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(54) Title: A FEED INGREDIENT COMPRISING BUTYRATE AND A SELECTED FERMENTATION PRODUCT

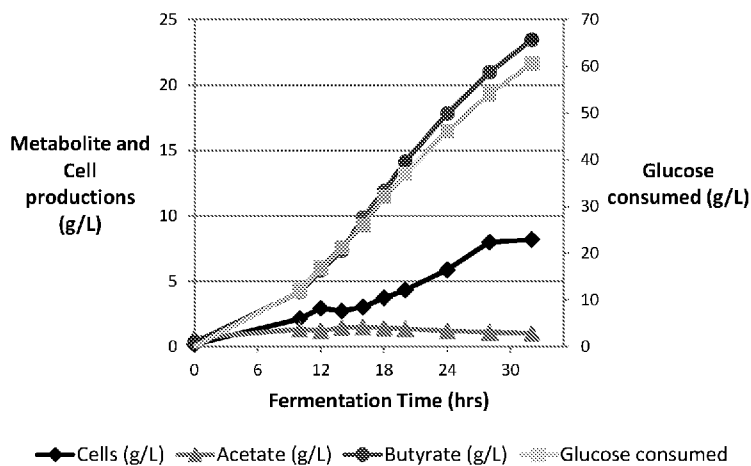


FIG.1

(57) Abstract: Provided is a composition comprising a) butyrate and b) a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid. Further provided are a feed ingredient, an animal feed and an anti-icing product comprising the composition, methods of manufacturing and uses thereof.



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A FEED INGREDIENT COMPRISING BUTYRATE AND A SELECTED FERMENTATION PRODUCT

Field of the invention

[001] The present invention relates to animal feeds, and more specifically to a feed ingredient comprising a) butyrate and b) a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid, and methods of use thereof.

Background

[002] There is an ongoing need for improved feed ingredients that better achieve improvements, such as increased feed intake, improved feed conversion rate, faster daily weight gain, greater ileum surface area and consistent results between sexes when fed to an animal.

Summary of the invention

[003] According to an aspect of some embodiments of the present invention, provided is a composition comprising butyrate and a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid.

[004] According to a further aspect of some embodiments of the present invention, provided is a feed ingredient comprising the composition as disclosed herein.

[005] According to a further aspect of some embodiments of the present invention, provided is an animal feed comprising selected nutrients, the feed ingredient as disclosed herein and optionally biomass.

[006] According to a further aspect of some embodiments of the present invention, provided is an anti-icing product comprising the composition as disclosed herein.

[007] According to a further aspect of some embodiments of the present invention, provided is a method for manufacturing the composition as disclosed herein, the method comprising:

- (i) providing said carbon-source-comprising feedstock; and
- (ii) fermenting said feedstock with said Clostridia class bacteria, whereby a fermentation broth comprising a biomass, butyrate and the by-product is formed.

[008] According to a further aspect of some embodiments of the present invention, provided is a feed ingredient comprising the composition as disclosed herein.

[009] According to a further aspect of some embodiments of the present invention, provided is a method for treating an animal comprising feeding said animal with the feed disclosed herein.

[0010] According to a further aspect of some embodiments of the present invention, provided is method for manufacturing a feed ingredient, comprising (i) providing a carbon-source-comprising feedstock; (ii) fermenting said feedstock with a Clostridia class bacterium which natively produces butyric acid, whereby a fermentation broth comprising biomass is formed.

Brief description of the figures

[0011] Some embodiments of the invention are described herein with reference to the accompanying figures. The description, together with the figures, makes apparent to a person having ordinary skill in the art how some embodiments of the invention may be practiced. The figures are for the purpose of illustrative discussion and no attempt is made to show structural details of an embodiment in more detail than is necessary for a fundamental understanding of the invention. For the sake of clarity, some objects depicted in the figures are not to scale.

