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(54) A PROCESS FOR PREPARING NON-SPECIFIC PROTEIN CONCENTRATE AND OTHER FODDER ADDITIVES HAVING A BIOLOGICAL ACTIVITY

(71) We, VEPEX FŐVÁLLALKOZÁSI IRODA RT., of 1 Dembinszky utca, Tatabánya II., Hungary, a body corporate organized under the laws of Hungary, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a process for preparing non-specific protein concentrates and other fodder additives having biological activity out of pressed juice of green plant and out of the obtained pressed cake.

The utilization of the nutritive components and protein produced by green plants gains an ever increasing importance to satisfy the nutritive substance and protein needs of animal and human nutrition. A broader industrial utilization of fibrous or fibre-free nutritive substances and protein fractions prepared from green leafy material is restricted owing to the circumstance that, in contrast to the common soya, fish-meal and other protein sources, the protein is only available in vegetative plants accompanied by several substances and a separation of the protein from the accompanying substances is rather difficult. The kind of the accompanying substances influences the quality and biological value of the obtained protein, that is, the protein obtained from the green plants concerning the utility value cannot be considered identical with common proteins and nutritive substance bases although the plant protein has a very advantageous composition. The prevailing protein demand and the composition thereof depends on whether it will be used for human consumption or feeding animals. In animal feeding the demand can be further divided because the quality or composition of the fodder varies according to the demands of the animals.

The technical methods directed to the processing of leafy proteins are quite

developed but, in spite of this, they are utilisable only to a very limited extent. The removal of the accompanying substances from the leafy protein and obtaining a certain protein concentration are very complicated to carry out in an economical way and constitute a very difficult technical problem.

In addition to the preparation of leaf protein concentrates substantially free from accompanying substances there is a very important task to isolate the provitamins, growth factors and pigment substances preserved in a natural state and obtaining these components of the crude plant in a concentrated form.

A series of experimental work has been done to purify the chloroplastic and cytoplasmic protein fractions which are separable from plant juice prepared by pressing of green leafy substances. In spite of these efforts no economical method could be elaborated relating to the fractioning of protein curd obtained under heat treatment of plant juices and the separation of the disadvantageous accompanying substances. The removal of accompanying substances generally requires many steps and a decomposition of the natural protein values cannot be avoided. In addition the isolation of the substances can be carried out only to a certain extent. A further difficulty is caused by the fact that a part of the accompanying substances is lipid-soluble, that is the removal thereof can be only effected by means of a non-polar solvent. The water soluble accompanying substances on the other hand can be removed only by means of a polar solvent. The accompanying substances, e.g. the chlorophyll and its derivatives, further the decomposition products thereof, are not detrimental from a biological point of view. In course of the treatment, however, such decomposition products are formed or enriched in the end-product which may cause damage on utilizing the obtained

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protein concentrate as a fodder. Among the accompanying substances the triterpenes and steroidal saponins can be mentioned, which are toxic compounds owing to their haemolytic effect. The presence of phenolic compounds and tannic acid is disadvantageous on utilizing the protein concentrate because these substances inhibit enzymes having an important biological role and in addition, they can cause the coagulation of the protein. Among the noxious accompanying substances the nitrates are of significance, the removal thereof being necessary at least to such an extent that the presence thereof does not hinder the use of leaf proteins in animal feed.

It is well known that from the protein fraction obtainable from plant juices the cytoplasmic (white) protein fraction is more advantageous because after the isolation of the chloroplastic fraction the cytoplasmic fraction contains accompanying substances only in very small amounts and it can be considered as a non-specific concentrate which can be utilized in human nutrition as well.

In the present invention those protein fractions are considered as non-specific ones which have a raw protein content of higher than 60 weight % and contain secondary metabolite products and specific components only in an unnoxious quantity which are characteristic of crude material. The composition of the non-specific protein fraction can be characterized as essentially consisting of proteins, carbohydrates and mineral substances. Known methods directed to the separation of the two protein fractions have only partly been successful as a certain increase of the obtainable ratio of cytoplasmic protein fraction can be attained through improving the fractionation of the two protein fractions or by means of using auxiliary substances. The major part of the leaf protein, however, contained in the chloroplast fraction and the transformation thereof into non-specific protein fraction or the isolation thereof in such a form constitute an unsolved problem according to the state of art.

