

PATENT SPECIFICATION

(11) 1 468 385

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- (21) Application No. 47565/74 (22) Filed 4 Nov. 1974
 (31) Convention Application No. 417 535
 (32) Filed 20 Nov. 1973 in
 (33) United States of America (US)
 (44) Complete Specification published 23 March 1977
 (51) INT CL² A23L 1/00
 (52) Index at acceptance A2B 1J1 1JY 1X
 (72) Inventors ARTHUR JOSEPH MOSHER and DONALD
 EUGENE YINGST



(54) PRODUCT AND PROCESS FOR PRODUCING FOOD EXTRUDATE

(71) We, NESTLE S.A., of La Tour-de-Peilz, Switzerland, a Swiss company, 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 present invention is concerned with the preparation of a porous expanded food product having a meat-like taste.

It is an object of this invention to provide edible compositions having a meat-like flavour and aroma and to do so by simple and efficient process means.

More particularly, the present invention comprises a process whereby certain desirable flavour components for porous, expanded food products, viz. reducing sugars and sulphur-containing substances, may be extruded as part of a feed comprising finely divided food material and water without detrimental effect to the extrusion process or the resultant product.

It has heretofore been proposed to employ various flavourings in porous expanded food products produced through the extrusion of finely divided food materials and water under elevated conditions of temperature and pressure. This incorporation of flavorings has most frequently been effected through impregnation of the expanded porous products with aqueous solutions of the flavorings. However, impregnation generally needs to be followed by drying of the flavour product in order to restore the crisp character of the product on to reduce its moisture content so that the product may be stored for relatively long periods of time without appreciable change in its structure and taste.

The expression "finely divided food material" identified herein as compound (A) is intended to encompass a material in the form of particles such as a plant flow of semolina rich in carbohydrates, for example, maize, starch or rice flour or semolina, or a material rich in protein, for example, soya bean flour or

a product containing protein of animal or microbial origin.

More preferably, the present class of food material comprises protein-containing materials such as soy flour or peanut flour. Any such food material, most preferably containing at least 30% by dry weight of protein, however, is encompassed by this terminology. Additionally, such protein-containing materials desirably have a low fat content, for example not exceeding 2.5%, or most desirably less than 0.5%, by dry weight of the food material.

The reducing sugar, identified herein as compound (B), may be any sugar within the normal meaning of the term, including mono and polysaccharides but is most desirably a pentose or hexose. Suitable examples comprise ribose, xylose, arabinose, lactose, and glucose. Any reducing sugar which is susceptible to undergoing the well-known Maillard reaction may be employed within the scope of the present invention. Additionally, mixtures of these sugars are also useful.

The compositions falling within the meaning of the term, "sulphur-containing substance," identified herein as compound (C), are myriad. These compositions may be further characterized, however, by the necessity that such sulphur be in, or be readily transformed under the present extrusion condition into, a reactive sulphur radical. Exemplary of such radicals are the sulphide and sulphhydryl groups. Preferably, the substances are amino acids or are employed in conjunction with amino acids.

All sulphur-containing amino acids or corresponding salts, for example, are useful within the scope of the present invention. Cysteine, however, is the preferred sulphur-containing amino acid, although cystine has also proved particularly useful.

As an alternative, an amino acid not containing sulphur, such as alanine, may be used together with a substance containing reactive sulphur radical, for example, hydrogen sulphide or sodium sulphide. These components

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appear to react prior to, or during, the present extrusion process so as to provide a product consonant in activity to the above indicated sulphur-containing amino acids. It is not intended, however, that the scope of the present invention be limited by the suggested reaction between an amino acid and a sulphur-containing substance. It may well be that these two components merely act in congress to provide essentially the same effect as the preferred sulphur-containing amino acids. Accordingly the recitation of a "sulphur-containing substance" is not intended to be limited by the proposed theory that a reaction actually takes place. Rather, such a term is intended to encompass both possible reaction products thereof as well as admixtures which provide the function discussed herein below.

Finally, sulphur-containing substances which are not amino acids or used in conjunction with amino acids are useful. Thus, for example, mercaptosuccinic acid or sodium hydrosulphide have proved efficacious within the scope of the present invention.

The final component necessary for the extrusion feed is water. Ordinarily, the amount of water contained in the extrusion feed should be between 18 and 45% by weight of the admixture, more preferably between 22 and 30%. The actual amount of water present in the admixture is generally selected within the foregoing parameters having regard to the water adsorption by the food material. The resultant mixture has a moistened to dough-like consistency without a liquid phase. The only critical aspect of water content, however, is the requirement that there be sufficient water so as, under the elevated conditions of temperature and pressure produced during extrusion, to develop a sufficient amount of steam for the production of an expanded porous structure in the extrudate product.

