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Fractionation of Chinese Cabbage Juice

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Abstract: The fractionation of green juice could be one of the ways to treat the green juice for saving the bio re-sources by using the basic processes of protein coagulation and separating juice coagulation into protein paste and brown juice and storing the final products. The fractionation of Chinese cabbage juice can be accomplished by applying the combine method of the formic acid with rate of 0.3% and the propionic acid with rate of 0.1% added 4 hours later in the juice with maximum recovery of protein coagulation. The separation of coagulation into the protein paste and the brown juice completed in 6.5 hours by set up method in a special designed storage. The protein paste could be stored safely for 30days in anaerobic condition.

Keywords: Chinese Cabbage juice, Wet Fractionation, Coagulation, Storage, Protein Paste, Brown Juice

Introduction

The traditional agriculture definitely limits what is presently possible to obtain from agricultural lands. And production of raw material has been strongly advocated during last decades. The more and better global demands for food and feed materials prescribe optimal utilization of every potential sources of plants and lands. The alternative is an ecologically better adapted agriculture based on production by pho-tosynthesis in green plants (Carlson, 1992).

The food problem is the extremely significant one as it's called to satisfy the public's need in feeding. The animal origin protein on its amino acid composition has been required by the human being for the indis-pensable amino acids. This is one of the reasons for the stockbreeding development. But the productivity of the stockbreeding directly depends upon the stability of the fodder supply. One of the ways to solve the problems could be the modernization of the traditional system and development of the new concepts of technologies to produce fodder and protein supplements.

Green crops can be used for a simultaneously manufacturing of several food and non-food industrial products by a process called green crop fractionation or wet fractionation of green crops. Wet fractiona-tion of green vegetation yields initially two fractions, a fibrous residue and a fiber free extract. Further treatment of the extract results again in two fractions, a wet "coagulum" and the deproteinised fluid or "whey" (Singh, 1996).

Now the plants for the green vegetative biomass fractionation are working in France, New Zealand, Rus-sia and other countries (Singh, 1996). But the different technological versions of fractionation show vari-ous problems like high-energy consumption and high-price of the set of equipment (Proydak and kireeva, 1993).

The fresh vegetable should be supplied to the human beings as a vital food everyday. The most popular method to remove the waste is to transport it to a garbage dump. But the volume of vegetable waste is such a large amount that the expenditure for the transportation is quite high. Also the valuable energy sources become just a trivial trash on a dumping ground. To save the transportation cost and accelerate the fermentation in a field, the vegetable waste should be treated mechanically and reduced the volume. In the process of the mechanical treatment, large amount of juice should be extracted from vegetable waste.

One of the main problems is how to treat the green juice without using municipal wastewater treatment system. The fractionation of green juice could be one of the ways to treat the green juice for saving the bio resources by coagulation protein and separating juice coagulation into protein paste and brown juice and storing the final products.

1. Coagulation Method

In the industrial practice ("Pro-Xan", "Vepex", "France-Lucerne") for vegetative protein coagulation, the thermal methods of heating green juice (temperature 85-88℃) were

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used. However it was reported that the temperature was too high to have an negative effect on quality and safety of the protein, vitamins, and biologically active substances. Beside those temperature effects, the large energy expenditure was another problem (Singh, 1996). The other effective method was chemical treatment for the vegetative protein co-agulation by different acids (Dolgov et. al., 1978). Based On the chemical treatment, the biochemical methods were also used by using the fermented green juice (Stahman, 1976), the aerobic and anaerobic conditions (Beker, 1991), the previously fermented green juice (Ohshima et. al., 1997), and the previously fermented brown juice (Ge Danzhi et. al., 1996). Lately the combine method was developed with differ-ent combination of acids which can work for the protein coagulation and the storage of the protein paste and brown juice (Proydak and Dolgov, 1994). However these perspective methods excluding the combine method were not tested in industrial conditions. Some researchers investi-gated the vegetative protein co-agulation by using electrical current, different kind of radiation, and the new hydro mechanical method. However large energy expenditure res-trained these new methods developed from industrialization (Proy-dak and Kireeva, 1993). Application of the molecular filtration for vegetative protein extraction did not success because of the expensive membranes (Proydak N., 1990).

