Notice

DESCRIPTION CN119422853A

Methods for improving duckweed protein cultivation

提高浮萍蛋白的培养方法

[0001]

Technical Field

技术领域

[n0001]

This invention relates to the field of duckweed cultivation technology, and more particularly to a cultivation method for improving duckweed protein.

本发明涉及浮萍培养技术领域，尤其涉及一种提高浮萍蛋白的培养方法。

[0003]

Background Technology

背景技术

[n0002]

Duckweed, a monocotyledonous aquatic floating plant, belongs to the subfamily Lemnoideae of the family Araceae. Due to its simple structure and strong adaptability, it is distributed in various freshwater bodies in my country.

浮萍作为单子叶水生漂浮植物之一，属于天南星科浮萍亚科，因其结构简单，适应能力强，在我国各类淡水水体均有分布。

Meanwhile, duckweed is rich in starch, protein, vitamins and minerals, making it an important potential food source, feed and bioenergy.

同时，浮萍富含淀粉、蛋白质、维生素和矿质元素，是重要的潜在食品源、饲料和生物能源。

[n0003]

Currently, using duckweed as a substitute for soybean meal in feed is a popular research topic. It has the advantages of fast growth, high protein content, low fiber content, easy harvesting, and no serious pests, and has broad application prospects.

目前，以浮萍代替豆粕应用于饲料是目前较为热门的研究，其具有生长速度快、蛋白质含量高、纤维含量低、易于采收和无严重害虫等特点，应用前景广阔。

There are two most common techniques for cultivating duckweed: one is to use Hoagland nutrient solution, and the other is to use Hunter nutrient solution.

其中，培养浮萍最常用的技术有两种，一种为使用霍格兰（Hoagland）营养液进行培养，另一种为使用亨特（Hunter）营养液进行培养。

Comparatively, the nitrogen-to-phosphorus ratio of the former is 6.5 times that of the latter, therefore Hoagland nutrient solution is more conducive to duckweed growth.

相对来说，前者的氮磷比是后者的6.5倍，因此Hoagland营养液更利于浮萍生长。

[n0004]

However, in order to ensure the growth and protein content of duckweed are stable, the Hoagland nutrient solution needs to be changed every three days or so to ensure the stability of the nutrient composition of the culture medium and the stable growth of duckweed.

但是，为了能够使浮萍的生长和蛋白含量稳定，需要每隔三天左右更换一次Hoagland营养液，保障培养液营养成分稳定，以及浮萍的稳定生长。

However, frequent changes in the nutrient solution not only increase cultivation costs but also affect the large-scale cultivation of duckweed.

然而营养液的频繁更换不仅会造成培养成本增加，还会影响浮萍的大量培养。

In addition, although Hoagland nutrient solution has a certain positive effect on improving the growth rate and protein content of duckweed, it still cannot achieve a more ideal effect, that is, it cannot be applied to the production of duckweed as feed.

除此之外，尽管Hoagland营养液对浮萍生长速度与蛋白含量的提高存在一定积极作用，但仍无法达到较为理想的效果，即无法应用于浮萍饲料化生产中。

[n0005]

Therefore, providing a cultivation method that can reduce the use of nutrient solution, increase the protein content of duckweed, and realize feed production is an urgent problem to be solved.

因此，提供一种能够减少营养液的使用，提高浮萍蛋白含量的培养方法，实现饲料化生产，是目前亟待解决的问题。

[0008]

Summary of the Invention

发明内容

[n0006]

In view of this, embodiments of this application provide a method for improving the culture of duckweed protein to solve the above problems.

有鉴于此，本申请实施例提供了一种提高浮萍蛋白的培养方法，以解决上述问题。

[n0007]

In a first aspect, embodiments of this application provide a method for enhancing the culture of duckweed proteins, comprising the following steps:

第一方面，本申请实施例提供了一种提高浮萍蛋白的培养方法，包括如下步骤：

[0011]

The duckweed was purified in Hogland's working solution to obtain purified duckweed.