[0012] In the Figures:

[0013] Fig. 1 is a line graph showing metabolite and cell production and glucose consumed as a function of fermentation time for *Clostridium tyrobutyricum* batch fermentation with glucose as the feedstock

Detailed description of the invention

[0014] The present invention relates to a composition comprising a) butyrate and b) a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid, and methods of use thereof.

[0015] The particulars shown herein are by way of example and for purposes of illustrative discussion of the various embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show details of the invention in

more detail than is necessary for a fundamental understanding of the invention, the description making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[0016] The present invention will now be described by reference to more detailed embodiments. This invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0017] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The terminology used in the description of the invention herein is for describing particular embodiments only and is not intended to be limiting of the invention.

[0018] As used herein, the term “feed ingredient” refers to a component, part, constituent or any combination/mixture to an animal food.

[0019] As used herein, the term “feedstock” refers to a component or components added to a fermentation

[0020] As used herein, the term “animal feed” refers to a product intended for consumption by a non-human animal, such as livestock, poultry, companion animal, or the like.

[0021] As used herein, the term “anti-icing material” refers to a material which can remove ice from a surface and/or prevent or reduce formation of ice on a surface.

[0022] As used herein, the term “protected” with regard to butyrate refers to a butyrate molecule that is provided in a bound or reversibly reacted form in order to enable the molecule to pass through the upper gastrointestinal tract.

[0023] As used herein, the term “treating” includes ameliorating, mitigating, and reducing the instances of a disease or condition, or the symptoms of a disease or condition.

[0024] As used herein, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0025] Unless otherwise indicated, all numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following

specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should be construed in light of the number of significant digits and ordinary rounding approaches.

[0026] Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. Every numerical range given throughout this specification will include every narrower numerical range that falls within such broader numerical range, as if such narrower numerical ranges were all expressly written herein. Additional advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed. As used herein, when a numerical value is preceded by the term "about", the term "about" is intended to indicate +/-10% of that value.

[0027] As used herein, the terms "comprising", "including", "having" and grammatical variants thereof are to be taken as specifying the stated features, integers, steps or components but do not preclude the addition of one or more additional features, integers, steps, components or groups thereof. These terms encompass the terms "consisting of" and "consisting essentially of".

[0028] According to an embodiment, provided is a composition comprising butyrate and a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid.

[0029] According to an embodiment, the composition further comprises acetate.

[0030] According to an embodiment, said organism said organism is selected from the group consisting of *Butyribacterium methylotrophicum*, *Clostridium tyrobutyricum* and combinations thereof.

[0031] According to an embodiment, the composition further comprises butyrate. According to an embodiment, said butyrate is protected for the transport through the stomach for higher yield of delivery to the intestine. According to an embodiment,

said butyrate is bound to a glyceride. According to an embodiment, said butyrate is encapsulated or coated. According to an embodiment, said butyrate is protected by being encapsulated by a protein and/or by being bound to a protein. According to an embodiment, said butyrate forms between 10% by weight and 90% by weight of the composition on a dry basis. According to an embodiment, said butyrate forms at least 15%, at least 20% or at least 30% of the composition. According to an embodiment, said butyrate forms less than 80% of the composition, less than 70% or less than 60%.

[0032] According to an embodiment, said by-product of fermentation forms between 0.01% by weight and 90% by weight of the composition on a dry basis. According to an embodiment, said by-product of fermentation forms at least 0.05%, at least 0.1%, at least 0.2%, at least 1%, at least 2% at least 5% of the composition. According to an embodiment, said by-product is water soluble. According to an embodiment the solubility of said by-product in water at 20 degrees Celsius is greater than 3% by weight, greater than 5%wt, greater than 7%wt or greater than 9%wt.