In the production of expanded porous food products, within the scope of the present invention, a dough comprising at least the components of the food material, the reducing sugar, and the sulphur-containing substance with water, is thoroughly mixed and then subjected to extrusion under conditions of elevated temperature and pressure.

The extrusion step may be performed with any of a number of commercially available forms of apparatus. Particularly useful such forms, for example, are extruders produced by Wenger and Troester. Most preferably, of course, such extruders should permit flexibility of conditions such as temperature, pressure, and feed rate so as to permit adaptation to processing variations such as the texture composition and/or consistency of the food materials intended to be expanded.

Suitable extruders should preferably be capable of processing the extrusion feed within a very short time, for example between 10 to 60 seconds. Such time is measured from

introduction of the feed to heightened temperature and pressure conditions to exit from the extrusion die, during which the critical factors which transform the dough into a coherent, porous expanded food product are experienced.

The foregoing conditions are generally known in the art. They should, however, at least include pressures of the order of from 5 to 100 atmospheres and a temperature between 80 and 200°C. More preferably, these conditions should range from 10 to 40 atmospheres and 100 to 150°C over an extruded time of the order of 10 to 30 seconds. These conditions are interdependent, however, and may be modified accordingly.

The product exiting from the extruder comprises an expanded porous food product, useful within its own right. Preferably, however, this product is subjected to additional drying, for example for a period of from 5 to 30 minutes at an air temperature of from 45 to 170°C so as to stabilize the food against deterioration.

When the abovementioned further drying of expanded porous food extrudates is performed, a moisture content of from 2 to 10% is normally achieved. Accordingly, utilization of the food product then usually requires rehydration in order to transform it from a crisp, brittle form to a texture more analogous to that of meat. Such rehydration may very easily be accomplished, simply through immersion of the porous dried food in an aqueous medium.

The essence of the present invention resides in the fact that, despite the foregoing discovery that it is highly desirable to incorporate a reducing sugar and a sulphur-containing substance into an extrusion feed for the production of expanded porous food products, such incorporation may detrimentally effect the physical form of the resultant food product.

More particularly, it has been discovered that most extrusions performed on feeds of moistened finely divided food material which additionally include either a reducing sugar and/or a sulphur-containing substance produce extrudates with little or no uniformly expanded composition.

Thus, whereas the extrusion of finely divided food materials and water has long been known to be an effective means for producing uniform, expanded porous products having desirable textures, where such simple feed has been modified to incorporate reducing sugars and/or sulphur-containing substances, the resulting extrudate has been found to exhibit widely variant and often undesirable density, flavour and rehydration characteristics so as to be relatively undesirable as a food product.

Not only do the present flavour additives (B) and (C) often adversely affect the present food products, but additionally the

reducing sugar and sulphur-containing substance detrimentally affect the extrusion step itself. Thus, incidental to the presence of these additives in the feed, the normally uniform, steady process of extrusion is subjected to severe and erratic interruptions. These interruptions can be characterized as a form of "surging" of the extrusion product and appear to be caused by intermittent pressure build-ups within the extruder itself. These pressure build-ups are spontaneously reduced with the result that extrusion product is blown from the extruder and thus material is subjected not only to uncontrolled pressure and temperature variation, but additionally to variation in residence time within the extruder.

The effect of "surging" on the extrudate itself is also pronounced. Apparently incident to the conditions to which it is exposed during such sporadic extrusion, the extrudate exhibits wide variation in physical and textural form. Thus, for example, the product issuing from a surging extrusion will display variation in colour from light to dark, as well as differences, of a factor of from 0.2 to 4 in the physical dimensions of the extrudate after issuing from the same die pores. Further, particles having each of the foregoing characteristics within the entire spectrum of possible forms are normally produced incident to surging. Consequently, it becomes impossible even to separate reasonable, if any, yields of the desired product from the resultant variant forms.

Finally, even where subsequent drying and rehydration steps are performed on extrudate compositions which have been produced during surging, their undesirable characteristics of texture, density, size, flavour and rehydratability are retained.

The essence of the present invention resides in the discovery that, despite the identification

of low threshold, extrusion inhibitory concentrations, i.e. the concentration of (B) and (C) at which swaging occurs, for each of the present flavoring (B) and (C), a means for providing concentrations of such ingredients sufficient to provide desired flavour enhancement has been found. Moreover, such means permits the practice of extruding compositions containing combinations of the present additives in concentrations which are far in excess of their individual threshold limits.

