ARTICLE IN PRESS

Available online at www.sciencedirect.com

SCIENCE DIRECT®

ELSEVIER

Journal of Food Engineering xxx (2004) xxx–xxx

JOURNAL OF
FOOD
ENGINEERING

www.elsevier.com/locate/jfoodeng

Role of ferulic acid in preparing edible films from soy protein isolate

Shiyi Ou *, Yong Wang, Shuze Tang, Caihuan Huang, Michael G. Jackson

Department of Food Science and Engineering, Jinan University, Shipai, Guangzhou 510632, People's Republic of China

Received 24 May 2004; accepted 25 September 2004

Abstract

Different concentrations of ferulic acid were added to film-forming solutions when preparing soy protein isolate-based edible films. The results showed that an optimal concentration of ferulic acid increased the tensile strength, elongation percentage at break and antioxidant activity of films for preservation of fresh lard. The optimal concentration for ferulic acid in film forming solution is 100 mg/100 g. Moreover, the properties of the film were further improved when ferulic acid was oxidized by hydrogen peroxide. A possible mechanism for the role of ferulic acid in the preparation of SPI-based films is that it reacted with amino acids and increased cross-linking of the protein. It is interesting that the absorbance wavelength for ferulic acid-protein (or amino acids) is much longer than ferulic acid or protein (or amino acids) alone. The absorbance shift indicates the formation of a ferulic acid-protein cross-link that may enhance the shelf life of foods by decreasing oxygen permeability.

Keywords: Ferulic acid; Soy protein isolate; Edible film

1. Introduction

Packaging is a necessary step for preserving the organoleptic, nutritional and hygienic characteristics of food during storage and commercialization. The wide variety of packaging films can be divided into synthetic and edible or biodegradable. Constant progress in the technology of synthetic film preparation has expanded and supported their utilization in the food industry. However, most synthetic films are petrochemical-based and non-biodegradable, leading to environmental pollution and serious ecological problems (Tharanathan, 2003). In contrast, edible films use renewable resources as raw materials and are biodegradable, making them more compatible with the environment. Additionally, other adjuncts such as antimicrobials, antioxidants, nutrients, colorants, etc. are easier to add to edible films, thus further enhancing their protective functions.

Edible films can be prepared from proteins, polysaccharides, lipids or the combination of these components (Gontard & Guilbert, 1994). Among them, proteins-based edible films are the most attractive. These films have impressive gas barrier properties compared with those prepared from lipids and polysaccharides. When they are not moist, the O_2 permeability of soy protein-based film was 500, 260, 540 and 670 times lower than that of low-density polyethylene, methylcellulose, starch and pectin respectively (Cuq, Gontard, & Guilbert, 1998). The mechanical properties of protein-based edible films are also better than that of polysaccharide and fat-based films because proteins have a unique structure (based on 20 different monomers) which confers a wider range of functional properties, especially a high intermolecular binding potential (Cuq, Aymard, Cuq, & Guilbert, 1995). Protein-based edible films can form bonds at different positions and offer high potential for forming numerous linkages.

Unfortunately, SPI films do not show satisfactory mechanical properties or vapor barrier properties for practical applications, and these properties become even

---

* Corresponding author. Tel.: +86 20 85224235; fax: +86 20 85224235/85226630.

E-mail address: tosy@jnu.edu.cn (S. Ou).

0260-8774/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jfoodeng.2004.09.025

poorer under conditions of high humidity (Gontard, Guilbert, & Cuq, 1993). It was reported that the addition of cross-linking agents into film forming solutions or other physical methods might improve the mechanical properties and water vapor permeability of protein-based edible films. The cross-linking agents include gossypol, formaldehyde, glutaralaldehyde (Marquie, Aymard, Cuq, & Guilbert, 1995), calcium salts, glucono-δ-lactone, carbodiimide, acetylated monoglyceride and transglutaminase (Mariniello et al., 2003; Morel, Bonicel, Micard, & Guilbert, 2000; Park, Rhee, Bae, & Hettiarachchy, 2001), and thiol oxidation (Anker, Berntsen, Hermansson, & Stading, 2002). The physical methods include ultrasound or γ-irradiation treatment (Banerjee, Chen, & Wu, 1996; Sabato et al., 2001). However, there are no reports on the cross-linking properties of ferulic acid in the preparation of edible films, although it is a cross-linking agent in plant cell walls (Liyama, Lam, & Stone, 1984).