[0033] According to an embodiment, said by-product is selected from the group consisting of nitrogen compounds, nucleotides, vitamins, salts, complexes of transition metals, biomass and combinations thereof. According to an embodiment, said biomass comprises an organism selected from the bacteria class of Clostridia. According to an embodiment, said biomass comprises an organism selected from *Butyribacterium methylotrophicum*, *Clostridium tyrobutyricum* and combinations thereof.

[0034] According to an embodiment, the composition further comprises a butyrate counter ion selected from the group consisting of ammonium, potassium, calcium, magnesium and combinations thereof.

[0035] According to an embodiment, said carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.

[0036] According to an embodiment, said composition comprises less than 20% water, less than 15%, less than 10% or less than 5%.

[0037] According to an aspect of some embodiments of the present invention, there is provided a feed ingredient comprising the composition as disclosed herein.

[0038] According to an aspect of some embodiments of the present invention, there is provided an animal feed comprising selected nutrients and the feed ingredient as disclosed herein. According to some such embodiments, the animal feed further comprises biomass.

[0039] According to an aspect of some embodiments of the present invention, there is provided an anti-icing product comprising the composition as disclosed herein.

[0040] According to some embodiments, the anti-icing product further comprises a butyrate counter ion selected from the group consisting of calcium, magnesium, potassium and combinations thereof.

[0041] According to some embodiments, the anti-icing product further comprises sodium chloride.

[0042] According to an aspect of some embodiments of the present invention, provided is a method for manufacturing the composition as disclosed herein, the method comprising (i) providing the carbon-source-comprising feedstock; (ii) fermenting said feedstock with said Clostridia bacteria, whereby a fermentation broth comprising a biomass, butyrate and a by-product is formed.

[0043] According to an embodiment, the method further comprises separating said biomass from said fermentation product to form a clarified fermentation broth, wherein said clarified fermentation broth comprises butyrate and said by-product. According to an embodiment, said separating comprises at least one of filtering and centrifuging.

[0044] According to an embodiment, the carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.

[0045] According to an embodiment, said fermenting comprises pH control by adding to said fermentation broth a base selected from the group consisting of ammonia, urea, a calcium base, a potassium base, a magnesium base and combinations thereof.

[0046] According to an embodiment, said fermenting comprises pH control by adding ammonia to said fermentation broth and wherein said clarified fermentation broth comprises ammonium butyrate, the method further comprising:

adding to said clarified fermentation broth at least one selected from the group consisting of a calcium base and a magnesium base, whereby ammonia vapors are formed, and

collecting said ammonia vapors.

[0047] According to an embodiment, said collected ammonia vapors are used for said pH control.

[0048] According to an embodiment, the method further comprises adding butyrate to said clarified fermentation broth.

[0049] According to an embodiment, the method further comprises protecting at least a fraction of the butyrate in said clarified fermentation broth or in products thereof.

[0050] According to an embodiment, the method further comprises at least partially removing water from said fermentation broth and/or from said clarified fermentation broth.

[0051] According to an aspect of some embodiments of the present invention, there is provided a method for treating an animal comprising feeding said animal with the feed as disclosed herein.

[0052] According to an aspect of some embodiments of the present invention, there is provided the feed as disclosed herein for use in treating an animal.

[0053] According to an embodiment, said feed comprises butyrate at a concentration between 10 ppm and 20,000 ppm.

[0054] According to an embodiment, at least 50% by weight of the butyrate in said feed results from said feed ingredient.

[0055] According to an embodiment, said animal is selected from the group consisting of avian, porcine, bovine, equine, ovine, piscine, caprine, canine, feline and lagomorph groups of animals.

[0056] According to an embodiment, the method provides an improved result compared with feeding same selected nutrients without said feed ingredient.

[0057] According to an embodiment, said improved result comprises at least one of increased feed intake, improved feed conversion rate, faster daily weight gain, greater ileum surface area, and consistent results between sexes

[0058] According to an embodiment, provided is a method for manufacturing a feed ingredient, comprising (i) providing a carbon-source-comprising feedstock; (ii) fermenting said feedstock with a Clostridia class bacterium which natively produces butyric acid, whereby a fermentation broth comprising butyrate and biomass is formed.