将浮萍在霍格兰工作液中进行纯化处理，得到纯化后的浮萍；

[0012]

A duckweed culture medium is prepared by mixing biogas slurry with Hoagland working solution; wherein the concentration of biogas slurry is 1.5%-5% and the concentration of Hoagland working solution is 95%-98.5%.

将沼液与霍格兰工作液混合，制备浮萍培养液；其中，所述沼液的浓度为1.5%-5%，所述霍格兰工作液的浓度为95%-98.5%；

[0013]

After the purified duckweed is added to the duckweed culture solution, it is placed in an incubator with preset culture conditions for cultivation to obtain cultured duckweed.

将纯化后的浮萍投萍至所述浮萍培养液后，置于预设培养条件的培养箱中进行培养，得到培养后的浮萍。

[n0008]

In some embodiments, the Hogland working solution comprises the following components:

在其中一些实施例中，所述霍格兰工作液，包括如下成分：

[0015]

Magnesium sulfate heptahydrate 49.2 μg/L, calcium nitrate tetrahydrate 108.6 μg/L, potassium dihydrogen phosphate 27.2 μg/L, potassium nitrate 50.2 μg/L, boric acid 0.286 μg

/L, manganese chloride tetrahydrate 0.186 μg/L, zinc sulfate heptahydrate 0.022 μg/L, sodium molybdate dihydrate 0.009 μg/L, copper sulfate pentahydrate 0.009 μg/L, ferrous sulfate heptahydrate (II) 1.98 μg/L, and disodium ethylenediaminetetraacetic acid 6 μg/L.

七水硫酸镁49.2 μg/L、四水合硝酸钙108.6 μg/L、磷酸二氢钾27.2 μg/L、硝酸钾50.2 μg/L、硼酸0.286 μg/L、四水氯化锰0.186 μg/L、七水硫酸锌0.022 μg/L、二水钼酸钠0.009 μg/L、五水硫酸铜0.009 μg/L、七水硫酸亚铁(II) 1.98 μg/L和二钠乙二胺四乙酸6μg/L。

[n0009]

In some embodiments, the Hogland working solution is obtained by adding pure water to a Hogland stock solution and bringing it to a final volume; wherein the Hogland stock solution comprises the following components:

在其中一些实施例中，所述霍格兰工作液由霍格兰储备液加纯水定容得到；其中，所述霍格兰储备液，包括如下成分：

[0017]

Magnesium sulfate heptahydrate 49.2 g/L, calcium nitrate tetrahydrate 108.6 g/L, potassium dihydrogen phosphate 27.2 g/L, potassium nitrate 50.2 g/L, boric acid 2.86 g/L, manganese chloride tetrahydrate 1.86 g/L, zinc sulfate heptahydrate 0.22 g/L, sodium molybdate

dihydrate 0.09 g/L, copper sulfate pentahydrate 0.09 g/L, ferrous sulfate heptahydrate (II) 1.98 g/L, and disodium ethylenediaminetetraacetic acid 6 g/L.

七水硫酸镁49.2 g/L、四水合硝酸钙108.6 g/L、磷酸二氢钾27.2 g/L、硝酸钾50.2 g/L、硼酸2.86 g/L、四水氯化锰1.86 g/L、七水硫酸锌0.22 g/L、二水钼酸钠0.09 g/L、五水硫酸铜0.09 g/L、七水硫酸亚铁(II) 1.98 g/L和二钠乙二胺四乙酸6 g/L。

[n0010]

In some embodiments, the purification of duckweed in Hoagland working solution to obtain purified duckweed includes:

在其中一些实施例中，所述将浮萍在霍格兰工作液中进行纯化处理，得到纯化后的浮萍，包括：

[0019]

Obtain duckweed and remove debris from it to obtain pretreated duckweed;

获取浮萍，并去除所述浮萍上的杂物，得到预处理后的所述浮萍；

[0020]

The pretreated duckweed was placed in a culture dish and the Hogland working solution was added for purification for one week to obtain purified duckweed.