2. Separation of Coagulations

For the separation of green juice coagulation, the different kinds of centrifuges and filter presses were used even though unstable on the technical process and high price of facilities (Dolgov et. al., 1978). Re-cently the cheapest effective method of separation of the alfalfa green juice coagulation by set up was de-veloped and successful tested at the industrial conditions (Dolgov and Proydak, 1990).

3. Storage of Protein Paste

In different technical versions of wet fractionation for longtime storage, the drying of protein paste can be used and the protein paste can be concentrated with the moisture contents 8 to 12% as a result of drying. But for the process of drying, expensive equipments and high-energy expenditure are needed (Singh, 1996). The previous research suggested the effective storage of alfalfa protein paste in anaerobic condi-tions in a special storage system. The anaerobic conditions can be obtained by the layer of brown juice thickness 15 to 20 cm. above the protein paste (Proydak, 1996).

Objectives

The main objective of the research is to find out a method of fractionating the green juice extracted from Chinese cabbage waste. The specific objectives are as follows;

1. to investigate various coagulation techniques of Chinese cabbage juice for recycling the protein,
2. to choose an effective method of separating the coa-gulation from the Chinese cabbage juice for the protein paste and the brown juice,
3. to investigate a method of storing protein past,
4. to discuss an effective resource saving technology for treatment of the green pure juice from Chinese cabbage waste by producing the protein paste, the fibrous residue, and the brown juice.

Materials and Methods

The material for test was Chinese cabbage waste at 90.9-92.1% moisture content and extracted green juice from the Chinese cabbage waste at 95.9-96.5% moisture content.

1. Coagulation Methods

Base on the analysis of previous informations (Singh, 1996) and results from our own previous investiga-tion (Proydak, 1996), the next methods of protein coagulation of Chinese cabbage juice were developed for tests and listed as follows;

A - the chemical method using the formic acid as a coagulant,
B - the combine method using the formic acid as a coagulant and the propionic acid as a preservative,
C - the combine method same as method B but appli-cation time of the propionic acid was delayed 4 hours,
D - the biochemical method using lactic acid,
E - the combine and biochemical method using lactic acid as a coagulant and the propionic acid as a pre-servative,
F - the combine and biochemical method same as method E exception on using different application time for the propionic acid as delayed 4 hours.

Different kinds of acids and levels of their application as a coagulant and a preservative were selected base on the results of our own previous investigation on protein coagu-lation of Chinese cabbage juice.

As a function of response on the process of the protein coagulation of Chinese cabbage waste, the coef-ficient of protein coagulation K was introduced.

$$K = Mnp / Mnj = Mp\ Dp\ Pp / Ml\ Dl\ Pl \quad (1)$$

where Mnp, Mnj – mass of protein at the protein paste and the green juice, g,
Mp, Ml – mass of the protein paste and the green juice, g,
Dp, Dl – dry material contents of the protein paste and the green juice, a part of one,
Ppl, Pl – protein contents of dry material of the protein paste and the green juice, a part of one.

Methods of investigation were as follows;

1) Test A for chemical coagulation
   (1) to determine dry material and protein contents in the green juice,
   (2) to put 100 g of the green juice in glass and add 2 g (2% of the green juice, test A1) and 3 g (3% of the green juice, test A2) of the formic acid as the coagulant,
   (3) to separate the coagulation by a centrifuge for 30 min at 7000 g,
   (4) to determine the mass of the protein paste, dry material and protein contents of the separated coagu-lant.
2) Test B for combine coagulation by 2 acids applied at the same time,
   to put 100 g of the green juice in glass and add 0.3 g (0.3% of the green juice) of the formic acid and 0.1 g (0.1% of the green juice, test B1), 0.25 g (test B2), 0.4g (test B3) of the propionic acid as the preservative.
3) Test C for combine coagulation by 2 acids applied with 4 hours interval,
   to put 100 g of the green juice in glass and add 0.3 g of the formic acid and in 4 hours 0.1 g (test C1), 0.25 g (test C2), or 0.4 g (test C3) of the propionic acid.
4) Test D for biochemical coagulation, to put 100 g of the green juice in glass and add 3.5 g (3.5%) of the lactic acid as the coagulant.
5) Test E for combine-biochemical coagulation by 2 acids applied at the same time, to put 100 g of the green juice in glass and add 3.5 g (3.5%) of the lactic acid as the coagulant and 0.25 g (0.25%) of the propionic acid as the preservative.
6) Test F for combine-biochemical coagulation by 2 acids applied at 4 hour interval, to put 100 g of the green juice in glass and add 3.5 g (3.5%) of the lactic acid as the coagulant and in 4 hours 0.25 g (0.25%) of the propionic acid as the preservative.