An aim of the present invention is the processing of leaf protein curds into non-specific stable protein concentrates which are practically free of the major part of the pigments and accompanying substances characterizing the plants and in this form can be utilised in animal fodder without special limitation.

Another aim of the present invention is the fractionated processing of the separated pigment and accompanying substances from the protein curd into a fodder additive

which in itself or mixed with stabilizers or carriers and other nourishing substances respectively, may constitute an important component in feeds for animals.

The present invention provides a process for preparing a protein concentrate from green plant material, wherein juices expressed from the material, leaving a green plant material residue, are heated and protein coagulated by the heating is collected; the collected protein, containing more water than its dry weight, is treated with a solvent comprising a glycolether or diglycolether, in an amount in excess of its dry weight; and the treated protein is washed with water and recovered.

The present invention also provides a process for preparing a protein concentrate and other fodder additives having a biological activity, which process comprises pressing green plant material to form a residue of green plant material as a press cake and expressed juices, further processing the press cake to express juices, coagulating the protein fraction of the plant juices, treating the coagulated protein fraction having at least 1.5 times more water than its dry weight with at least 1.5 times more solvent than its dry weight, the solvent comprising a glycolether or diglycolether, and optionally methanol, washing the treated protein with water, drying the washed protein, separating the materials dissolved from the solvent phase and mixing them with the press cake, regenerating the solvent and recirculating it for further treatment of collected protein.

Preferably, protein curd obtained via heat coagulation of the protein at a temperature of 80 to 85°C containing both chloroplastic and cytoplasmic protein fraction is processed. The protein fraction to be processed may contain only the chloroplastic fraction which is coagulated from a pressed juice at 55 to 60°C. On separating the protein fraction in certain cases it is advantageous to use surface active substances which make the precipitation and the separation of the protein fraction and precipitate easier. As a surface active agent a substance can be selected which have HLB-value (Hydrophilic-Lipoid-Balance) in the range of 8 to 18 or a mixture of such surface active substances which are used in a quantity of about 2400 to 6000 ppm calculated on the dry matter weight of the plant juice.

The glycolether or dyglycolether is preferably selected from ethyleneglycol monomethylether, ethylene-glycol monoethylether, ethyleneglycol propylether, diethyleneglycol monomethylether and diethyleneglycol monoethylether. These solvents are generally referred as

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Cellosolve* or Carbitol* solvents. The treatment with the glycolethers can be effected stepwise or continuously. A treatment of the protein fraction in four steps proved especially preferable because in such cases there is a possibility of isolating the accompanying substances in a fractionated way. The solvent (extract) phase separated in the first two steps can be worked up to xanthophyll and the solvent (extract) phase separated in the further steps to carotenoids.

According to our experience a treatment of the green protein curd with a mixture of a glycolether and methanol constitutes a highly preferable embodiment of the invention. The weight ratio of the glycolether and methanol is preferably adjusted between the limits of 3:1 to 2:1.

On processing the solvent (extract) phase with another solvent non-miscible with the first solvent a liquid-liquid extraction is carried out. The second solvent used in this extraction is preferably a non-polar one preferably a benzine (petroleum ether) in the boiling point range of 80 to 100°C. On treating the glycolether solvent phase with benzine a major part of the pigments and of the lipids can be removed from the glycolether phase and on processing the benzine phase after distilling off the benzine the pigment and lipids can be separated from the residue. However, without using a second solvent and a liquid-liquid extraction there is a possibility of utilizing the accompanying substances and pigments obtained from the glycolether phase if the distillation residue obtained after the removal of the first solvent is mixed with the fibrous press cake and thus the fodder value thereof is essentially improved.

The accompanying substances—already described—may be utilized per se, mixed with other nourishing components or in given cases with carriers.

The scope of the invention extends to the products obtained. The non-specific plant (leafy) protein concentrates contains 65—75% by weight crude protein practically free from chlorophyll, carotenoids, xanthophyll and the decomposition products thereof, up to 4% by weight of mineral substances, up to 1.5% by weight of raw fibre, 14 to 22% by weight of nitrogen free extract, 0.8 to 1.0% by weight lipids and about 6% by weight water. The non-specific plant protein concentrates may be mixed with other protein components, for texturising purposes and are especially preferable in animal fodder.