[0059] According to an embodiment, the method further comprises separating said biomass from said clarified fermentation broth to form a clarified fermentation broth, wherein said clarified fermentation broth comprises butyrate. According to an embodiment, said separating comprises at least one of filtering and centrifugation.

[0060] According to an embodiment, said carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.

[0061] According to an embodiment, said fermenting is anaerobic. According to an embodiment, said fermenting is conducted at pH greater than 4.8, greater than 5, greater than 5.2, greater than 5.4 or greater than 5.6. According to an embodiment, said fermenting is conducted at a temperature in the range between 25 and 40 degrees Celsius. According to an embodiment, said fermenting is conducted for between 10 hours and 50 hours after inoculation. According to an embodiment, said fermenting is continuous. According to an embodiment, said fermenting is conducted in a fed-batch mode.

[0062] According to an embodiment, said fermenting comprises pH control by adding to said feedstock a base selected from the group consisting of ammonia, urea, a calcium base, a magnesium base and combinations thereof.

[0063] According to an embodiment, said fermenting comprises pH control by adding ammonia to said feedstock and wherein the clarified fermentation broth comprises ammonium butyrate, the method further comprising: adding to said clarified fermentation broth at least one selected from the group consisting of a calcium base and a magnesium base, whereby ammonia vapors are formed, and collecting said ammonia vapors. According to some such embodiments, said collected ammonia vapors are used for said pH control.

[0064] According to an embodiment, said method further comprises adding butyrate to said clarified fermentation broth. According to an embodiment, said method further comprises protecting at least a fraction of the butyrate in said clarified fermentation broth or in products thereof. According to an embodiment, said method further comprises at least partially removing water from said fermentation broth and/or from said clarified fermentation broth. According to an embodiment, said water removal comprises water evaporation.

[0065] According to an aspect of some embodiments of the present invention, there is provided a method for treating an animal comprising feeding said animal with the feed as disclosed herein.

[0066] According to an aspect of some embodiments of the present invention, there is provided the feed as disclosed herein for use in treating an animal.

[0067] According to an embodiment of the method, the nutrients of the feed comprise energy sources and protein sources. According to an embodiment, said feed comprises butyrate at a concentration between 10 ppm and 20,000 ppm. According to an embodiment, said feed comprises at least 50ppm butyrate, at least 100ppm, at least 300ppm, at least 500ppm butyrate, at least 700ppm, or at least 1000ppm. According to an embodiment, at least 50% by weight of the butyrate in said feed results from said feed ingredient, at least 60%, at least 70% or at least 80%.

[0068] According to an embodiment, said animal is selected from the group consisting of avian, porcine, bovine, equine, ovine, piscine, caprine, canine, feline and lapine groups of animals.

[0069] According to an embodiment, the method is characterized by providing an improved result compared with feeding the same selected nutrients without the feed ingredient.

[0070] According to an embodiment, said improved result comprises at least one, at least two, at least three, or at least four selected from the group consisting of increased feed intake, improved feed conversion rate, faster daily weight gain, greater ileum surface area, consistent results between sexes and combinations thereof.

[0071] According to an embodiment, said provides an improved result compared with feeding same selected nutrients without said feed ingredient. According to an embodiment, said improved result comprises increased feed intake. According to an embodiment, feed intake increases by at least 0.5%, at least 1%, at least 2%, at least 3%, or at least 4%. According to an embodiment, said improved result comprises improved feed conversion rate (FCR). According to an embodiment, FCR improves by at least 0.1%, at least 0.2%, at least 0.3%, at least 0.4%, at least 0.5%, at least 1%, at least 2.5%, at least 3%, at least 4%, at least 5%, at least 6%, at least 7%, at least 8%, at least 9%, or at least 10%.