All tests repeat 3 times. The coefficients of protein coagulation K were calculated by the equation (1).

Table 1 Treatment methods

Treatments	Levels	Application (Coagulant and/or Preservative, %)	Evaluation
A	A1 A2	Formic acid 0.2% Formic acid 0.3%	Coagulation Separation Storage
B	B1 B2 B3	Formic acid 0.3%, prop acid 0.1% Formic acid 0.3%, prop acid 0.25% Formic acid 0.3%, prop acid 0.4%	Coagulation Separation Storage
C	C1 C2 C3	Formic acid 0.3%, prop acid 0.1% Formic acid 0.3%, prop acid 0.25% Formic acid 0.3%, prop acid 0.4%	Coagulation
D	D	Lactic acid 3.5%	Coagulation Separation Storage
E	E	Lactic acid 3.5%, prop acid 0.25%	Coagulation Separation Storage
F	F	Lactic acid 3.5%, prop acid 0.25%	Coagulation

2. Separation of the Coagulations

By using the set up method, the separation of green juice coagulation from Chinese cabbage waste was tested.

During the separation of the coagulation by set up, the coagulation got a change of vertical coordinate border between protein paste in low part of glass column and brown juice in its upper part.

For the test, 1000 g of the green juice was put in glass column marked vertical scale. The separation of the green juice was prepared by using the chemical (A), the combine (B), the biochemical (D) and the combine-biochemical (E) methods, described by the methods of coagulation part except C and F which is included in the combine method B and combine-biochemical method E. The vertical coordinate of border of the separated coagulant was checked from bottom of glass every 30 minutes for 40 hours. Every test repeats 3 times.

3. Storage of the Protein Paste

The evaluation of the protein paste storage in anaerobic condition was obtained by measurements of the change of the protein contents and the value of pH of protein paste.

The methods of investigation were as follows;

1) to put the protein paste in 1000 ml glasses which was made by methods of coagulation A, B, D, E, F, describing in Methods of coagulation except C and F which is included in method B and E,
2) to measure the protein contents and pH of protein paste at beginning and every 5 days for 30 days, each test repeats 3 times.

Results and Discussion

1. Coagulation of Chinese Cabbage Juice

The protein coagulation coefficients (K) of the different methods for coagulation were determined and shown in Table 1. The chemical coagulation method, A, shows the largest values of coefficients K and the combine-biochemical method, E, and combine method, C, also show relatively high value of K. In the chemical method, the coefficients of protein coagulation K increased from 34.2 (A1) to 36.4 (A2) with increase of the rate of the coagulant, the formic acid, from 0.2% to 0.3%. These results showed the previ-ous results of alfalfa protein coagulation investigation (Dolgov and Proydak, 1990). The combined method C showed 10% larger coefficient of protein coagulation K as compared with method B.

The combine (C) and combined-biochemical (F) methods which were distingushed from methods B and E by the delayed application time of two acids showed better coagulating and preserving performance compared with those of the methods B and E.

Table 2 Coefficients of protein coagulation of Chinese cabbage juice

Treatment	Levels	Average coefficients of Protein coagulation K, %
A	A1	34.2
	A2	36.4
B	B1	29.8
	B2	29.1
	B3	29.1
C	C1	33.9
	C2	33.9
	C3	32.1
D	D	31.5
E	E	34.2
F	F	33.0

2. Separation of the Coagulation

The results of separation of coagulation by set up method are shown in Fig. 1 according to the chemical (A), the combine (B), the biochemical (D) and the combined-biochemical (E) coagulation methods. The stable separation of coagulation of Chinese cabbage juice can be obtained by the chemical and the com-bine methods in 5.5 and 6.5 hours, respectively. For coagulations getting by biochemical (D) and the combine-biochemical (E) methods, the time of separation is about 16 hours. The big differences between of the separating time came from the different chemical properties of the formic and the lactic acids.