The xanthophyll concentrate contains up to 3.1% by weight xanthophyll and up to 0.5 weight % of beta-carotene, about 3 weight % humidity and the rest lipids. This

concentrate can be preferably used in chicken-farming.

The beta-carotene concentrates contain at least 0.8 weight % of beta-carotene, up to 0.5 weight % xanthophyll, about 3 weight % water and the rest lipid.

The fodder flour or granulate prepared according to the invention consists of the press cake of green plant and of extracted lipids and can be characterized by containing about 35 weight % of crude fibre, 10 to 15 weight % of crude protein, 10 to 14 weight % of mineral substances, 2 to 3 weight % of crude fat, 25 to 30 weight % nitrogen free extract, finally at least 30 mg/kg of beta-carotene and 40 to 60 mg/kg of xanthophyll.

The plant pigment concentrates may contain xanthophyll and carotenoids and chlorophyll, and further lipids, separately or mixed with one another. The selected separating of the two types of carotenoid pigments is also possible according to the present invention.

The process of the invention enables one to transform the leaf protein curd isolated from press juices into a stable, non-specific protein concentrate, which contains secondary metabolite products only in a non-toxic quantity. As a result of the treatment with glycolether the majority of lipid-soluble and water-soluble accompanying substances can be removed and at the same time the decomposition and enrichment of the chlorophylls and the derivatives thereof can be avoided. The importance of the glycolether treatment is that, this solvent exerts a selective solubility action to the carotenoids and xanthophyll depending on the water content of the protein curd and this recognition can be utilized to process and isolate each pigment substance separately. The protein concentrate does not contain the characteristic ingredients and properties of the plant processed and the necessity of separating the chloroplastic and cytoplasmic protein fractions or the necessity of increasing the ratio of the cytoplasmic fraction can be eliminated. Thus both protein fractions and their analogous amino acid composition can be utilized free from the accompanying substances. The possibility of the selective processing of the pigment substances represents an additional advantage, which could not be foreseen.

Examples of the process according to the invention are illustrated with reference to the attached Figures.

According to Fig. 1 the press juice obtained from green plants is heated to

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80°C and a green protein curd is separated in decanter 2a, the effluent liquid from the decanter is conducted to the self-discharging separator 3 and the obtained dilute sludge is recirculated into decanter 2a, and the separated pressed juice can be subjected to an optional further processing.

The green protein curd separated in decanter 2a is extracted twice in extractor 4a with fresh or regenerated solvent. Between the extraction steps there is always a separation carried out in decanter 2b. After the second separation effected in decanter 2b the liquid obtained from the two extraction steps is treated with a non-polar solvent in pigment extractor 7a. The upper phase of the extraction is distilled in apparatus 8a and the residue of the distillation is dried in vacuum drier 9a. The lower phase of the extraction liquid is regenerated and the solvent recirculated to 4a. The isolated pigment concentrate I contains mainly xanthophyll. The twice extracted protein curd in decanter 2b is extracted again twice in extractor 4b. The liquid phase obtained is subjected to a liquid-liquid extraction in extractor 7b with a non-polar solvent, thereafter in distillation apparatus 8b the non-polar solvent is regenerated and the obtained pigment concentrate II is vacuum-dried at 9b. The pigment concentrate II contains, in addition to liquids, mainly carotenes.

The four times treated protein curd is washed in apparatus 5 generally by means of suspending it in water, thereafter decanting it in decanter 2d. The product is dried in apparatus 6. The obtained non-specific protein concentrate III can be utilized due to its composition both for animal fodder and for human consumption.

In Fig. 2 similar processing as in Fig. 1 is illustrated with the difference that is treatment of the green protein curd is repeated four times, always after intermediate decanting in apparatus 2b. The obtained extract phase is distilled in apparatus 11 and in apparatus 12 the liquid phase is subjected to a liquid-liquid extraction with a non-polar solvent. The upper phase of the extraction is distilled in apparatus 13 and the united pigment concentrate IV is dried in vacuo in drier 9c. The separated protein curd from decanter 2b is conducted to the washing apparatus 5 where it is washed twice with water, the water suspension is separated twice in decanter 2d thereafter the protein curd is dried in drier 6; a non-specific protein concentrate III is thus obtained.