将预处理后的浮萍置于培养盆中，并加入所述霍格兰工作液进行纯化处理1周，得到纯化后的浮萍。

[n0011]

In some embodiments, the duckweed species is *Lemna minor* or *Lemna minor*.

在其中一些实施例中，所述浮萍的品种为稀脉浮萍或少根紫萍。

[n0012]

In some embodiments, when the biogas slurry is mixed with the Hogland working solution, the concentration of the Hogland working solution is 95%-98%, and the concentration of the biogas slurry is 2%-5%.

在其中一些实施例中，在将沼液与霍格兰工作液混合时，所述霍格兰工作液的浓度为95%-98%，所述沼液的浓度为2%-5%。

[n0013]

In some embodiments, the biogas slurry contains 980 mg/L of total nitrogen and 90 mg/L of total phosphorus.

在其中一些实施例中，所述沼液中，总氮含量为980mg/L，总磷含量为90mg/L。

[n0014]

In some embodiments, the step of adding the purified duckweed to the duckweed culture medium and then culturing it in an incubator with preset culture conditions to obtain cultured duckweed includes:

在其中一些实施例中，所述将纯化后的浮萍投萍至所述浮萍培养液后，置于预设培养条件的培养箱中进行培养，得到培养后的浮萍，包括：

[0025]

After obtaining purified duckweed, impurities were removed and the water on the leaves and roots was dried to obtain duckweed to be cultivated.

获取纯化后的浮萍，依次进行除杂和吸干叶片及根系上的水分，得到待培养浮萍；

[0026]

The duckweed to be cultivated is placed into a culture basin containing the culture solution; wherein the leaf surface of the duckweed to be cultivated is facing upward.

将所述待培养浮萍投入放置所述培养液的培养盆中；其中，所述待培养浮萍的叶片表面朝上；

[0027]

The culture pot is placed in the culture box and cultured for 5 days according to the preset culture conditions to obtain cultured duckweed.

将所述培养盆置于所述培养箱中，按照预设培养条件培养5天，得到培养后的浮萍。

[n0015]

In some embodiments, when the duckweed to be cultivated is placed into a culture basin containing the culture solution, the duckweed covers more than 60% of the surface area of the culture solution.

在其中一些实施例中，在将所述待培养浮萍投入放置所述培养液的培养盆中时，所述浮萍覆盖在所述培养液的表面面积大于60%。

[n0016]

In some embodiments, the preset culture conditions include:

在其中一些实施例中，所述预设培养条件，包括：

[0030]

The light duration is 16 hours, the darkness duration is 8 hours, the light intensity is 6000 LUX, the temperature is 25°C, and the humidity is 75%.

光照时长为16h、黑暗时长为8h、光照强度为6000LUX、温度为25°C和湿度为75%。

[n0017]

Technical effects of the present invention:

本发明的技术效果：

[0032]

By adding biogas slurry to the Hogland working solution, the protein content of the cultured duckweed can be significantly increased. This not only enables efficient use of biogas slurry from pig farms, saving water resources and providing an ideal way to recycle livestock

wastewater and reduce sewage treatment costs, but also utilizes the nitrogen and phosphorus in the biogas slurry to promote the synthesis of duckweed proteins, enhance protein synthesis efficiency, reduce the use of nutrient solution, or even completely replace nutrient solution in large-scale duckweed cultivation in production practice to obtain stable and reliable duckweed feed, thus providing a good foundation for the research on the feed application of duckweed.

通过在霍格兰工作液中添加沼液，能够使得培养出的浮萍蛋白含量显著提高，不仅能够高效利用养猪场沼液，节约水资源，为养殖废水循环利用、降低污水处理费用提供一个理想途径，同时还能够利用沼液中的氮磷促进浮萍蛋白质的合成，增强蛋白质合成效率，减少营养液使用甚至完全替代营养液在生产实践中大量养殖浮萍来获得稳定可靠的浮萍饲料，为浮萍的饲料化研究提供良好基础。

Moreover, duckweed can grow year-round, has a wide range of pH tolerance, and can grow normally in a pH range of 5-9. It can adapt to the ecological conditions of biogas slurry, requires no additional fertilization or irrigation, and does not compete with agricultural production for land.