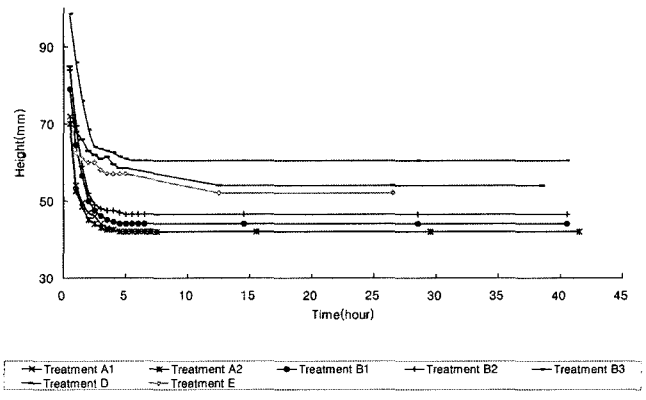

Fig. 1 Seperation of coagulation by set up method.

3. Storage of Protein Paste

During the storage of the protein paste in an anaerobic condition for 30 days, the protein contents de-creased from 1.6 to 2.8% without significant difference among the methods of A, B, D, E, F.

In 30 days, pH of protein paste from chemical coagulation (Fig. 2) was reduced from 3.77 to 3.68 (A1) and from 3.52 to 3.45 (A2). After combine coagulation, pH of protein paste is reduced from 3.50 to 3.43 (B1), from 3.46 to 3.40 (B2) and from 3.50 to 3.45 (B3). The values of pH of protein paste, getting by biochemical and combine-biochemical method, is reduced from 5.37 to 3.27 (D), from 5.33 to 4.41 and then to 3.47 (E) in 30 days. The pH of protein paste, getting by combine-biochemical method F, is re-duced from 5.38 to 3.54 and then is increased to 3.85. This result indicate the beginning of spoiling of protein paste. So, the combine method showed the least change of pH and the best condition for anaerobic storage protein paste from Chinese cabbage juice.

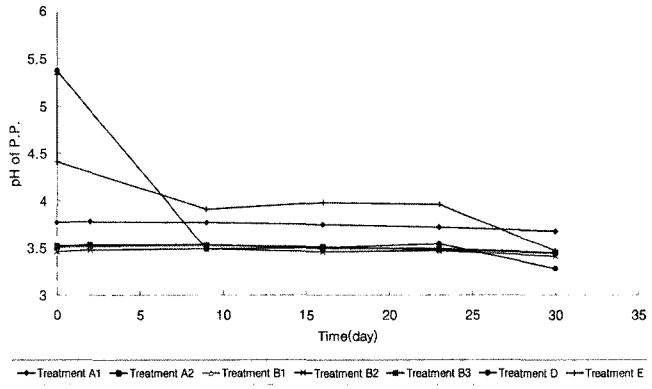

Fig. 2 pH of protein paste during the storage.

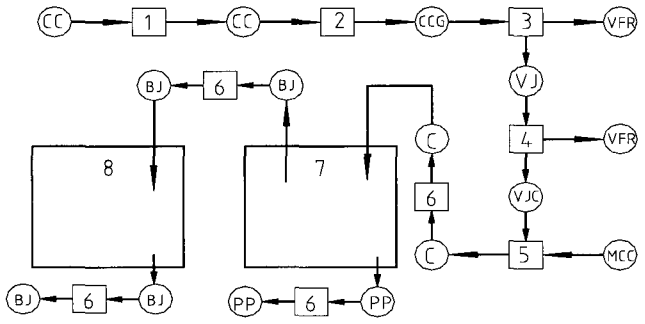

Fig. 3 Technical system for treatment of Chinese cabbage waste.

CC-Chinese cabbage; CCG-cutting CC; VFR- vegetative fibrous residue; VJ-green juice; VJC-clear VJ; MCC-mixture of coagulant and preservative; C-coagulation of VJC; BJ-brown juice; PP-protein paste.