Fig. 3 illustrates the process of Fig. 2 with the difference that the product of distillation of the separated solvent fractions, obtained in the decanters, in apparatus 11 is not subjected to a liquid-

liquid extraction: instead, the residue of the distillation is either dried in a separate step or it is mixed with the press cake obtained on processing the fibrous plant substance. In such cases the press cake contains not only the ingredients present in the protein concentrate and dissolved by means of the non-polar solvent but all accompanying substances removable with glycol ether, that is the triterpenes, steroidal saponin and phenolic compounds.

As a result of the processing method illustrated in Figs. 1 and 2, the obtained pigment concentrates, II, and IV can be dried. In necessary cases a hydrolysis with an alkali can be carried out before the drying step. The pigment concentrate can be isolated according to the invention in a fractionated form, that is pigment concentrate I contains mainly xanthophyll and lipids, pigment concentrate II contains mainly carotenes. The two kinds of pigment concentrate can be united in pigment concentrate IV. The significance of the fractionated pigment isolation is that the pigment concentrate can be selectively used as an additive in itself, depending on the kind of animal to be fed. Such a method was not possible according to the known methods.

Example 1

1000 kg. of alfalfa (*Medicago sativa*) in green bud state with 18 weight % dry matter content and containing 4.9 weight % of crude protein are processed. After disintegration the obtained ground products are pressed twice, first under a pressure amounting to 10 to 15 atm., thereafter under high pressure of about 50 to 100 atm. The united press juice, weight 800 kg. with 10 weight % of dry matter content and 38 weight % of crude protein, is pumped to a heat treating unit. Before heat treating 300 ppm. of a surface active substance (Kontramin 210) is added to the pressed juice. The heat treatment takes place at 80°C by means of direct heat treatment. The thus heated juice is conducted continuously to the separation. The time of heat treatment is about 5 minutes. The separation is carried out in two apparatuses coupled in series, the first one being a decanter type self-triggering separator in which the major part of the protein precipitate (curd) coagulated under heat treatment is removed. The functioning of this decanter is adjusted to separate a green protein curd with a dry matter content of about 28 to 33 weight %. The clarified though not entirely clear juice leaving the first decanter is conducted to the second separator unit, which is a disc separator, wherein the post-clarifying of the juice takes place. The dilute sludge

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separated in the second decanter, having a dry matter content of about 10 to 15% by weight is recirculated to the first decanter, to the storage tank thereof. In the separator unit consisting of two separators therefore only two products are isolated, in the first decanter the green protein curd and the clarified juice in the second separator, which juice is concentrated in vacuo. The green protein curd amounting to 184 kg. is treated with 300 kg. of ethyleneglycol monoethylether and is stirred for 1 hour.

The suspension is separated from the treating fluid in a decanter and the previous operation is repeated, with an identical amount of treating fluid. The first two extraction fluids are left separately standing until further processing. The treated sludge is treated, twice using 200 kg. of ethyleneglycol in each operation and the treating time being 1 hour. The treated residue is suspended twice by using always 200 litres of water, the solid matter is separated and washed until it becomes free from solvent. The juice obtained from the washing with water is united with the solvent used in the second two treatment steps and it is stored until further processing. The protein curd freed from solvent is dried. The drying is carried out in a pneumatic drier apparatus with an entry temperature of 220°C and 105°C exit temperature.

The extract juice obtained from the treatment of the protein curd in the first two steps, which contains water as well as the water from the decanter sludge, is extracted with a benzene (petroleum ether) having a boiling point in the range of 80 to 100°C. The employed benzene quantity is about 20 times more than the amount of ethylene glycol water mixture. The benzene leaving the liquid-liquid extraction is continuously regenerated and recirculated into the extraction. The distillation residue containing a slight solvent excess is removed from the distillation apparatus and the solvent content thereof is eliminated in a vacuum drier apparatus at 50°C and it is dried. The product isolated is green owing to its chlorophyll content and it is enriched in xanthophyll. The product may be used *per se* or after purification as a fodder additive. If the protein fraction is dried directly a product containing 2000 to 2500 mg/kg of betacarotene and xanthophyll is obtained, in which the ratio of the two main pigments is about 30 to 40 percent of beta-carotene and 60 to 70% of xanthophyll whereas the isolated product according to the invention contains 30,000—40,000 mg./kg. of xanthophyll and only 5,000 to 10,000 mg./kg. of beta-carotene. The green protein curd is treated with ethyleneglycol-monoethyl-ether in a third and fourth step, as well, and

the extract liquids are extracted similarly as in the foregoing with benzene, thus isolating a product containing mainly beta-carotene and only slighter amounts of xanthophyll. The latter product contains 15,000 to 20,000 mg./kg. of beta-carotene and 4,000 to 5,000 mg./kg. of xanthophyll.