[0072] According to an embodiment, said improved result comprises faster daily weight gain. According to an embodiment, daily weight gain increases by at least 0.1%, at least 0.2%, at least 0.3%, or at least 0.4%.

Examples

[0073] Example 1: Glucose fermentation

A glucose-based fermentation media, containing 60-160 g/L of glucose, was fermented in a batch fermentation with *Clostridium tyrobutyricum*. Additional media components include those listed in Tables 1, 2, and 3. Temperature was maintained at 35°C and pH was controlled at minimum of 5.7 with 8M NH₄OH. Results of glucose consumption, cell production and metabolite production during 30 hours of fermentation are shown in Fig.1. Butyrate concentration and cell concentration reached about 60g/L and 20g/L, respectively.

Table 1. Bulk media components.

Component	Concentration (g/L)
KH ₂ PO ₄	3
K ₂ HPO ₄ *3H ₂ O	0.1975
NaCl	0.6
MgSO ₄ *7H ₂ O	0.24
MnSO ₄ *H ₂ O	0.01
FeSO ₄ *7H ₂ O	0.03
(NH ₄) ₂ SO ₄	1.5
CaCl ₂ *2H ₂ O	0.16
Antifoam	0.1

Table 2. Trace elements added to media.

Component	Concentration (mg/L)
MnSO ₄ *H ₂ O	20
Fe(SO ₄) ₂ (NH ₄) ₂ *6H ₂ O	16
CoCl ₂ *6H ₂ O	4

ZnSO ₄ *7H ₂ O	0.004
CuCl ₂ *2H ₂ O	0.4
NiCl ₂ *6H ₂ O	0.4
Na ₂ MoO ₄ *2H ₂ O	0.4
Na ₂ SeO ₄	0.4
Na ₂ WO ₄	0.4

Table 3. Vitamins added to media.

Component	Concentration (mg/L)
Biotin	0.04
Folic Acid	0.04
Pyridoxine-HCl	0.2
Thiamine-HCl	0.1
Riboflavin	0.1
Nicotinic acid	0.1
Calcium-D-(+)-pantothenate	0.1
Vitamin B12	0.002
p-Aminobenzoic acid	0.1
Thioctic acid	0.1

Example 2: Manufacture of the feed ingredient

[0074] Fermentation was conducted similarly to Example 1. Biomass was filtered out. The clarified fermentation broth was concentrated up by water evaporation to reach total solids concentration of 52.6% by weight to form the feed ingredient. Its density was 1.076 Kg/L. The formed feed ingredient was analyzed. The results are summarized in Table 4.

Table 4. Example composition of butyrate feed ingredient

Component	Value	Units
Total solids	52.6	wt%
Density	1.076	kg/L
Ammonium Butyrate	361.0	g/kg
Ammonium Acetate	112.0	g/kg
Crude Protein (on AA basis)	35.5	g/kg
Crude Fat	4.0	g/kg

Ash	5.5	g/kg
Calcium	0.1	g/kg
Phosphorous	0.4	g/kg
Magnesium	0.4	g/kg
Potassium	2.0	g/kg
Sodium	0.2	g/kg
Iron	6.0	ppm
Zinc	5.0	ppm
Copper	<1	ppm
Manganese	20	ppm
Molybdenum	0.7	ppm
Sulfur	200	ppm
Amino acids (hydrolyzed values)		
Lysine	1.13	g/kg
Methionine	1.59	g/kg
Threonine	0.52	g/kg
Aspartic acid/asparagine	2.75	g/kg
Glutamic acid/glutamine	5.85	g/kg
Serine	0.66	g/kg
Histidine	0.30	g/kg
Glycine	1.17	g/kg
Arginine	0.68	g/kg
Alanine	13.47	g/kg
Tyrosine	0.45	g/kg
Valine	4.04	g/kg
Phenylalanine	0.74	g/kg
Isoleucine	0.65	g/kg
Leucine	0.93	g/kg
Proline	0.55	g/kg

[0075] Example 3: Corn-mash fermentation

A fermentation similar to Example 1 was conducted except that instead of glucose, corn mash was used as the feedstock. Corn mash was diluted and filtered to a concentration of 60-160 g/L assumed glucose, and an amylase enzyme was added during the fermentation. Only trace elements (Table 2) and vitamins (Table 3) were added to the fermentation. Other operating conditions were the same and a similar production profile was achieved with a similar product as Example 2.

