PROCEEDINGS

2nd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

September 16 - 17, 2013

IPB International Convention Center
Bogor - Indonesia

Organized by:

Department of Agroindustrial Technology

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Indonesian Agroindustry Association

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3. Endang Gumbira Said, Prof.
   (Departement of Agroindustrial Technology, IPB)
4. Suprihatin, Prof.
   (Secretary of Departement of Agroindustrial Technology, IPB)
5. Ono Suparno, Prof.
   (Departement of Agroindustrial Technology, IPB)
6. Agus Buono, Dr.
   (Head of Department of Computer Science, IPB)

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Organized by :

Departement of Agroindustrial Technology, Faculty of Agricultural Engineering and Technology Bogor Agricultural University

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WELCOMING ADDRESS

Prof. Dr. Ir. Nastiti Siswi Indrasti
Head of Agroindustrial Technology Department
Faculty of Agricultural Engineering and Technology
Bogor Agricultural University

On

Second International Conference on Adaptive and Intelligence Agroindustry (2nd ICAIA)

Bogor, September, 16 – 17, 2013

Assalamu'alaikum Warohmatullahi Wabarokatuh
In the name of Allah, the beneficent and the merciful,

Distinguish Guest, Ladies and Gentlemen
Let me first thank you all for accepting the invitation to participate in this 2nd International Conference on Adaptive and Intelligence Agroindustry (ICAIA). In particular I would like to thank Rector of IPB (Institut Pertanian Bogor/Bogor Agricultural University) Prof. Herry Suhardiyanto for supporting this event as part of the series academic event in celebrating the 50th Anniversary of Bogor Agricultural University.

In fact, the idea of organizing this conference was the continuation of the International Workshop on Computational Intelligence and Supercomputing Technology for Adaptive Agroindustry held by the Department of Agroindustrial Technology, Bogor Agricultural University last year.

Professor Kenneth A De Jong from George Mason University, US has successfully conducted joint international research with some staff from the Department of Agroindustrial Technology and Department of Computer Science, Bogor Agricultural University. The research aims to develop an integrated and intelligent system (namely SMART-TIN©) for the design of adaptive agroindustrial system in order to achieve a sustainable agroindustry that can mitigate global climate change and at the same time secure food, water, energy and natural medicine supply.

We are certainly proud to have been able to assemble this event in IPB, Bogor. The range of participants and audience at this conference is precisely something I would like to stress. The main goal of the conference is to provide an effective forum for distinguished speakers, academicians, professional and practitioners coming from universities, research institutions, government agencies and industries to share or exchange their ideas, experience and recent progress in Adaptive and Intelligent Agroindustry.

Distinguish Guest, Ladies and Gentlement,
Global climate change is the most challenging problems for us today and in the near future. This global change in our climate can lead to the shortage of the food, water, bioenergy and natural medicine that will affect the quality of human life. Many studies indicate that the threat of food, water, bioenergy and natural medicine crisis due to global climate change still worries our society. This problem can be solved by the development of agroindustry, i.e. an interrelated value chain entities from farming, to agro-processing industry and then to the end-customers. In fact, the design of agroindustry is complex and involves many factors and large data bases and more importantly, needs a good intelligence to process data and information to good decisions. Therefore, the way to design and manage agroindustry should be improved in order to meet the design objectives.

Agroindustries consume quite significant amount of energy on one side, on the other side they generate sizable amount of industrial wastes and its utilization as a captive energy resource is a kind of potential. Based on our study, a plywood industry with the production capacity of 200.000 m^3/year could generate 32 percentage of solid waste. If this amount of waste used as an energy alternative, it may result on the saving of 131.037.768.597 rupiah per month. Similar to plywood industry, sugarcane industry with the production capacity of 480 ton per hour could generate 154 ton per hour of waste (bagasse) and this amount of waste contribute to the saving of energy consuming by 19.250 Kwh. Recent study we conducted, indicated that cassava starch industry may contribute to a significant amount of waste. It has also potential usage as an energy resource. Based on our study the conversion of its waste into energy will contribute to the saving of energy usage of 4100 liter biogas per ton material.