This discovery is based on an unexpected interaction which has been evidenced by the combination of reducing sugars and sulphur-containing substances, where such additives are present in concentrations having specific ratios. Once the existence of essential ratios for a number of specific combinations was discovered, it was realized that a general relationship existed between reducing sugars and sulphur-containing substances. Accordingly, operable ratios for additional combinations have been found. These additional determinations are, of course, hereby rendered within the ordinary skill in the art, as they merely require routine experimentation with varying percentage weights of the two desired constituents, until continuous extrusion, devoid of surging, is obtained.

Nor do these additional determinations need be entirely empirical. Various successful ratios for specific reducing sugars to specific sulphur-containing substances are set forth in the table below. While serving as appropriate examples, the entries in this table are additionally presented as further guidance in the formulation of additional such combinations within the scope of this invention; such additional combinations being to some extent theoretically determinable on the basis of the relative activities of reducing sugars and/or sulphur-containing substances sought to be employed.

TABLE I

Non-Surge Ratios

Based on total (B)-(C) Weights of 1 to 2% of (A)

Sugar/Sulphur substance	Ranges of ratios	
	Preferred	Operable
Xylose/Cysteine	0.8:1 to 4:1	0.5:1 to 7:1
Glucose/Cysteine	2:1 to 15:1	1:1 to 25:1
Lactose/Cysteine	6:1 to 20:1	4:1 to 30:1
Xylose/Mercaptosuccinic Acid	0.8:1 to 2.5:1	0.4:1 to 4:1
Xylose/NaSH	0.8:1 to 3:1	0.4:1 to 5:1
Xylose/Cystine	0.6:1 to 3:1	0.4:1 to 5:1

For example, a comparison of the preferred xylose/cysteine ratios with those for glucose/cysteine conform with the relative activities of these two reducing sugars. The respective "surge-free" ratios reflect such difference in activity inasmuch as xylose exhibits a lower surge-free ratio than does glucose. In a similar manner, it is possible, based on the relative activities of additional sugars to those set forth herein, and of additional sulphur-containing substances to those set forth herein, to employ a degree of predictability as to the desired ratios. Accordingly, those wishing to practice additional specific combinations within the scope of the present invention or wishing to practice the present invention utilizing combinations of reducing sugars and/or combinations of sulphur-containing substances may do so easily.

The foregoing discussion of essential ratios is not intended to suggest that unlimited amounts of other "surge-producing" additives may be successfully extruded. As may be observed from the examples which follow, these ratios appear merely to raise the aforementioned low threshold of extrusion-inhibition to tolerable concentrations. Thus, for example, concentrations of flavorings of up to 5% by weight of finely divided food material may be achieved, while 0.5% is the usual lower limit.

In many instances the desired total concentration of flavorant (B) and (C) will not reach the maximum extrudable amounts, although they would be higher than the threshold concentrations of individual additives. Thus, for example, total concentration of components (B) and (C) might desirably reside in the range of from 0.5 to 3% by weight of component (A). Where an inter-

mediate concentration is thus selected, some alteration from the recited ratios may prove necessary as the surge-free parameters for the present flavorings have exhibited a limited total concentration dependency.

This dependency, or drift, of the surge-free ratio parameters should not, however, produce undue difficulty in the practice of the present invention. The variations in total concentration of the present flavorants would not be expected to be great and thus the particular limits of "surge-free" ratios could readily be determined.

The invention is illustrated by the following Examples, in which the percentages are by weight.

EXAMPLE I.

91 kilograms of defatted soy flour (Baker's Nutrisoy [Registered Trade Mark] produced by Archer-Daniels-Midland) and 289 grams cysteine hydrochloride monohydrate were dry-blended in the feed bin of a Wenger [Registered Trade Mark] extruder (Model X25CF). The blend was then passed to an extruder load chamber of high speed mixing capacity, which chamber was provided with side ports through which water and/or aqueous flavoring solutions could be added to the blend.

The dry blend was fed into the load chamber at a rate of 2.63 kilograms/minute while the total amount of water and/or solution was added at a total constant rate of 650 cc/minute. By varying the rates of addition of pure water and of glucose solution into the load chamber, it was possible to observe the effect which different ratios of glucose to cysteine produced in the extrusion process and upon the extrudate product. The data thus derived by varying the glucose/cysteine ratio are reported in the table below.