Claims

1. A composition comprising a) butyrate and b) a by-product of fermentation of a carbon source-containing feedstock with a Clostridia class bacterium which natively produces butyric acid.
2. The composition of Claim 1, further comprising acetate.
3. The composition of Claim 1, wherein said organism is selected from the group consisting of *Butyribacterium methylotrophicum*, *Clostridium tyrobutyricum* and combinations thereof.
4. The composition of Claim 1, wherein said by-product is selected from the group consisting of nitrogen compounds, nucleotides, vitamins, salts, complexes of transition metals, biomass and combinations thereof.
5. The composition of Claim 1, wherein said butyrate is protected.
6. The composition of Claim 1, comprising between 10% by weight and 90% by weight on a dry basis of said butyrate.
7. The composition of Claim 1, comprising between 0.01% by weight and 90% by weight on a dry basis of said by-product.
8. The composition of Claim 1, comprising less than 20% water.
9. The composition of Claim 1, further comprising a butyrate counter ion selected from the group consisting of ammonium, potassium, calcium, magnesium and combinations thereof.
10. The composition of Claim 1, wherein said carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.
11. A feed ingredient comprising the composition of Claim 1.
12. An animal feed comprising selected nutrients, the feed ingredient of Claim 11 and optionally biomass.
13. An anti-icing product comprising the composition of Claim 1.
14. The anti-icing product of claim 13, further comprising a butyrate counter ion selected from the group consisting of calcium, magnesium, potassium and combinations thereof.
15. The anti-icing product of claim 13, further comprising sodium chloride.

16. A method for manufacturing the composition of Claim 1, comprising
 - (i) providing said carbon-source-comprising feedstock; and
 - (ii) fermenting said feedstock with said Clostridia bacteria, whereby a fermentation broth comprising a biomass, butyrate and said by-product is formed.
17. The method of Claim 16, further comprising
 - (iii) separating said biomass from said fermentation broth to form a clarified fermentation broth, wherein said clarified fermentation broth comprises butyrate and said by-product.
18. The method of Claim 17, wherein said separating comprises filtering.
19. The method of Claim 16, wherein said carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.
20. The method of Claim 16, wherein said fermenting comprises pH control by adding to said fermentation broth a base selected from the group consisting of ammonia, urea, a calcium base, a magnesium base and combinations thereof.
21. The method of Claim 16, wherein said fermenting comprises pH control by adding ammonia to said fermentation broth and wherein said clarified fermentation broth comprises ammonium butyrate, the method further comprising:
 - adding to said clarified fermentation broth at least one selected from the group consisting of a calcium base, a potassium base and a magnesium base, whereby ammonia vapors are formed, and
 - collecting said ammonia vapors.
22. The method of Claim 21, wherein said collected ammonia vapors are used for said pH control.
23. The method of Claim 17, further comprising adding butyrate to said clarified fermentation broth.
24. The method of Claim 17, further comprising protecting at least a fraction of the butyrate in said clarified fermentation broth or in products thereof.
25. The method of Claim 17, further comprising at least partially removing water from said fermentation broth and/or from said clarified fermentation broth.