不仅如此，由于浮萍可全年生长，对水平pH值适应范围较广，可以在pH为5-9的范围内正常生长，可适应沼液的生态条件，无需额外的施肥或灌溉，并且不与农作物生产竞争土地。

[n0018]

Other features and aspects of this disclosure will become clear from the following detailed description of exemplary embodiments with reference to the accompanying drawings.

根据下面参考附图对示例性实施例的详细说明，本公开的其它特征及方面将变得清楚。

[0034]

Attached Figure Description

附图说明

[n0019]

The accompanying drawings, which are included in and form part of this specification, illustrate exemplary embodiments, features, and aspects of this disclosure together with the specification and serve to explain the principles of this disclosure.

包含在说明书中并且构成说明书的一部分的附图与说明书一起示出了本公开的示例性实施例、特征和方面，并且用于解释本公开的原理。

[n0020]

Figure 1 shows a flowchart of a method for improving duckweed protein cultivation according to an embodiment of this application;

图1示出为本申请实施例的提高浮萍蛋白的培养方法的流程图；

[0037]

Figure 2 shows the protein content determination results of *Lemna minor* as an embodiment of this application;

图2示出为本申请实施例的稀脉浮萍的蛋白质含量测定结果图；

[0038]

Figure 3 shows the protein content determination results of *Lysimachia christinae* as an embodiment of this application.

图3示出为本申请实施例的少根紫萍的蛋白质含量测定结果图。

[0039]

Detailed Implementation

具体实施方式

[n0021]

Various exemplary embodiments, features, and aspects of this disclosure will now be described in detail with reference to the accompanying drawings.

以下将参考附图详细说明本公开的各种示例性实施例、特征和方面。

The same reference numerals in the accompanying drawings indicate elements that have the same or similar functions.

附图中相同的附图标记表示功能相同或相似的元件。

Although various aspects of the embodiments are shown in the accompanying drawings, the drawings are not necessarily drawn to scale unless otherwise specified.

尽管在附图中示出了实施例的各种方面，但是除非特别指出，不必按比例绘制附图。

[n0022]

The term “exemplary” as used here means “used as an example, embodiment or illustration”.

在这里专用的词“示例性”意为“用作例子、实施例或说明性”。

Any embodiment illustrated herein as “exemplary” should not be construed as superior to or better than other embodiments.

这里作为“示例性”所说明的任何实施例不必解释为优于或好于其它实施例。

[n0023]

Furthermore, numerous specific details are provided in the following detailed description of the embodiments to better illustrate this disclosure.

另外，为了更好的说明本公开，在下文的具体实施方式中给出了众多的具体细节。

Those skilled in the art will understand that this disclosure can be practiced even without certain specific details.

本领域技术人员应当理解，没有某些具体细节，本公开同样可以实施。

In some instances, methods, means, components, and circuits well known to those skilled in the art have not been described in detail in order to highlight the spirit of this disclosure.

在一些实例中，对于本领域技术人员熟知的方法、手段、元件和电路未作详细描述，以便于凸显本公开的主旨。

[n0024]

Example 1

实施例一

[0044]

This application provides a method for enhancing the culture of duckweed protein. Figure 1 is a flowchart of the steps of the method for enhancing the culture of duckweed protein according to this application. As shown in Figure 1, the method includes the following steps:

本申请实施例提供了一种提高浮萍蛋白的培养方法，图1是根据本申请实施例的提高浮萍蛋白的培养方法的步骤流程图，如图1所示，该方法包括以下步骤：

[0045]

S100. The duckweed is purified in Hogland working solution to obtain purified duckweed.

S100、将浮萍在霍格兰工作液中进行纯化处理，得到纯化后的浮萍；

[0046]

In this step, before the formal cultivation of duckweed, it is necessary to purify the duckweed in Hoagland working solution. That is, there is a purification pre-process. The purpose is to reduce the influence of other impurities on the duckweed cultivation results, so as to obtain duckweed products with consistent growth status.