Ferulic acid, a health component of food with multiple phytochemical functions (Ou & Kwok, 2004), is a phenolic acid derivative existing ubiquitously in the plant kingdom. It can cross-link with protein and polysaccharides by producing a resonance-stabilized free radical intermediate (Hopkins et al., 2003; Oudgenoeg et al., 2001). Ferulic acid was used to prepare satisfactory gels from arabinoxylans and proteins or pectin (Figueroa-Espinoza et al., 1999; Oosterveld, Beldman, & Voragen, 2000).

As the quinone, (oxidized ferulic acid), it can react with amino and thiol groups in protein (Figueroa-Espinoza et al., 1999). Additionally, the free radical formed from ferulic acid can react with tyrosine and with itself to form diferulic acid (Oudgenoeg et al., 2001; Vansteenkiste, Babot, Rouau, & Micard, 2004), which act as a bridge between protein molecules. This suggests that ferulic acid could act as a satisfactory cross-linking agent in preparation of protein-based edible films.

Our previous preliminarily research proved that ferulic acid could increase the mechanical properties of edible films prepared from soy protein isolate (Ou, Kwok, & Kang, 2004). In this study, the effect of the addition of different amounts of ferulic acid to the film forming solution was determined on both the mechanical properties and water vapor permeability of the films. Additionally, the O_2 barrier properties of the films were determined by measuring the antioxidant properties of the film in preventing the oxidation of fresh lard.

2. Materials and methods

2.1. Materials

Soy protein isolate (SPI) with protein content 93% was purchased from Hong Kong Advanced Science and Technology Co. Ltd (Hong Kong); Glycerol, ferulic acid and amino acids, including cysteine, lysine, tyrosine, phenylalanine, arginine, serine, tryptophane were purchased from Sigma Chemical CO, St Louis, MO, USA; Hydrogen peroxide (33%) from the Guangzhou Chemicals Company Ltd (Guangzhou, China).

2.2. Preparation of film added with ferulic acid

Film forming solution was prepared as follows: 5.0 g soy protein isolate (SPI) was dispersed in approximately 50 ml deionized water by constant stirring, 3.0 g glycerol was added, and different amounts of un-oxidized or oxidized ferulic acid (50, 100, 150, 200 mg respectively). The total weight of each solution was adjusted to 90.0 g with deionized water, the pH was adjusted to 8.0 and 9.0 respectively using 0.1 mmol/L NaOH and HCl, and then deionized water was added to a final weight of 100.0 g.

The film forming solution was heated for 30 min at 85 °C in a water bath under constant stirring at 150 rpm, then cooled to room temperature. 16.0 g portions of the film forming solution were poured into a polyethylene box (20 × 20 × 1 cm) and kept at 50 °C for 24h in an oven, then cooled, and finally the film was conditioned in a desiccator over saturated $Mg(NO_3)_2$ solution at 25 °C, 50% RH for 48 h.

Thickness of the films was measured with a micrometer with a sensitivity of 0.001 mm. Films were cut into 2.0 × 6 cm pieces and the thickness of each film was measured at five random positions.

Oxidized ferulic acid: Ferulic acid (50, 100, 150, 200 mg respectively) was mixed with 50 ml of 500 mg/L hydrogen peroxide and kept at room temperature for 30 min, then the pH was adjusted to 9.0 to remove residual hydrogen peroxide. SPI and glycerol were added and the pH was adjusted according to the method described above, deionized water was added to a final weight of 100.0 g.

2.3. Determination of mechanical properties of films

Tensile strength and percentage elongation at break (TE) were determined according to Jangchud & Chinnan (1999) with a TA500 model Texture Analyzer (Harvey, Main & Co. LTD). Films were preconditioned at 50% relative humidity for 48 h at 25 °C. Five replicate samples, 2.0 × 4 cm, for each kind of film were tested.