The three industries mentioned is only examples of how potential the role of agroindustrial waste as an alternative resource in replacing the conventional energy resource as its presence will be significantly reduced. The new, incremental energy contributions that can be obtained from waste biomass will depend on future government policies, on the rates of fossils fuel depletion, and on extrinsic and intrinsic economic factors, as well as the availability of specific residues in areas where they can be collected and utilized. All of these factors should be in detail examined to evaluate the development of the industrial waste contribution. Hope this conference will also discuss this issue in more detail as it is an important matter for all of us. We should no more think just how to produce high value product but it is also necessarily important how to keep our live in good quality by understanding following old saying…" only when the last tree has been cut, only when the last fish has been angled, and only when the last river has been polluted, then we realized that we could not eat money".

I do not to take up any more of your time with these opening remarks. Let me simply thank you once again for sharing your thoughts with us. Here's wishing every success for the conference. May Allah bless all of us.

Thank you for your kind attention,
Wassalamu'alaikum Warohmatullahi Wabarokatuh

AGENDA of
2nd International Conference on Adaptive and Intelligent Agroindustry (ICAIA)

Time	Activities			Room
Day 1 (16 September 2013)				
08.00 – 09.00 (60’)	Registration			
09.00 – 10.00 (60’)	Opening Ceremony • Welcoming Address: Prof. NastitiSiswiIndrasti (Head of Dept TIN, Fateta, IPB) • Conference Opening: Prof. HerrySuhardiyanto(Rector of IPB) o ABET Certification announcement and short ceremony o Launching International Double Degree Master Program in Innovation and Technopreneurship in Cooperation with University of Adelaide, Australia o Soft-launching Master in *Logistik Agroindustri* (Agroindustrial Logistics)			Ballroom
10.00 – 10.45 (45’)	Opening Speeches: Prof. IrawadiJamaran (Agroindustry Guru, IPB: 25’) Prof. Eriyatno (Industrial and System Engineering, IPB: 20’)			Ballroom
Session 1				
10.45 – 11.15 (30’)	Keynote Speech Dr. YandraArkeman (IPB)			Ballroom
11.15 – 12.00 (45’)	Keynote Speech Prof. Kenneth De Jong (George Mason University, USA)			Ballroom
12.00 – 13.30 (90’)	Lunch Break			
Session 2				
13.30 – 15.15 (105’)	Moderator: Prof. EndangGumbiraSa’id (IPB) Invited Speakers (1-4) (4 x 20 minutes) Discussion (25 minutes) Tentative Schedule: Prof. Kim Bryceson (Australia), Prof. SyamsulMa’arif (IPB), Prof. KudangBoro Seminar (IPB), Prof. HaruhiroFujita (Japan)			Ballroom
15.15 – 15.45 (30’)	Break			
15.45 – 17.30 (105’)	Moderator: Prof. Marimin (IPB) Invited Speakers (5-8) (4 x 20 minutes) Discussion (25 minutes) Tentative Schedule: Dr. Gajendran (UK), Prof. Noel Lindsay (University of Adelaide), Dr. KuncoroHartoWidodo (UGM), Prof. UtomoSarjonoPutro (ITB)			Ballroom
Day 2 (17 September 2013)				
08.00 – 08.30 (30’)	Registration			
08.30 – 10.15 (105’)	Moderator: Prof. KudangBoro Seminar (IPB) Invited Speakers (9-12) (4 x 20 minutes) Discussion (25 minutes) Prof. Egum (IPB), Prof. Marimin (IPB), Dr. AgusBuono (IPB), Dr. HeruSukoco (IPB)			
10.15 – 10.30 (15’)	Coffee Break			
10.30 – 12.30 (120’)	Parallel Session 1 Moderator: Prof. Fujita (7 paper @ 15 minutes) Discussion (15 minutes)	Parallel Session 2 Moderator: Prof. Ono Suparno (7 paper @ 15 minutes) Discussion (15 minutes)	Parallel Session Moderator: Prof. Suprihatin (7 paper @ 15 minutes) Discussion (15 minutes)	