According to the example the following products are prepared out of the starting material:

1. Non-specific protein fraction: 47.5 kg.

Composition:

water	6.0%	
crude protein (N×6.25)	70.0%	80
lipids	0.5%	
crude fibre	1.5%	
mineral substances	4.0%	
nitrogen-free extract	18.0%	85

The decomposition products of chlorophyll cannot be traced in the product. Saponin content calculated on basis of the haemolytic index is less than 10 ppm.

2. Xanthophyll concentrate: 1.5 kg.

Composition:

water	3.0%	
xanthophyll	3.1%	
beta-carotene	0.5%	
lipids	ad 100%	95

This product is green due to its chlorophyll content and contains 1000 mg./kg. of Santoquin* antioxidant.

3. Carotene concentrate: 2.5 kg.

Composition:

water	3.0%	
beta-carotene	0.8%	
xanthophyll	0.4%	
lipids	ad 100%	100

The product has a green colour and contains 1000 mg./kg. of Santoquin* antioxidant.

Example 2

According to the method of Example 1, 1000 kg. of alfalfa are processed. The treatment with ethyleneglycol monoethyl-ether is carried out identically as in Example 1. The extracted juices, however, are not isolated but are processed together with the washing liquids obtained in the solvent washing of the product. To the obtained 1400 kg. of aqueous ethyleneglycol monoethylether solution 10 g. of Santoquin* emulsion is added and the solvent and water are distilled in vacuo to obtain 100 kg. of

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residue. The ratio of ethylene-glycol monoethylether to water is adjusted in the distillation residue to 70:30 and the extraction with benzine is carried out in accordance with Example 1. The benzine is thereafter distilled off and the residue is processed as described in Example 1. In this way the valuable carotenoid pigments are isolated together with the directly dried protein concentrate. The advantage of this kind of processing is that the concentration of the beta-carotene and xanthophyll can be substantially increased. After the extraction with benzine the aqueous ethyleneglycol monoethylether fraction is distilled, the solvent is removed and the major part of the water as well. The distillation residue amounting to 20 to 25 kg. contains 7 kg. of dry matter, this residue is intermingled with the fibrous fraction obtained in the course of pressing the green plant and before drying thereof. This method enables one to reunite the lipids present in the plant material and precipitated together with the protein fraction after the isolation of the carotene to the fibrous fraction where it can be utilized in fodder for ruminants. The following products can be obtained as a result of the method described in this Example:

1. Non-specific protein concentrate.

The weight and composition is identical with that of Example 1.

2. Pigment concentrate: 4.5 kg.

Composition:	
water	3.0%
beta-carotene	0.6%
xanthophyll	1.2%
lipids as	100%

The product is green owing to the presence of chlorophyll and contains 1000 mg./kg. xanthophyll antioxidant.

3. Dried fodder flour or granulate: 145 kg.

Composition:	
water	12.0%
crude protein	12.0%
crude fibre	35.0%
mineral substances	12.0%
nitrogen free extract	27.0%
crude fat	2.0%
beta-carotene	30 mg./kg.
xanthophyll	50 mg./kg.

Example 3

1000 kg. of Amaranthus sp. are processed before blossoming. The characteristic properties of this crude material are a dry matter content of 17.5 weight % and a crude protein content of 4.0%. Disintegration and

pressing of the green plant before the isolation of the protein fraction are carried out in accordance with Example 1. The green protein curd obtained in the separator unit is treated according to Example 2. The following products can be obtained:

1. Non-specific protein concentrate: 37.5 kg.

Composition identical with that of Example 1.

2. Pigment concentrate: 4.0 kg.

Composition:	
water	3.0%
beta-carotene	0.5%
xanthophyll	1.3%
lipids ad	100%

The product has a green colour owing to the presence of chlorophyll and contains 1000 mg./kg. of xanthophyll antioxidant.