2.4. Water vapor permeability

Water vapor transmission of films was measured using the ASTM method (ASTM, 1993). Circular glass cups with a diameter of 3 cm and depth 4 cm were used. After placing 3 g of dried $CaCl_2$ in each cup, they were covered with various edible films prepared in our experiment, cut circularly ($\phi = 7$ cm) and sealed using melted paraffin. The cups were weighed along with their contents and placed in desiccators kept at 25 °C. The relative humidity was maintained by placing 1000 mL of pure water or saturated solutions of KBr, NaCl, and $MgCl_2$ in the bottom of the desiccator to provide 100%, 83%, 75%, 33% RH respectively at 25 °C. Cups were weighed every 12 h for one week. The water vapor transferred through the films was determined from the weight gain of the cups. Water gain velocity (slopes), WVTR (water vapor transmission rate) and WVP (water vapor permeability) were calculated according to Kaya and Kaya (2000). The vapor pressure of pure water at 25 °C is 3.1671 kPa and the vapor pressures of the saturated solutions were equal to their RH times the vapor pressure of pure water at the same temperature.

2.5. Role of ferulic acid in film for prevention against oxidation of lard

A 250 ml jar was filled with 20.0 g of fresh lard, covered with different films, sealed using melted paraffin, and stored at 60 °C in an oven for 12 days. The peroxide value of the lard samples was determined by sodium thiosulfate titration (Ogungbenle, 2003).

2.6. Absorbance spectra of ferulic acid in films and its complex with SPI solution and several amino acids

The absorption spectra of ferulic acid solutions, the ferulic acid-amino acids adducts and the SPI films with ferulic acid added (determined by covering the cuvette on one side), were scanned by using a UV-2101 PC UV–VIS Scanning Spectrophotometer (Shimadzu). The data was transferred to Excel format for illustrating figures. Ferulic acid and amino acids adducts were prepared by reaction of 20 μg/mL ferulic acid with 1 mg/mL of cysteine, lysine, tyrosine, phenylalanine, arginine, serine, tryptophane respectively at 85 °C, pH 9.0 for 30 min, cooling the mixture and diluting to 100 ml with deionized water.

2.7. Statistical analysis

Statistics on a completely randomized design were determined using SPSS 10.0 for Windows. Duncan's multiple-range test ($p \leqslant 0.05$) was used to determine significance of differences between means.

3. Results and discussion

3.1. Effect of ferulic acid on mechanical properties and water vapor permeability of films

The addition of ferulic acid into the film forming solutions at two different pH levels improves the mechanical properties in the films of both (Table 1). In our experiment, the optimal level, judging by increased mechanical properties of film and of ferulic acid in the film forming solutions is 100 mg and 150 mg/100 g respectively at the two-pH levels. When the level of ferulic acid was increased to 200 mg/100 g, the tensile strength and percentage elongation at break decreased slightly.

Ferulic acid did not significantly decrease the vapor permeability of the SPI films, and even increased water vapor permeability at higher levels (Table 2). However, oxidized ferulic acid significantly decreased the water vapor permeability of the films, possibly due to the formation of quinones which have a higher protein cross-linking capacity (Figueroa-Espinoza et al., 1999) and the production of free radicals which also promote cross-linking (Oudgenoeg et al., 2001).

3.2. Effect of ferulic acid in film on prevention of oxidation in lard

In this experiment, edible films were used to cover fresh lard-filled jars to test their O_2 barrier properties in the prevention of the oxidation of lard. The results showed that the addition of ferulic acid into film forming solutions significantly decreased the peroxide value of the lard covered by those films. Furthermore, the oxidation prevention capacity of the oxidized ferulic acid

Table 1
Effect of ferulic acid on tensile strength (TS) and percentage of elongation at break (E)[a]