12.30 – 13.30 (60’)	Lunch Break	
13.30 – 15.00 (90’)	Open Discussion (Open Forum) with Prof. Kenneth De Jong Topic: Foundations and Applications of Genetic/Evolutionary Algorithms	Ballroom
15.00 – 15.30 (30’)	Conference Closing	Ballroom
15.30 – 17.00 (90’)	Indonesian Agroindustry Association (AGRIN) National Congress (PIC: Prof. Suprihatin)	Ballroom
17.00 – 17.45 (45’)	Refreshment and Closing of AGRIN National Congress	Ballroom

CONTENT LIST

Color Stability of Beet (*Beta vulgaris* L.) Dyes Label During Heating

Endang Warsiki
Department of Agroindustrial Technology, Faculty ofAgriculture Technology
Bogor Agriculture University
Fateta Building 2nd floor, Darmaga Campus Bogor 16658
Email: warsiki@yahoo.com.au

Asih Setiautami
Department of Agroindustrial Technology, Faculty ofAgriculture Technology
Bogor Agriculture University
Fateta Building 2nd floor, Darmaga Campus Bogor 16658
Email: warsiki@yahoo.com.au

ABSTRACT

The development of smart sensor in food packaging was continuously performed. The development of which is being done, that is a smart label with the form of film which given additional color as an indicator. The purpose of this research is to study and develop smart packaging by addition of natural dyes of beet (*B. vulgaris L. var cicla L.*) as well as finding the best drying techniques for label producing. This label was produced form chitosan and chitosan - polyvinyl alcohol (PVA). Two form (chitosan and chitosa-PVA) films were compared to its properties. Three drying techniques were carried out in this experiment, i.e. oven blower, oven vacuum and freeze drying. A result showed that films made from chitosan-PVA has the appearance of a more clear, shiny, and looks more refined than the indicators of chitosan films. The use of beet extract as dyes of color indicator did not allowed for the drying in conjunction with the film solution. Natural dye staining technique that can still be used as an indicator dye in smart packaging was freeze drying in temperature of -10^{o}C. Indicators with natural dyes of beet responded through changes in color of the storage temperature. Color changes that occur in the film made from chitosan had a vulnerable time longer in the retention time than films made from chitosan-PVA.

Keywords: Smart label, color stability, heat, beet dyes

1. INTRODUCTION

Currently a new breakthrough in the world of packaging has been resulted a smart and intelligent packaging. The packaging serves as an indicator/sensor, wherein the indicator can be placed internally and externally the package. This indicator will communicate and inform the quality of the packaged product to the consumer directly and continuously monitor the quality and safety of the product during handing and storing. The development is being done in the form of smart packaging films or label with the addition of color as an indicator. Researches on smart indicator in the form of label with an indicator dye were previously done. For example, research have been conducted to detects the decay of tilapia fillet [1]. It was also [2,3] with a color indicator label made from synthetic and natural dye to detect the freshness of cutted pine apple [4]. Research [5] had developed the color changing of label made from Erpa (*Aerva sanguinolenta*) leaf extract. Furthermore, the label was applied for pasteurized milk and gave a color changing of red when the milk was fresh and yellow when the milk was off quality [6].

Generally, the indicator changing in color was driven by temperature [3,5], pH [1,7,8], microorganism growth [9] and gas/volatile compound [10]. The color of dyes used in this indicator was made from either synthetic or natural dyes. Synthetic dyes gave a better quality in color, resist to water and high temperature, but it will change due to food pH changing [2,4]. On the other hand, instead of pH, natural dyes was sensitive to temperature thus producing label using this natural dye need a proper technique especially when the process involving on drying. Brushing method was one of the techniques for producing color indicator label with erpa leaf dye [3]. Off course, this technique was time and cost consuming and difficult to be applied as a commercial process. It is therefore finding other technique of drying for producing color indicator label (with natural dye) is much needed to improve the quality of color as well as good in mechanical and physical properties of the label. Thus the purpose of this research is to study the color stability of smart indicator label producing from beet (*Beta vulgaris)* extract as color dye and chitosan as well as PVA as a matrix of the label. Beet or known as beetroot or garden beet is a vegetable which is rich with purple or red purple betasianin pigment. This pigment has been using as natural dye for vary Indonesia tradition food and beverage such as "pepe" and "lapis" cake. Exploring the beet dyes for color indicator of a smart label is very interesting to be studied.