本步骤中，在对浮萍的正式培养前，需要先针对浮萍在霍格兰工作液中进行纯化处理，即存在一个纯化前置的过程，其目的在于减少其他杂质对于浮萍培养结果的影响，从而获得生长状态一致的浮萍产品。

[n0025]

Therefore, Hoagland working solution needs to be prepared in advance before purification.

因此，在纯化处理之前需要先预先配制出霍格兰工作液，即Hoagland工作液。

Among them, Hogland working solution, as a nutritionally balanced culture medium, includes various mineral elements required for plant production.

其中，霍格兰工作液作为一种营养均衡的培养基，包括了植物生产所需的各种矿质元素。

Specifically, these elements include potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), and boron (B). After being mixed with biogas slurry, these elements can work synergistically with nitrogen and phosphorus in the biogas slurry to promote the growth of duckweed and the synthesis of proteins.

具体的，包括钾（K）、钙（Ca）、镁（Mg）、硫（S）、铁（Fe）、锰（Mn）、锌（Zn）、铜（Cu）、钼（Mo）和硼（B），后续与沼液混合后，上述元素能够与沼液中的氮磷协同作用，共同促进浮萍的生长以及蛋白质的合成。

[n0026]

In some embodiments, the Hogland working solution comprises the following components: magnesium sulfate heptahydrate 49.2 μg/L, calcium nitrate tetrahydrate 108.6 μg/L, potassium dihydrogen phosphate 27.2 μg/L, potassium nitrate 50.2 μg/L, boric acid 0.286 μg

/L, manganese chloride tetrahydrate 0.186 μg/L, zinc sulfate heptahydrate 0.022 μg/L, sodium molybdate dihydrate 0.009 μg/L, copper sulfate pentahydrate 0.009 μg/L, ferrous sulfate (II) heptahydrate 1.98 μg/L, and disodium ethylenediaminetetraacetic acid 6 μg/L.

在其中一些实施例中，霍格兰工作液，包括如下成分：七水硫酸镁49.2 μg/L、四水合硝酸钙108.6 μg/L、磷酸二氢钾27.2 μg/L、硝酸钾50.2 μg/L、硼酸0.286 μg/L、四水氯化锰0.186 μg/L、七水硫酸锌0.022 μg/L、二水钼酸钠0.009 μg/L、五水硫酸铜0.009 μg/L、七水硫酸亚铁(II) 1.98 μg/L和二钠乙二胺四乙酸6 μg/L。

[n0027]

The Hogrange working solution in this embodiment is preferably prepared by mixing MgSO・7HO, Ca(NO)・4HO, KHO・PO・7HO, KNO・8HO, HO・BO, MnCl・4HO, ZnSO・7HO, NaMoO・2HO, CuSO・5HO, FeSO・7HO, and NaEDTA.

本实施例中的霍格兰工作液，优选MgSO₄.7H₂O、Ca (NO₃)₂.4H₂O、KH₂PO₄、KNO₃、H₃BO₃、MnCL₂.4H₂O、ZnSO₄.7H₂O、Na₂MoO₄.2H₂O、CuSO₄.5H₂O、FeSO₄.7H₂O、Na₂EDTA混合配制而成。

[n0028]

In some embodiments, the Hogland working solution is obtained by adding pure water to the Hogland stock solution and making up to a final volume; wherein the Hogland stock solution comprises the following components: magnesium sulfate heptahydrate 49.2 g/L, calcium nitrate tetrahydrate 108.6 g/L, potassium dihydrogen phosphate 27.2 g/L, potassium nitrate 50.2 g/L, boric acid 2.86 g/L, manganese chloride tetrahydrate 1.86 g/L, zinc sulfate heptahydrate 0.22 g/L, sodium molybdate dihydrate 0.09 g/L, copper sulfate pentahydrate 0.09 g/L, ferrous sulfate (II) heptahydrate 1.98 g/L, and disodium ethylenediaminetetraacetic acid 6 g/L.