Ferulic acid (mg/100 g)	TS (Mpa)		E (%)		Thickness (μm)	
	pH = 8.0	pH = 9.0	pH = 8.0	pH = 9.0	pH = 8.0	pH = 9.0
0	1.472 ± 0.044^a	1.598 ± 0.056^a	61.7 ± 7.8^a	156.3 ± 7.1^a	70.3 ± 0.4^a	70.8 ± 1.6^a
50	1.688 ± 0.139^b	2.065 ± 0.138^b	94.7 ± 3.9^b	167.0 ± 3.5^b	72.4 ± 3.2^a	72.8 ± 1.5^b
100	1.622 ± 0.057^b	2.602 ± 0.073^d	85.1 ± 10.9^b	165.3 ± 7.2^b	71.0 ± 1.2^a	70.2 ± 1.0^a
150	1.638 ± 0.098^b	2.438 ± 0.059^c	93.0 ± 12.4^b	166.5 ± 5.3^b	71.4 ± 1.8^a	71.8 ± 1.3^a
200	1.476 ± 0.062^a	2.172 ± 0.175^b	86.4 ± 7.6^b	155.4 ± 8.5^a	71.4 ± 0.7^a	72.2 ± 1.3^{ab}

[a] Values (means ± SD. $n = 5$) with different letters within a column are significantly different at 5% level.

Table 2
Effect of ferulic acid on water vapor permeability of films and their prevention capacity against oxidation of fresh lard

Films	Peroxide value (mgI_2/kg)	WVP ($g\,mm/m^2\,d\,kPa$)	Thickness (μm)
SPI film with no FLA	231.7 ± 9.7^e	2.31 ± 0.06^c	72.4 ± 2
FLA 50 mg/100 g	194.3 ± 7.8^d	2.27 ± 0.05^c	71.8 ± 3
Oxidized FLA 50 mg/100 g	100.4 ± 7.3^b	2.01 ± 0.13^b	71.4 ± 2
FLA 100 mg/100 g	173.9 ± 7.4^c	2.31 ± 0.06^c	70.8 ± 3
Oxidized FLA 100 mg/100 g	74.8 ± 3.4^a	1.81 ± 0.05^a	71.0 ± 3
FLA 150 mg/100 g	177.5 ± 5.0^c	2.38 ± 0.08^c	70.8 ± 3
Oxidized FLA 150 mg/100 g	67.8 ± 1.3^a	1.88 ± 0.06^a	71.0 ± 3
FLA 200 mg/100 g	195.4 ± 7.6^d	2.61 ± 0.08^d	70.8 ± 3
Oxidized FLA 200 mg/100 g	78.4 ± 4.2^a	2.36 ± 0.07^c	71.2 ± 2
Polyethylene film	249.5 ± 6.3^e	—	10.2 ± 0.3

[a] Values (means ± SD, $n = 5$) with different letters within a column are significantly different at 5% level. FLA, ferulic acid.

quinone is much greater than that of its native ferulic acid form (Table 2). One possible mechanism for the prevention of oxidation in lard is that ferulic acid has decreased the oxygen permeability of the film. This is consistent with the results of our previous study (Kwok & Ou, 2002), which showed that adding 100 mg/100 g ferulic acid to SPI film forming solution decreased the permeability of O_2, CO_2 and N_2 by 18.8%, 18.1% and 14.9% respectively.

3.3. *Absorbance spectra of ferulic acid-added SPI film and ferulic acid-added film forming solution*

UV–VIS scanning results showed that the absorbance peak of ferulic acid-added film moved from 300 nm (with no ferulic acid added) to 360–380 nm (Fig. 1). Fig. 2 indicates that the absorbance peak shift toward longer wavelengths is not caused by ferulic acid itself but by the complex of SPI and ferulic acid. The ferulic acid solution reaches an absorbance peak at 320 nm, but the reaction solution of ferulic acid and SPI has a peak of 360 nm (Fig. 2). This suggests that ferulic acid reacted with the soy proteins.

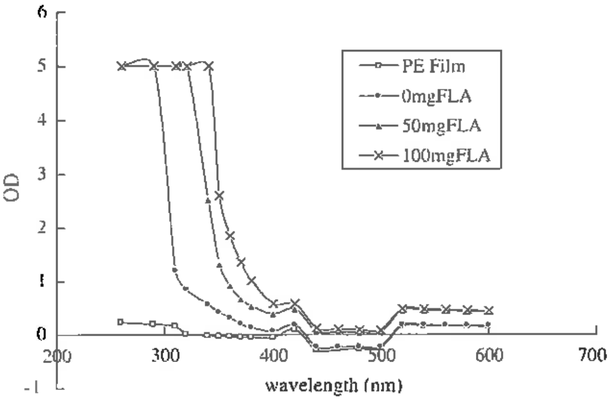

Fig. 1. Absorbance spectra of films.