1-feeder; 2-grinder; 3-screw press; 4-filter; 5-pump; 6-unit for C, PP, and BJ separation; 7 and 8-unit for BJ storage.

4. System for Chinese Cabbage Juice Treatment

Based on the test results, the new technical system for treatment of Chinese cabbage waste was worked out (Fig. 3). The Chinese cabbage waste disintegrates in special unit 2 and then squeezed out the green juice by screw press 3. Then the fibrous residue can be used for the silage or the pellets of grass flour. The green juice separated from the fibrous mixture by filter 4.

Then the combine coagulation method using the mixture of coagulant (the formic acid) and the preserva-tive (the propionic acid) can be used to obtain the coagulation from the clean juice of the Chinese cabbage waste. The coagulation will be collected into the special storage 6, where the protein paste can be sepa-rated from the brown juice on top. Finally the brown juice pumped to the storage 7.

Conclusions

1. An coagulation of juice from Chinese cabbage waste was established by applying the formic acid of 0.3% as a coagulant and then in 4 hours the propionic acid of 0.1% as a preservative with maximum re-covery of protein coagulation among the various methods.
2. The separation of coagulation into the protein paste and the brown juice completed in 6.5 hours by set up method in a special storage.
3. The protein paste in anaerobic condition can be stored at least 30 days.
4. The resource saving system allowed to treat the Chinese cabbage waste for the protein paste with pro-tein contents of 35 to 40% in dry materials.

Refferences

Beker M. 1991. Closed and semiclosed biotechnological systems for agriculture. In: Bioprocess Tech-nology for Closed Cycle Production. Reprint of Workshop (Event N65). Grsz, Austria, pp. 45-56.

Carlsson R., 1992. Green crops selected for polyvalent use as industrial raw material. In proceedings fo workshop ecologic bioprocessing-challenges in practice. Postam, pp. 141-146.

Dolgov I.A., Novicov Y.F. and Yatsko M.A. 1978. The protein concentrate of the green plants, Moscow, Koloc, p. 159 (in Russian).

Dolgov I.A. and Proydak N.I 1990. Technology and equip-ment for production fodder and protein supple-ments. J.

Technique in agricultural, Moscow, pp. 3-9 (in Russian).

Ge Danzhi, Zhang Bikai and Fu Shaohui. 1996. The technology and application of extraction leaf protein by fermentation acids method. Pros. of the Fifth Intern. Congr. on Leaf Protein Research "LeafPro-96". In 4 vol. / Edited by N.I. Proydak. - Rostov-on-Don, Vol. 1, pp. 99-102.

Ohshima M., Proydak N. and Nishino N. 1997. Effect of addition of lactic acid bacteria or previously fer-mented juice of the yield and the nutritive value of alfalfa protein concentrate coagulated by anaerobic fer-mentation. J. Animal Science and Technology-Japan -N9, pp. 820-826.

Singh N. 1996. Green vegetation fractionation technology. Oxford & IBH Publishing Co., New Delhi, Pp 1··· XX1V, pp. 1-250.

Proydak N. 1990. Application of molecular filtration in retreatment of fluid fraction of green plants. The 3 Intern. Conf. On Leaf Protein Research: Proc.- Italy, pp. 173-174.

Proydak N. and Kireeva, V. 1993. Hydromechanics process for production of chloroplastic and cytoplas-mic protein fractions from green alfalfa juice. Pros. of the Fourth. Intern. Conf. "Leaf Processing and Fractionation" / Edited by G. Ostrowski-Meissner. -Sydney, pp. 115-120.

Proydak N. and Dolgov I. 1994. Strategy of the development of technology of leafstalk biomass complex retreatment on basis of wet fractionation. Proc. of X11 World Congr. on Agricultural Engineering. - Mi-lano, pp. 1483-1489.

Proydak N.I. and Proydak N.N. 1996. Chemical coagulation of alfalfa protein fraction. Contemporary Achievement of Biotechnology. Proc. of Conf., - Stavro-pol, pp. 149-150 (in Russian).

Stahman M. 1976. Coagulation of protein from the juice of green plants by fermentation and preserva-tion. US Pat. N3.975.544.