2. RESEARCH METHOD

2.1. Materials and Apparatus

The materials and apparatus used in this study were chitosan, Polyvinyl Alcohol (PVA), 1% glacial acetic acid, plasticizer of glycerin, distilled water, beet extract, and 70% alcohol. While the apparatus were oven blower, oven vacuum, free dryer, hot plate and magnetic stirrer, thermometer, volumetric puppet, glass plate with the size of 20 cm × 20 cm × 1 cm, analytical balance, micrometer screw and Chromameter.

2.2. Method

2.2.1. Beet extraction

Beet was peeled and crushed in a blender and was given an additional water with the ratio (w/w) of 2 (part of beet) and 1 (part of water). Beet extract was filtered by filter paper 100 µm sizes. The red purple dye extract was collected and used to make an indicator label.

2.2.2. Chitosan – PVA solution

Preparation of a mixture of chitosan and PVA films (polyvinyl alcohol) based on research conducted Warsiki *et al* (2013). In this study, chitosan - acetate 1 % of 48 mL, PVA 1% of 48 mL, and beet dye of 4 mL was mixed in a solution. In making the film sheet was performed in three phases, namely, PVA solution preparation, chitosan solution preparation, and the mixing the two of the solutions. At first, 3 gr of PVA was dissolved in distilled water at temperature 80ºC, and then homogenized with a stirrer until it was dissolved perfectly. Then weighing of 3 gr of chitosan and dissolved in 50 mL of 1% glacial acetic acid. The next stage was mixed the two solutions in the breaker glass. Comparisons were used of 6:4 (PVA solution: chitosan solution).

2.2.3. Indicator film coloring and drying

The film solution of 100 mL was carefully poured in a glass plate with size of 20 cm × 20 cm and then dried. Firstly, it mixed the beet dye into the film solution and then dried. There were three drying technique was used i.e. oven, vacuum and freeze dying. Based on the results of the study [4], indicator of natural dye colors were very easy to change color when heated thus a drying method with low temperature could be applied to improve the label color quality. These colors were measured by Chromameter and the data was tested by parametric statistical using Paired Samples t test. The test of t was conducted to determine whether there was a difference between the three techniques of drying.

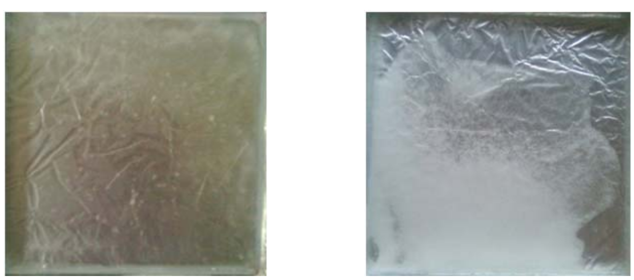
2.2.4. Color stability observing

Color changing of the film during the heating process was observed. It was also observed color stability during the storage in different temperature. A label was made by cutting the color indicator film in a size of 3 cm × 3 cm and then stored in five different places, i.e. room temperature (± 27ºC), the temperature of the refrigerator (3-5ºC), the temperature of the freezer (-5 - (-10)°C), dark space, and exposure to sunlight. The color changes observed visually every hour until the color of film was definitely constant or no more in color changing. Time needed for the color stain in the film was defined as Retention Time.

3. RESULT AND DISCUSSION

3.1. Chitosan and Chitosan –PVA film

The film was produced from the two materials has different visual appearance (see Figure 1 and 2). A Chitosan film sheet was yellowish while the chitosan-PVA film sheets was colored translucent, shiny, and looks smoother surface. In addition, chitosan-PVA films look more like a sheet of plastic. This was because the PVA was included into the plastic material. However, both have the same flexibility. Both films of chitosan and chitosan-PV were easy to be separated from the glass plate and not easily torned.



