP of 2 samples stored at the oxygen content <2% (G11-2 and G13-2) still retains the criteria compared with the original sample (G0), giving seed quality good. Until 9 and 12 months, only the G11-2 sample meets the seed quality requirements. Seeds with a moisture content of 13.2% are not suitable for preservation for more than 9 months even when the oxygen content is low <2%.

3.3.2.3. Effect of oxygen on growth of young plants

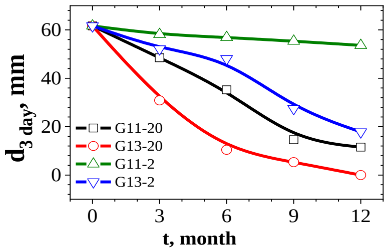


Figure 3.13. *Average height of corn plants after 3 days*

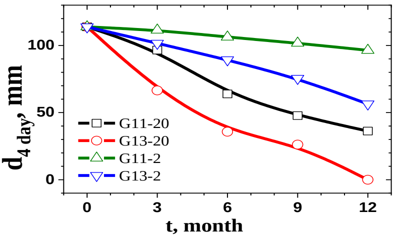


Figure 3.14. *Average height of corn plants after 4 days*

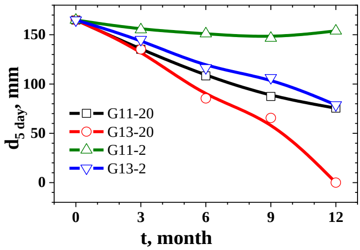


Figure 3.15. *Average height of corn plants after 5 days*

After 6 months of storage in an oxygen-poor environment, at the oxygen content <2%, samples of seed corn with 11.7% moisture and 13.2% had maximum GP germination, seeding and normal growth good standard. However, at a high oxygen level of 20.9% even a high germination rate, the young plants showed slow growth patterns, especially for samples with moisture content of W = 13.2%.

Only seed corn with W = 11.7% moisture, stored for 12 months at <2% (G11-2) oxygen, kept its germination at the best quality, and growth good seedling.

CONCLUSIONS

1. Has fabricated 5 minienvironments media in the laboratory that are airtight with 5 stable oxygen contents, <2%, 5.0%, 10.0%, 15.0%, 20, 9%, and maintained during storage

2. The effect of oxygen content on the quality of kernel corn preserved in the laboratory was studied, the results were

2.1. Determined: the appropriate oxygen content for storage is <2%, the quality of kernel corn storaged for 12 months always meets the industry standard TCN 513-2002, the nutrition content was quantitatively well preserved with high performance: for over 98.29% protein, 99.63% starch, and 97.59% over lipids.

2.2. Identified the functional correlation between nutrient degradation. (protein, lipid and starch) with storage time in the form of kinetic equations of first order, as a scientific basis for estimating the storage performance and time.

3. Compared with the most common methods of fumigation using Quickphos 56%, the FOCOAR oxygen-poor method has superior organoleptic and quantitative quality while the storage time doubles to 12 months; Furthermore, it is easy to deploy, non-toxic to health and the environment.

4. The above experimental results have been applied to preserve 5 tons of maize at oxygen content <2% for 12 months; The results obtained are sensory quality according to standards, preservation efficiency for protein over 98.08%, lipid. 97.49%, starch 99.62%; This result is equivalent to experimental results in the laboratory.

5. The above experimental results have been applied to preserve the seed maize at <2% oxygen content, after 12 months the germination level reached QCVN 01-47: 2011/BNNPTNT, moreover, young plants are well developed.

LIST OF PUBLICATION

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3. **Le Quoc Khanh**, Nguyen Van Duong, Le Linh Chi, Do Tra Huong and Le Xuan Que (2018) Lipid degradation of corn preservated in oxi depleted minienvironment, *International Journal of Development Research* , vol. 08, No, 12, pp.24670-24673.

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5. **Le Quoc Khanh**, Nguyen Van Duong, Le Linh Chi, Do Tra Huong, Le Xuan Que (2019)Study on nutritional degradation of corn preserved in micro-environments with different oxygen concentrations. 1-reducing starch content, *Journal of Analytical sciences,* No 24, vol 2, 2019, 2019, Page 111-116.

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