TABLE II

Glucose (Wt. % of Total Solids)	Ratio (Glucose/ cysteine)	Extrusion Process	Product Characteristics
0%	0	Surging	Puffing, stringy, light tan
0.64%	2.9:1	Uniform	Minor puffing, tan
1.28%	5.8:1	Uniform	Controlled expansion, brown
1.92%	8.7:1	Uniform	Controlled expansion, brown
2.55%	11.6:1	Mild surging	Partial fibre, dark brown
3.19%	14.5:1	Surging	No fibre, dark brown

EXAMPLE II (Comparative).

The process of Example I was repeated with the exception that the cysteine hydro-

chloride was deleted from the dry blend fed to the load chamber and only water was injected into the load chamber. Accordingly, the

composition extruded consisted solely of appropriate amounts of soy flour and water. The extrusion ran smoothly, without any surging, and the resultant extrudate was well defined and textured while exhibiting a light brown colour. Accordingly, this example shows that in the absence of reducing sugar and sulphur-containing substance, proper extrusion is obtained.

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EXAMPLE III (Comparison).

The process of Example II was repeated with the addition of a number of secondary additives to the dry blend. These additives were blended on the following basis:

15	NaCl	954 grams
	CaCl ₂ dihydrate	1,262 grams
	Lactic acid (88%)	1,020 grams
	Ribotide	290 grams
	Monosodium glutamate	480 grams
20	Beta-alanine	118 grams
	Histidine hydrochloride monohydrate	278 grams

The extrusion of the foregoing composition

was performed smoothly without surging. The resultant extrudate exhibited well defined and textured composition and was only a slightly darker brown than the extrudate of Example II.

Accordingly, this example evidences the minimal effect which secondary additives, i.e., additives which are not reducing sugars or sulphur-containing substances, have on the extrusion of moistened finely divided food material.

EXAMPLE IV.

630 grams of glucose were dry blended with 91 kilograms of defatted soy flour, and cysteine hydrochloride was injected as an aqueous solution into the feed chamber of the Wenger extruder of Example I. The blend and aqueous solutions were mixed at rates of 2.0 kilograms/minute and 600 cc/minute, respectively, in the feed chamber. By varying the relative feed of pure water and cysteine-containing water into the chamber, again at a total constant rate of about 600 cc/minute, the following data was compiled respecting the effect of varying ratios of glucose/cysteine on the present extrusion.

TABLE III

Cysteine (Wt. % of Total Solids)	Ratio (Glucose/ cysteine)	Extrusion Process	Product characteristics
0	—	Surging	No fibre, burned
0.039	21.5:1	Mild surging	Partial fibre, brown
0.056	15 :1	Mild surging	Partial fibre, light brown
0.113	7.4:1	Uniform	Controlled expansion, tan
0.225	3.7:1	Uniform	Mild puffing, tan
0.28	3.0:1	Surging	Puffing, light tan

EXAMPLE V.

This example is performed in accordance with the process described in Example III with the exception that an aqueous feed containing both xylose and cysteine in a ratio of 3.0:1 was administered to the feed chamber. Accordingly, the composition undergoing ex-

trusion was provided with varying total concentrations of xylose-cysteine in set ratio. Additionally contained are the various secondary additives recited in Example III in the proportions disclosed therein. Data obtained pursuant to extrusion are reflected in the table below:

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TABLE IV

Xylose (Wt. % of Total Solids)	Ratio (Xylose/ cysteine)	Extrusion Process	Product Characteristics
0.52	3:1	Uniform	Controlled expansion, tan
1.04	3:1	Uniform	Controlled expansion, tan
1.55	3:1	Uniform	Partial fibre, light brown
2.07	3:1	Surging	Partial fibre, brown
2.59	3:1	Extreme surging	No fibre, burned

EXAMPLE VI

5 A dry blend of 45.5 kilograms of defatted soy flour, 45.5 kilograms of defatted peanut flour (Gold Nut produced by Gold Kist) and 396 grams of cysteine hydrochloride monohydrate was fed at a rate of 2.36 kilo-

grams/minute into the feed chamber of the extruder of Example I. Streams of water and/or aqueous solution of xylose were injected into the chamber at a total rate of 650 cc/minute. Extrusion results were obtained as follows:

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TABLE V

Xylose (Wt. % of Total Solids)	Ratio (Xylose/ cysteine)	Extrusion Process	Product Characteristics
0	0	Surging	Puffing
0.24	0.8:1	Mild surging	Mild puffing
0.48	1.6:1	Uniform	Controlled expansion
0.84	2.8:1	Uniform	Controlled expansion
0.96	3.2:1	Uniform	Acceptable fibre
1.20	4.0:1	Mild surging	Partial fibre, burned

15 WHAT WE CLAIM IS:—

1. A process for preparing an expanded porous food product which comprises

20 (A) Forming a mixture of finely divided food material with water and a reducing sugar and sulphur-containing substance in an amount sufficient to impart flavour to said food product, the sulphur being in or convertible under the extrusion conditions into a reactive sulphur radical, and

25 (B) Extruding said mixture under conditions of elevated temperature and pressure, wherein said reducing sugar and said sulphur-containing substance are present in an amount and ratio which stabilizes the extrusion flow rate.