(a) (b)

Figure 1. Indicator film before coloring : (a) kitosan, dan (b) kitosan-PVA

(a) (b)

Figure 2.. Indicator film after coloring : (a) chitosan, dan (b) chitosan-PVA

3.2. Color stability of indicator film during heating

Three drying techniques were tested to find the appropriate drying in order to obtain a stable color for film indicator. As [4] finding, a film beet colored change during the process of drying in an oven for 24 hours from purplish red to green. In this research, oven blowers has also resulted on changing in color form purplish red after drying become brown for 24 hours at a temperature of 50º C. Then vacuum drying has been done by colored beet subsequently poured into a glass plate and dried by vacuum drying for 3 hours. This technique was also resulted on changing color of the film to yellow-green. While freeze-drying, the film changed from red -purple into pink sheet film after 6 h. This means, for drying the film indicator with freeze drying should be taken less 6 hours to produce dried film. Figure 3 show the changing of color of indicator film using the three techniques of drying.

(i)

(a) (b) (c)

(ii)

Figure 2. Film : (i) before drying and (ii) after drying with : (a) oven blower, (b) freeze ; and (c) oven vacuum

Heat has degraded dye due to its sensitive. Betalain/betasianin, the pigment pf beet dye stability mainly was influenced by temperature. According to [11], the most stable betasianin color temperature was below 40ºC. According to [12] temperature and duration of heating have caused decomposition and changes in the structure of the pigment resulting in bleaching. It was also the nature of the beet betalain affected by pH, light, air, temperature and water activity [13]. When temperatures were used less than 50ºC, the film drying process will require a longer time thus the two drying techniques were not suitable for use in drying films with dye indicator beet. However, dry the film using freeze dryer looked good for the performance of film as long as the temperature was kept in low or it might be in minus.

Color changing using freeze-drying was not so high compared to blower and vacuum drying, although there was still more pale red color. This was because of betalain pigment has a high solubility in water [14] so that when it was dried in freeze, the dye was bound in a matrix of water and difficult to leach out. According to [15], freeze-drying has different working principle of vacuum drying. Freeze drying will draw the components of the material to be dried, including the physically bound water will also be interested while evaporative drying vacuum dried material components so that only the free water that has a great chance to evaporate and remain water that is physically and chemically bonded on it. Then freeze drying produced texture on film sheets more fibrous - fiber, not smooth or flat as in the vacuum drying and drying blower.

The three of drying techniques were resulted on the changing of color of the film unless only a small changing in freeze drying. Data analysis using Paired Sample Test was displayed in Table 1. It was shown that a value with significance level of 0.05 with data (n) of 3 has performed and obtained the degrees of freedom (df) equal to 2. T table value obtained was equal to 4.303. Based on this calculation, the t value calculation was smaller that t table thus it means there was a real relationship (significant) between the indicator color films before and after drying.

Table 1. Result of t test.

Drying technique	**t test**		**Remark**
	T calculation	**T table**	
Blower	1.073[(a)]		N
	0.339[(b)]		N
	-14.359[(c)]		N
Vaccum	-0.721[(a)]		N
	3.698[(b)]	4.303	N
	-12.016[(c)]		N
Freeze	-3.696[(a)]		N
	2.237[(b)]		N
	-0.215[(c)]		n

3.3.3. Color stability of the film during storage

Indicator film was produced by drying in a freezer (-10±1°C) to produce more stable color on that film. A label was made by cutting the sheet film into small pieces (3 cm × 3 cm) and then store in five different conditions, i.e. at room temperature, the temperature of 3-5ºC, the temperature of -5 - (-10)°C, dark room, and sun exposure. Visual observation was performed every hour until the film has no changes in color. The results were shown Table 2.

Tabel 2. Result of the retention time of color in the film

Storage condition	Chitosan (h)	Chitosan-PVA (h)
3-5ºC	30	13
-5-(-10)ºC	30	13
26-27ºC	14	5
Dark room	14	5
Sun exposure	3	2

Based on the above observations (Table 2) it can be seen that the film made from chitosan has a color changing in longer time than the indicator color films made from chitosan and PVA mixture. In addition, the temperature observations were selected for use in the main study was the temperature of 3-5 º C, the temperature of -5 - (-10) ° C, and exposure to the sun. This was because of the film color indicator of beet was expected to be applied as a sensor or indicator of products that are sensitive to temperature.