PE. polyethylene: FLA. ferulic acid

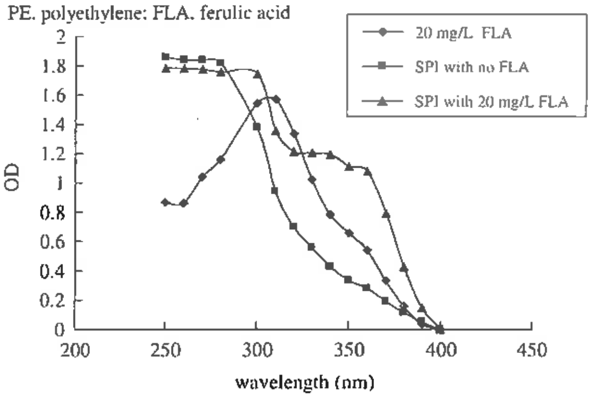

Fig. 2. Absorbance spectra of solution of ferulic acid, SPI and their complex at pH 9.0.

3.4. *Absorbance spectra of ferulic acid reacting with amino acids*

The absorbance spectra of ferulic acid reacting with cysteine, lysine, tyrosine, phenylalanine, arginine, serine, tryptophane was obtained by UV–VIS scanning. The results showed that there are two different absorbance spectra models for these amino acids after reacting with ferulic acid. Cysteine, tyrosine, phenylalanine, serine, tryptophane have similar absorbance spectra after reacting with ferulic acid, with their highest absorbance at 360 nm. While lysine and arginine have another similar spectra after reacting with ferulic acid, with their highest absorbance at 400 nm (Fig. 3). These results indicate that the reaction with amino acids shift the ferulic acid absorbance spectra toward longer wavelengths, a bathochromic shift, since these amino acids alone showed no

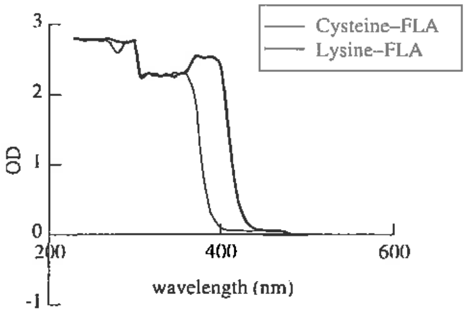

Fig. 3. Absorbance spectra of ferulic acid reacting with cysteine and lysine at pH 9.0.

light absorbance at wavelengths longer than 320 nm (data not shown). This is further indication that ferulic acid has reacted with the amino acids.

3.5. Possible mechanisms of ferulic acid in improving properties of films prepared from SPI

Ferulic acid can react with amino acids in protein thus cross-linking the proteins by several mechanisms. First, ferulic acid is oxidized to its quinone and then the quinone further reacts with amines on proteins (Hurell & Finot, 1984; O'Connell & Fox, 1999). Second, ferulic acid cross-links with tyrosine and other amino acids through a free radical mechanism (Oudgenoeg et al., 2001). A third possible way is esterification with hydroxyl amino acids such as serine. The cross-linking ability of ferulic acid with proteins has improved the mechanical properties of SPI-based edible films.

4. Conclusion

Ferulic acid, a protein cross linking agent, can form adducts with amino acids through various mechanisms. The cross linking activity of ferulic acid was applied to improve the mechanical properties of SPI based films by reaction with amines on proteins. The SPI films cross-linked with ferulic acid demonstrated increased tensile strength, increased percent elongation at break, and decreased oxygen permeability. The SPI films cross-linked with the ferulic acid quinone demonstrated further enhanced mechanical properties and also decreased water vapor permeability. These data indicate that ferulic acid act as a satisfactory cross-linking agent in preparation of protein-based edible films. Additional work is indicated to improve the mechanical properties and packaging film applications of SPI films.