在其中一些实施例中，霍格兰工作液由霍格兰储备液加纯水定容得到；其中，霍格兰储备液，包括如下成分：七水硫酸镁49.2 g/L、四水合硝酸钙108.6 g/L、磷酸二氢钾27.2g/L、硝酸钾50.2 g/L、硼酸2.86 g/L、四水氯化锰1.86 g/L、七水硫酸锌0.22 g/L、二水钼酸钠0.09 g/L、五水硫酸铜0.09 g/L、七水硫酸亚铁(II) 1.98 g/L和二钠乙二胺四乙酸6g/L。

[n0029]

Specifically, the formula should be prepared according to the ingredients and dosages in Table 1.

具体的，根据表1中的成分与用量进行配制。

First, prepare 11 500mL blue-capped glass reagent bottles. Prepare each reagent according to the stock solution concentration. Weigh the required weight of nutrient salt powder and dissolve it in pure water. After making up the volume, put it into the reagent bottle for later use so that each reagent can be stored separately to prevent some reagents from reacting over a long period of time. The stock solution in the reagent bottle should not be stored at room temperature for more than 3 months.

首先，需要准备11个500mL蓝盖玻璃试剂瓶，将各试剂按储备液浓度配制，分别称取所需重量的营养盐粉末溶解于纯水中，定容后装在试剂瓶中备用，以使各试剂能够单独存放，防止长时间下部分试剂发生反应，其中试剂瓶中的储备液常温存放不超过3个月。

[n0030]

Furthermore, when using the solution, mix the above-mentioned reagent stock solution according to the concentration and dosage of the working solution in Table 1, and then dilute to volume with pure water to prepare Hogland working solution. This solution is used to mix with biogas slurry in proportion when preparing duckweed culture medium to synergistically increase the protein content of duckweed.

进一步的，在使用时，按照表1中工作液的浓度和用量，将上述试剂储备液液体混合，随后用纯水定容，从而制成霍格兰工作液，用于在制备浮萍培养液时按比例与沼液混合，以协同提高浮萍的蛋白含量。

[n0032]

Table 1. Reference Table for Hoagland Working Solution Preparation

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表1 Hoagland工作液配制组成参照表

[0055]

In some embodiments, duckweed is purified in Hogrange working solution to obtain purified duckweed, including: obtaining duckweed and removing impurities from the duckweed to obtain pretreated duckweed; placing the pretreated duckweed in a culture dish and adding Hogrange working solution for purification treatment for 1 week to obtain purified duckweed.

在其中一些实施例中，将浮萍在霍格兰工作液中进行纯化处理，得到纯化后的浮萍，包括：获取浮萍，并去除浮萍上的杂物，得到预处理后的浮萍；将预处理后的浮萍置于培养盆中，并加入霍格兰工作液进行纯化处理1周，得到纯化后的浮萍。

[n0033]

In this embodiment, duckweed was cultured in Hogland working solution for 1 week, or 7 days, before formal cultivation.

本实施例中，在正式培养前，使用霍格兰工作液培养浮萍1周，即7天。

Specifically, use a net with a mesh size of less than 1 mm to scoop the duckweed out of the water and rinse the leaves and roots with tap water to remove debris, especially impurities, to reduce the impact of other algae and impurities on the duckweed cultivation.

具体的，优选孔径小于1mm的抄网将浮萍从水中捞出，并用自来水冲洗干净叶片和根系上的杂物，尤其是杂类，以减少其他水藻和杂质对浮萍培养的影响。

Then, use absorbent paper to dry the moisture on the leaves and roots.

随后，用吸水纸吸干叶片及根系上的水分。

Further, weigh 2g of fresh duckweed and place it in a 2L culture dish, add 1L of pre-prepared Hogland working solution, and place it in an incubator for 1 week.

进一步的，称取2g新鲜的浮萍放入2L的培养盆中，加入1L预先配制好的霍格兰工作液中，并放置在培养箱中培养1周。

It should be noted that all duckweed cultivation uses 2L white rectangular wide-mouth plastic cultivation pots of the same specification. Before cultivating duckweed, it is necessary to clean it thoroughly and then expose it to sunlight for 24 hours and sterilize it with ultraviolet light for 24 hours.