30 2. A process according to claim 1, in which the sulphur-containing substance is a sulphur-containing amino acid or a mixture of an amino acid and a substance containing sulphur.

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3. A process according to claim 1 or 2, in which the sulphur-containing substance comprises a substance which contains, or will yield under extrusion conditions, a compound having a sulphide or sulfhydryl radical.

40 4. A process according to any one of the preceding claims, in which the total weight of reducing sugar and sulphur-containing substance is from 0.5 to 5% by weight of finely divided food material.

45 5. A process according to any one of the preceding claims, in which at least one of the reducing sugar and sulphur-containing substance is present in the mixture in a concentration higher than the threshold extrusion-inhibition concentration, as herein defined, for said individual member.

50 6. A process according to any one of the preceding claims, in which the reducing sugar is ribose, xylose, arabinose, lactose or glucose.

55 7. A process according to any one of the



TABLE IV

Xylose (Wt. % of Total Solids)	Ratio (Xylose/ cysteine)	Extrusion Process	Product Characteristics
0.52	3:1	Uniform	Controlled expansion, tan
1.04	3:1	Uniform	Controlled expansion, tan
1.55	3:1	Uniform	Partial fibre, light brown
2.07	3:1	Surging	Partial fibre, brown
2.59	3:1	Extreme surging	No fibre, burned

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5 A dry blend of 45.5 kilograms of defatted soy flour, 45.5 kilograms of defatted peanut flour (Gold Nut produced by Gold Kist) and 396 grams of cysteine hydrochloride monohydrate was fed at a rate of 2.36 kilo-

grams/minute into the feed chamber of the extruder of Example I. Streams of water and/or aqueous solution of xylose were injected into the chamber at a total rate of 650 cc/minute. Extrusion results were obtained as follows:

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TABLE V

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0.24	0.8:1	Mild surging	Mild puffing
0.48	1.6:1	Uniform	Controlled expansion
0.84	2.8:1	Uniform	Controlled expansion
0.96	3.2:1	Uniform	Acceptable fibre
1.20	4.0:1	Mild surging	Partial fibre, burned

15 WHAT WE CLAIM IS:—

1. A process for preparing an expanded porous food product which comprises

20 (A) Forming a mixture of finely divided food material with water and a reducing sugar and sulphur-containing substance in an amount sufficient to impart flavour to said food product, the sulphur being in or convertible under the extrusion conditions into a reactive sulphur radical, and

25 (B) Extruding said mixture under conditions of elevated temperature and pressure, wherein said reducing sugar and said sulphur-containing substance are present in an amount and ratio which stabilizes the extrusion flow rate.

30 2. A process according to claim 1, in which the sulphur-containing substance is a sulphur-containing amino acid or a mixture of an amino acid and a substance containing sulphur.

3. A process according to claim 1 or 2, in which the sulphur-containing substance comprises a substance which contains, or will yield under extrusion conditions, a compound having a sulphide or sulfhydryl radical.

4. A process according to any one of the preceding claims, in which the total weight of reducing sugar and sulphur-containing substance is from 0.5 to 5% by weight of finely divided food material.

5. A process according to any one of the preceding claims, in which at least one of the reducing sugar and sulphur-containing substance is present in the mixture in a concentration higher than the threshold extrusion-inhibition concentration, as herein defined, for said individual member.

6. A process according to any one of the preceding claims, in which the reducing sugar is ribose, xylose, arabinose, lactose or glucose.

7. A process according to any one of the

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- preceding claims, in which the finely divided food material comprises at least 30% protein by dry weight.
- 5 8. A process according to claim 7, in which the food material comprises soya flour.
9. A process according to claim 8 in which the soya flour has a fat content below 3% by weight.
- 10 10. A process according to any one of the preceding claims, in which the extruded mixture is dried to a moisture content of from 2 to 10% by total weight.
11. A process for preparing an expanded

food product by extrusion under a stabilized flow rate, substantially as herein described with reference to any one of Examples I, IV, V and VI. 15

12. An extruded product when produced by a process according to any preceding claim. (19)

ELKINGTON & FIFE,
Chartered Agents,
High Holborn House, 52/54 High Holborn,
London, WC1V 6SH.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1977.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.