WHAT WE CLAIM IS:—

1. A process for preparing a protein concentrate from green plant material, wherein juices expressed from the material, leaving a green plant material residue, are heated and protein coagulated by the heating is collected; the collected protein, containing more water than its dry weight, is treated with a solvent comprising a glycolether or diglycolether, in an amount in excess of its dry weight; and the treated protein is washed with water and recovered.

2. A process for preparing a protein concentrate and other fodder additives having a biological activity, which process comprises pressing green plant material to form a residue of green plant material as a press cake and expressed juices, further processing the press cake to express juices, coagulating the protein fraction of the plant juices, treating the coagulated protein fraction having at least 1.5 times more water than its dry weight with at least 1.5 times more solvent than its dry weight, the solvent comprising a glycolether or diglycolether, and optionally methanol, washing the treated protein with water, drying the washed protein, separating the materials dissolved from the solvent phase and mixing them with the press cake, regenerating the solvent and recirculating it for further treatment of collected protein.

3. A process as claimed in claim 1 or claim 2 which comprises coagulating the protein fraction from plant juices at a temperature of 80° to 85°C, which fraction contains both chloroplastic and cytoplasmic protein fractions.

4. A process as claimed in claim 1 or claim 2 which comprises coagulating the protein fraction at a temperature of 55° to



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residue. The ratio of ethylene-glycol monoethylether to water is adjusted in the distillation residue to 70:30 and the extraction with benzine is carried out in accordance with Example 1. The benzine is thereafter distilled off and the residue is processed as described in Example 1. In this way the valuable carotenoid pigments are isolated together with the directly dried protein concentrate. The advantage of this kind of processing is that the concentration of the beta-carotene and xanthophyll can be substantially increased. After the extraction with benzine the aqueous ethyleneglycol monoethylether fraction is distilled, the solvent is removed and the major part of the water as well. The distillation residue amounting to 20 to 25 kg. contains 7 kg. of dry matter, this residue is intermingled with the fibrous fraction obtained in the course of pressing the green plant and before drying thereof. This method enables one to reunite the lipids present in the plant material and precipitated together with the protein fraction after the isolation of the carotene to the fibrous fraction where it can be utilized in fodder for ruminants. The following products can be obtained as a result of the method described in this Example:

1. Non-specific protein concentrate.

The weight and composition is identical with that of Example 1.

2. Pigment concentrate: 4.5 kg.

Composition:	
water	3.0%
beta-carotene	0.6%
xanthophyll	1.2%
lipids as	100%

The product is green owing to the presence of chlorophyll and contains 1000 mg./kg. xanthophyll antioxidant.

3. Dried fodder flour or granulate: 145 kg.

Composition:	
water	12.0%
crude protein	12.0%
crude fibre	35.0%
mineral substances	12.0%
nitrogen free	
extract	27.0%
crude fat	2.0%
beta-carotene	30 mg./kg.
xanthophyll	50 mg./kg.

Example 3

1000 kg. of Amaranthus sp. are processed before blossoming. The characteristic properties of this crude material are a dry matter content of 17.5 weight % and a crude protein content of 4.0%. Disintegration and

pressing of the green plant before the isolation of the protein fraction are carried out in accordance with Example 1. The green protein curd obtained in the separator unit is treated according to Example 2. The following products can be obtained:

1. Non-specific protein concentrate: 37.5 kg.

Composition identical with that of Example 1.

2. Pigment concentrate: 4.0 kg.

Composition:	
water	3.0%
beta-carotene	0.5%
xanthophyll	1.3%
lipids ad	100%

The product has a green colour owing to the presence of chlorophyll and contains 1000 mg./kg. of xanthophyll antioxidant.

WHAT WE CLAIM IS:—

1. A process for preparing a protein concentrate from green plant material, wherein juices expressed from the material, leaving a green plant material residue, are heated and protein coagulated by the heating is collected; the collected protein, containing more water than its dry weight, is treated with a solvent comprising a glycolether or diglycolether, in an amount in excess of its dry weight; and the treated protein is washed with water and recovered.

2. A process for preparing a protein concentrate and other fodder additives having a biological activity, which process comprises pressing green plant material to form a residue of green plant material as a press cake and expressed juices, further processing the press cake to express juices, coagulating the protein fraction of the plant juices, treating the coagulated protein fraction having at least 1.5 times more water than its dry weight with at least 1.5 times more solvent than its dry weight, the solvent comprising a glycolether or diglycolether, and optionally methanol, washing the treated protein with water, drying the washed protein, separating the materials dissolved from the solvent phase and mixing them with the press cake, regenerating the solvent and recirculating it for further treatment of collected protein.