26. A method for treating an animal comprising feeding said animal with the feed of Claim 12.
27. The method of Claim 26, wherein said feed comprises butyrate at a concentration between 10 ppm and 20,000 ppm.
28. The method of Claim 26, wherein at least 50% by weight of the butyrate in said feed results from said feed ingredient.
29. The method of Claim 26, wherein said animal is selected from the group consisting of avian, porcine, bovine, equine, ovine, piscine, caprine, canine, feline and lapine groups of animals.
30. The method of Claim 26, characterized by providing an improved result compared with feeding same selected nutrients without said feed ingredient.
31. The method of Claim 30, wherein said improved result comprises at least one selected from the group consisting of increased feed intake, improved feed conversion rate, faster daily weight gain, greater ileum surface area, and consistent results between sexes
32. A method for manufacturing a feed ingredient, comprising
 - (i) providing a carbon-source-comprising feedstock;
 - (ii) fermenting said feedstock with a Clostridia class bacterium which natively produces butyric acid, whereby a fermentation broth comprising butyrate and biomass is formed.
33. The method of Claim 32, further comprising
 - (iii) separating said biomass from said fermentation broth to form a clarified fermentation broth, wherein said clarified fermentation broth comprises butyrate.
34. The method of Claim 32, wherein said carbon source is selected from the group consisting of starch, dextrose, maltodextrin, glucose, liquefied corn mash, fructose, xylose, glycerol, sucrose, hemicellulose, cellulose and combinations thereof.
35. The method of Claim 33, further comprising adding butyrate to said clarified fermentation broth.
36. The method of Claim 33, further comprising protecting at least a fraction of the butyrate in said clarified fermentation broth or in products thereof.

37. The method of Claim 33 or Claim 33, further comprising at least partially removing water from said fermentation broth and/or from said clarified fermentation broth.
38. An animal feed comprising selected nutrients, said clarified fermentation broth of claim 33 or a product thereof and optionally biomass.
39. A method for treating an animal comprising feeding said animal with the feed of Claim 38.
40. The method of Claim 39, wherein said feed comprises butyrate at a concentration between 10 ppm and 20,000 ppm.
41. The method of Claim 39, wherein at least 50% by weight of the butyrate in said feed results from said feed ingredient.
42. The method of Claim 39, wherein said animal is selected from the group consisting of avian, porcine, bovine, equine, ovine, piscine, caprine, canine, feline and lapine groups of animals.
43. The method of Claim 39, characterized by providing an improved result compared with feeding same selected nutrients without said feed ingredient.
44. The method of Claim 43, wherein said improved result comprises at least one selected from the group consisting of increased feed intake, improved feed conversion rate, faster daily weight gain, greater ileum surface area, and consistent results between sexes.