Acknowledgement

This work was supported by Science and Technology Fund Grant 2003Z3-E0061 from Guangzhou government, Guangdong province.

References

Anker, M., Berntsen, J., Hermansson, A. M., & Stading, M. (2002). Improved water vapor barrier of whey protein films by addition of an acetylated monoglyceride. *Innovative Food Science and Emerging Technologies, 3*, 81–92.

ASTM standard test method for water vapor transmission of materials. Designation E96-93, 1993, pp. 701–708.

Banerjee, R., Chen, H., & Wu, J. (1996). Milk protein-based edible film mechanical strength changes due to ultrasound process. *Journal of Food Science, 61*, 824–828.

Cuq, B., Aymard, C., Cuq, J., & Guilbert, S. (1995). Edible packaging films based on fish myofibrillar proteins: formation and functional properties. *Journal of Food Science, 60*, 1369–1374.

Cuq, B., Gontard, N., & Guilbert, S. (1998). Proteins as agricultural polymers for packaging production. *Cereal Chemistry, 75*, 1–9.

Figueroa-Espinoza, M. C., Morel, M. H., Surget, A., Asther, M., Moukha, S., Sigoillot, J. C., & Rouau, X. (1999). Attempt to cross-link feruloylated arabinoxylans and proteins with a fungal laccase. *Food Hydrocolloids, 13*, 65–71.

Gontard, N., & Guilbert, S. (1994). Biopackaging: technology and properties of edible and/or biodegradable material of agricultural origin. In M. Mathlothi (Ed.). *Food packaging and preservation* (pp. 348–378). New York: Blackie Academic and Professional.

Gontard, N., Guilbert, S., & Cuq, J. L. (1993). Water and glycerol as plasticizers affect mechanical and water vapor barrier properties of wheat edible gluten film. *Journal of Food Science, 59*, 206–211.

Hopkins, M. J., Englyst, H. N., Macfarlane, S., Furrie, E., Macfarlane, G. T., & McBain, A. J. (2003). Degradation of cross-linked and non-cross-linked arabinoxylans by the intestinal microbiota in children. *Applied Environment and Microbiology*, 6354–6360.

Hurell, R. F., & Finot, P. A. (1984). Nutritional consequences of the reactions between proteins and oxidized polyphenolic acids. *Advances in Experimental Medicine and Biology, 177*, 421–435.

Jangchud, A., & Chinnan, M. S. (1999). Peanut protein film as affected by drying temperature and pH of film forming solution. *Journal of Food Science, 64*, 153–157.

Kaya, S., & Kaya, A. (2000). Microwave drying effects on properties of whey protein isolate edible films. *Journal of Food Engineering, 43*, 91–96.

Kwok, K. C., & Ou, S. Y. (2002). Effect of ferulic acid on water vapour and gas permeability of SPI-based film. *Science and Technology of Food Industry, 23*, 24–26 (in Chinese).

Liyama, K., Lam, T. B., & Stone, B. (1984). Covalent cross-links in the cell wall. *Plant Physiology, 104*, 315–320.

Mariniello, L., Di Pierro, P., Esposito, C., Sorrentino, A., Masi, P., & Porta, R. (2003). Preparation and mechanical properties of edible pectin-/soy flour films obtained in the absence or presence of transglutaminase. *Journal of Biotechnology, 102*, 191–198.

Marquie, C., Aymard, C., Cuq, J. L., & Guilbert, S. (1995). Biodegradable packaging made from cottonseed flour: formation and improvement by chemical treatments with gossypol, formaldehyde, and glutaraldehyde. *Journal of Agricultural and Food Chemistry, 43*, 2762–2767.

Morel, M. H., Bonicel, J., Micard, V., & Guilbert, S. (2000). Protein insolubilization and thiol oxidation in sulfide-treated wheat gluten films during aging at temperature and humilities. *Journal of Agricultural and Food Chemistry, 48*, 186–190.

O'Connell, J. E., & Fox, P. F. (1999). Proposed mechanism for the effect of polyphenols on the heat stability of milk. *International Dairy Journal, 9*, 523–536.