3. A process as claimed in claim 1 or claim 2 which comprises coagulating the protein fraction from plant juices at a temperature of 80° to 85°C, which fraction contains both chloroplastic and cytoplasmic protein fractions.

4. A process as claimed in claim 1 or claim 2 which comprises coagulating the protein fraction at a temperature of 55° to

60°C, which fraction contains the chloroplastic protein fraction.

5. A process as claimed in any one of claims 1 to 4 which comprises using a surface active substance or a mixture thereof having a HLB value in the range of 8 to 18 for the coagulation of the protein fraction and adding the surface active substance in a quantity of 2400 to 6000 ppm. calculated on the dry matter weight of the plant juice.

6. A process as claimed in any one of claims 1 to 5 which comprises using as glycol-ether or diglycol-ether, ethyleneglycol monomethylether, ethyleneglycol-monoethylether, ethyleneglycol-mono-propylether, diethyleneglycol-monomethylether or diethyleneglycol-monoethylether.

7. A process as claimed in any one of claims 1 to 6 wherein the collected protein is treated with a mixture of glycol-ether and methanol in which the weight ratio of the glycol-ether to methanol is adjusted in a range from 3:1 to 2:1.

8. A process as claimed in any one of claims 1, 2, 6 or 7 which comprises treating the protein fraction stepwise with glycol-ether.

9. A process as claimed in claim 8, which comprises carrying out the stepwise treatment in four steps, decanting the liquid phase between each treating step and isolating from the liquid phase obtained in the first two steps xanthophyll and isolating from the liquid phase of the second two steps β -carotene.

10. A process as claimed in any one of claims 1 to 7 which comprises treating the protein fraction continuously with glycol-ether or methanol containing glycol-ether.

11. A process as claimed in any one of claims 1, 2 or 6 to 10 which comprises subjecting the liquid phase obtained in the course of the treatment to a liquid-liquid extraction with a second solvent.

12. A process as claimed in claim 11 wherein the solvent is a non-polar one and is immiscible with the liquid phase.

13. A process as claimed in claim 12 which comprises using as a non-polar solvent, a benzene having a boiling point range of 80° to 100°C.

14. A process as claimed in any one of claims 11 to 13 which comprises processing the obtained pigment substances from the second solvent phase after the removal of the solvent into a pigment concentrate.

15. A process as claimed in any one of the preceding claims which comprises removing the glycol-ether or diglycol-ether solvent by distillation and mixing the residue of the distillation with the residue of the green plant material.

16. A non-specific protein concentrate prepared from coagulated chloroplast or coagulated chloroplastic and cytoplasmic protein fractions by a process as claimed in any one of the preceding claims comprising 65 to 75 weight % of crude protein, up to 4 weight % of mineral substances, up to 1.5 weight % of crude fibre, 14 to 22 weight % of nitrogen free extract, 0.8 to 1.0 weight % of lipids and up to 6 weight % of water said concentrate being substantially free from pigments and from decomposition products thereof.

17. Xanthophyll concentrate prepared via working up of a chloroplastic protein fraction by a process as claimed in any one of claims 1 to 15 comprising up to 3.1 weight % of xanthophyll, up to 0.5 weight % of β -carotene, about 3 weight % of water and the rest lipids.

18. β -carotene concentrate prepared from chloroplastic protein fraction by a process as claimed in any one of claims 1 to 15 comprising at least 0.8 weight % of β -carotene, up to 0.5 weight % of xanthophyll, about 3 weight % of water and the rest lipids.

19. A dried fodder-flour or granulate product consisting mainly of press cake of green plants and extracted lipids comprising about 35 weight % of crude fibre, 10 to 15 weight % of crude protein, 10 to 14 weight % of mineral substances, 2 to 3 weight % of crude fat, 25 to 30 weight % of nitrogen free extract, at least 30 mg./kg. of β -carotene and 40 to 60 mg./kg. of xanthophyll.

20. A process for preparing plant protein concentrate, or fodder additive, substantially as herein described in relation to any one of the drawings or any one of the Examples.

21. Plant protein concentrate or fodder additive when the product of the process of any one of claims 1 to 15 and 20.

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