Indicator chitosan-PVA films was stored in a refrigerator has been resulted on color changing after 13 hours of storage, which was from purplish red became dark purple. At room temperature and dark room, the color changed after 5 hours of storage, i.e. from purplish red to red, while the sun exposure changed after storage for 2 hours (pale purplish red to red and hardened). In meanwhile, the film made from chitosan indicator, the color changed after 3 hours of storage on sun-exposed films, from purplish red to orange. Film stored in the fridge (refrigerator and freezer) changed after 30 hours of storage (purplish red to red), and 14 hours of storage for the film stored in room temperature and dark room dark (purplish red to red-orange).

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Films made of chitosan - PVA had the appearance of a more clear, shiny, and more refined than the chitosan films. The use of dyes as a color indicator of beet, did not allow for drying in conjunction with the film solution. Freeze drying with temperature of -10^{o}C was the best technique for color indicator label producing. The film indicator with natural dyes responded by changing the color of the storage temperature. Color changes occurred in the chitosan -based films had vulnerable longer than films made from chitosan - PVA.

4.2. Recommendation

It was the need of other study of natural dyes that was more resistant to temperature and light. It was also needs further research on the application of this smart label for food product.

5. REFERENCES

1. Hasnedi YW. 2009. The development of smart packaging with a sensor from chitosan-asetat, polyvinyl alcohol and bromthymol blue indicator to detect the deterioration of tilapia fillet. [Bachelor Thesis]. Bogor Agricultural University, Bogor.
2. Warsiki E, Putri CW. 2012. Colored Label Indicator Using Natural And Synthetic Dye). *E-Journal Agroindustri Indonesia* 1 (2): 82 – 87.
3. Warsiki E, Nofrida R, Yuliasih I. 2013. The utilization color extract from Erpa (Aerva sanguinolenta) leaf for smart label color indicator. *Indonesian Journal of Agricultural Sciences* (In Press).
4. Putri CDW. 2012. Smart packaging of color indicator to detect the freshness of cut pineapple during storage. [Bachelor Thesis]. Bogor Agricultural University, Bogor.
5. Nofrida R, Warsiki E, Yuliasih I. 2013. The effect of storage temperature on the Erpa Leaf *(Aerva sanguinolenta*) color indicator smart label. *Journal of Agroindustrial Technology* (In Press).
6. Warsiki E, Nofrida R, Yuliasih I. 2013. Smart thermometer for quality assurance. 105 Innovations Indonesia. Jakarta: *Business Innovation Center* P18-19.
7. Hong SI, Park WS. 2000. Use of color indicators as an active packaging system for evaluating kimchi fermentation. *Journal of Food Engineering.* 46 (1) :67-72.
8. Rukchon, C. 2011. Volatile compounds as quality indicators of fresh chicken and possible application in intelligent packaging. The 12th ASEAN Food Conference 2011, 16-18 June, 2011. BITEC Bangna, Bangkok, Thailand.
9. Lestari IA. 2013. Smart label producing for *Escherichia coli* detector. [Bachelor Thesis]. Bogor Agricultural University, Bogor.
10. Kuswandi, B. Jayus, Restyana, A. Abdullah, A. L.Y.H. Ahmad, M. 2012. A Novel Colorimetric Food Package Label For Fish Spoilage Based On Polyaniline Film. *Journal of.Food control.* 25(1): 184-189
11. Pranutikagne EB. 2009. Extraction and stability testing of skin fruit dyes of betasianin from dragon fruit (*Hylocereus polyrhizus*) and its application as a natural food dyes. [Bachelor Thesis]. Diponegoro University, Semarang.
12. Sutrisno AD. 1987. Creation and improvement of the quality of the natural red dye produced by Monascus purpureus.. University Research Center, Bogor Agricultural University, Bogor.
13. Cai YZ, Sun M, Wu HX, Huang RH, Corke H. 1998. Characterization and quantification of betacyanin pigments from diverse Amaranthus species. *Journal of Agricultural.Food Chemistry.*, 46 (90):2063-2070.
14. Eder R. 1996. *Handbook of Food Analysis*. Vol. I. Marcel Dekker Inc, New York.
15. Ishak MC. 2012. The effect of the drying process and immobilization on the activity and stability of the enzyme bromelain from pineapple (*Ananas comosus* (L) Merr). [Bachelor Thesis]. Hasanudin University, Makasar.