Ogungbenle, H. N. (2003). Nutritional evaluation and functional properties of quinoa (Chenopodium quinoa) flour. *International Journal of Food Science and Nutrition, 54*, 153–158.

Oosterveld, A., Beldman, G., & Voragen, A. G. J. (2000). Oxidative cross-linking of pectic polysaccharides from sugar-beet pulp. *Carbohydrate Research, 328*, 199–207.

Ou, S. Y., & Kwok, K. C. (2004). Ferulic acid: pharmaceutical functions, preparation and application in foods. *Journal of the Science of Food and Agriculture, 84*, 1261.

Ou, S. Y., Kwok, K. C., & Kang, Y. J. (2004). Changes in *in vitro* digestibility and reactive lysine of soy protein isolate after formation of film. *Journal of Food Engineering, 64*, 301–305.

Oudgenoeg, G., Hilhorst, R., Piersma, S. R., Boeriu, C. G., Gruppen, H., Hessing, M., Voragen, A. G., & Laane, C. (2001). Peroxidase-mediated cross-linking of a tyrosine-containing peptide with ferulicacid. *Journal of Agricultural and Food Chemistry, 49*, 2503–2510.

Park, S. K., Rhee, C. O., Bae, D. H., & Hettiarachchy, N. S. (2001). Mechanical properties and water-vapor permeability of soy protein films affected by calcium salts and glucono-δ-lactone. *Journal of Agricultural and Food Chemistry, 49*, 2308–2312.

Sabato, S. F., Ouattara, B., Yu, H., D'Aprano, G., LeTien, C., Mateescu, M. A., & Lacroix, M. (2001). Mechanical and barrier properties of cross-linked soy and whey protein based films. *Journal of Agricultural and Food Chemistry, 49*, 1397–1403.

Tharanathan, R. N. (2003). Biodegradable films and composite coatings: past, present and future. *Trends in Food Science and Technology, 14*, 71–78.

Vansteenkiste, E., Babot, C., Rouau, X., & Micard, V. (2004). Oxidative Gelation of feruloylated arabinoxylans as affected by protein. Influence on protein enzymatic hydrolysis. *Food Hydrocolloids, 8*, 557–564.

From: kenneth@colorama.co.za
To: "Colorama mail" <colorama@mylist.worldonline.co.za>
Date: 27/11/2004 14:05:06
Subject: [Colorama Garden Centre] V.I.P. Special and tip of the week 01December 2004.

We are open over the festive season

Opening times
Monday to Friday 08H00 till 17H00
Saturday 08H00 till 17H30
Sunday 08H30 till 17H00

We are open every day except day as listed below.

Days and times closed for December & January
24 December open half day till 13H00
25 December closed
31 December open half day till 13H00
01 January 2005 closed

———

Tip of the week.

If you live in a townhouse and have problems with ants in your garden and/or home, try this: mix 1 teaspoon of the blue tin Jays Fluid, with 1 litter of water in a old bucket and poor a line along your boundary walls. The ants will not cross this line. Mix Baythion (ant and harvester termite killer) from Bayer and spray in the garden. In the house you can use Fendona 6 SC. You will now be ant free! Remember to do a follow up spray and do the boundary walls every two weeks and the ants will not come back.

V.I.P. Special for 01 December 2004.
Purchase any ant killer today and we will give you a 200ml bottle of sea gro to feed your plants with.

Managers Special.
Artemisia yellow fun (ground cover)
Now only
R2-55 Each

———

Happy gardening
Kenneth, Marisa & The team
Colorama Garden Centre
Plot 72, Lynnwood Rd.
Tel: 012 807 4444
E-mail: info@colorama.co.za <mailto:info@colorama.co.za>
Web: www.colorama.co.za <http://www.colorama.co.za>
Unsubscribe

If you ever want to unsubscribe or change your options (egg: change your password, etc.), visit your
subscription page at:
http://mylist.worldonline.co.za/mailman/options/colorama/kenneth%40colorama.co.za
<http://mylist.worldonline.co.za/mailman/options/colorama/kenneth%40colorama.co.za>