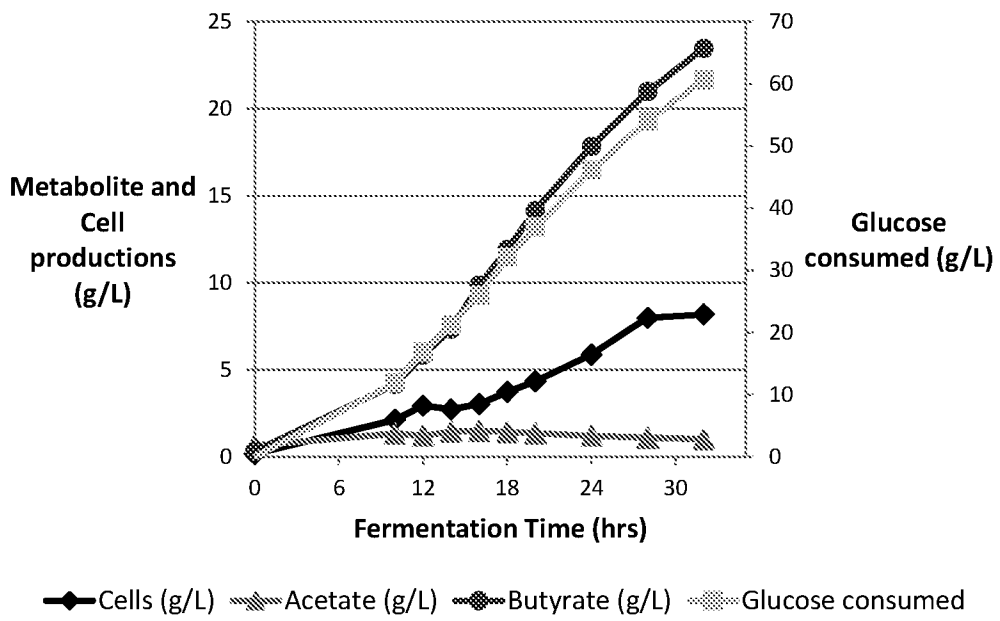


FIG.1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2020/051607

A. CLASSIFICATION OF SUBJECT MATTER See extra sheet.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) IPC (20200101) A23K 10/00, A23K 20/00, A23K 40/00, A23L 33/00, C07C 53/00, C09K 3/00, C12N 1/20, C12P 7/00, C12R 1/00 CPC (20160501) A23K 10/00, A23K 20/00, A23K 40/00, A23L 33/00, C07C 53/00, C09K 3/00, C12N 1/20, C12P 7/00, C12R 1/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Databases consulted: Orbit, SIMILARI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	XIAO Z. et al. Production of butyric acid from acid hydrolysate of corn husk in fermentation by <i>Clostridium tyrobutyricum</i> : kinetics and process economic analysis. <i>Biotechnology for Biofuels</i> , Volume 11, Article 164, 2018, Pages 1-12, ISSN 1754-6834, <DOI: 10.1186/s13068-018-1165-1>. 15 Jun 2018 (2018/06/15) The whole document	1-12,16-44
Y		13-15
X	CN 106922987 A (ANHUI XINKANG FEED CO., LTD.) 07 Jul 2017 (2017/07/07) Translation retrieved from <Espacenet> The whole document	1-12,16-44
Y		13-15
X	US 2018125092 A1 (GREEN CELLULOSITY CORPORATION) 10 May 2018 (2018/05/10) The whole document	1-12,16-44
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"D" document cited by the applicant in the international application		"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date		"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 21 May 2020	Date of mailing of the international search report 24 May 2020	
Name and mailing address of the ISA: Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Email address: pctoffice@justice.gov.il	Authorized officer ZAKHARIA Imad Telephone No. 972-73-3927152	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2020/051607

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y		13-15
X	CN 107746862 A (ZHEJIANG UNIVERSITY) 02 Mar 2018 (2018/03/02) Translation retrieved from <Espacenet> The whole document	1-12,16-44
Y		13-15
X	CN 102234664 A (SINGAO AGRIBUSINESS DEVELOPMENT CO.,LTD.) 09 Nov 2011 (2011/11/09) Translation retrieved from <Espacenet> The whole document	1-12,16-44
Y		13-15
Y	WO 2013190332 A1 (ESSECO UK LIMITED) 27 Dec 2013 (2013/12/27) The whole document	13-15

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent document cited search report	Publication date	Patent family member(s)	Publication Date
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		CN 106922987 B	07 Aug 2018
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		CN 108060182 A	22 May 2018
		TW 201817316 A	16 May 2018
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		US 2015252239 A1	10 Sep 2015
		US 9434868 B2	06 Sep 2016

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2020/051607

A. CLASSIFICATION OF SUBJECT MATTER:

IPC (20200101) A23K 10/12, A23K 10/30, A23K 20/105, A23K 40/30, A23L 33/135, C07C 53/124, C09K 3/18, C12N 1/20, C12P 7/52, C12R 1/145

CPC (20160501) A23K 10/12, A23K 10/30, A23K 20/105, A23K 40/30, A23L 33/135, C07C 53/124, C09K 3/18, C12N 1/20, C12P 7/52, C12P 2203/00, C12R 1/145