此处，需要说明的是，浮萍培养均采用2L规格一致的白色长方形广口塑料培养盆，并且在培养浮萍前需要在刷洗干净之后，依次于阳光下暴晒24小时和用紫外灭菌24小时。

[n0034]

In some embodiments, the species of duckweed is *Lemna minor* or *Lemna minor*.

在其中一些实施例中，浮萍的品种为稀脉浮萍或少根紫萍。

[n0035]

In this embodiment, two species from two different duckweed genera are preferred for cultivation, specifically including *Lemna aequinoctialis* from the genus *Lemna* and *Landoltia punctata* from the genus *Lemna*.

本实施例中，优选两个浮萍属的两个种进行培养，具体包括青萍属的稀脉浮萍（Lemna aequinoctialis）以及少根紫萍属的少根紫萍（Landoltia punctata）。

Among them, *Lemna minor* and *Lemna minor* can grow year-round, have a wide range of adaptability to pH values, and can grow normally within a pH range of 5-9. They can adapt to the ecological conditions of biogas slurry, do not require additional fertilization or irrigation, and do not compete with crop production for land.

其中，稀脉浮萍，少根紫萍可全年生长，对水平pH值适应范围较广，可以在pH为5-9的范围内正常生长，可适应沼液的生态条件，无需额外的施肥或灌溉，并且不与农作物生产竞争土地。

[n0036]

S200. Mix biogas slurry with Hoagland working solution to prepare duckweed culture medium; wherein the concentration of biogas slurry is 1.5%-5%, and the concentration of Hoagland working solution is 95%-98.5%;

S200、将沼液与霍格兰工作液混合，制备浮萍培养液；其中，沼液的浓度为1.5%-5%，霍格兰工作液的浓度为95%-98.5%；

[0060]

In this step, in order to improve the low yield of traditional duckweed cultivation, especially the high cost and insufficient increase in protein content caused by simply using Hoagland culture medium, biogas slurry is added to the pre-made Hoagland working medium. This not only reduces the amount of Hoagland working medium used, but also significantly increases the protein content of the duckweed.

本步骤中，为了能够改善传统培养浮萍产量低，尤其是单纯的采用霍格兰培养液培养成本较高，蛋白含量提高成都不足等问题，通过在预制的霍格兰工作液中添加沼液，不仅降低了霍格兰工作液的用量，同时还能显著提高浮萍蛋白含量。

[n0037]

In addition, since biogas slurry contains large amounts of nitrogen and phosphorus, and the levels of metal ions such as manganese, iron and zinc exceed the standards, direct discharge or discharge after partial treatment will still cause problems such as eutrophication of water bodies, excessive growth of algae, and a sharp decline in the oxygen content of water bodies, which will have a serious impact on the ecology of rivers and lakes.

除此之外，由于沼液中含有大量的氮和磷，且金属离子锰、铁、锌含量超标，直接排放或部分处理后排放仍会造成水体富营养化、水藻大量滋生、水体含氧量急剧下降等问题，会对河流湖泊生态造成严重影响。

In this step, duckweed is cultivated using biogas slurry. On the one hand, this increases the protein content of the duckweed. On the other hand, duckweed has a high tolerance to the high concentration of nutrients in biogas slurry. It can quickly absorb harmful substances such as nitrogen and phosphorus, organic pollutants, and heavy metals and transform them into high-quality edible tissues, and rapidly reproduce and accumulate protein and starch.

而本步骤中通过利用沼液培养浮萍，一方面能够提高浮萍的蛋白含量，另一方面，浮萍会对沼液中高浓度营养物质具有较高的耐受性，能够快速吸附氮磷元素、有机污染物、重金属等有害物质并转化为高质量可食用组织，快速繁殖并累积蛋白质和淀粉。

[n0038]

Specifically, the biogas slurry used in this step is preferably pig manure wastewater that has been fermented in the fermentation tank of a pig farm wastewater treatment plant for more than 3 months, such as pig manure wastewater from Dongyuan Dongrui Branch of Dongrui Food Group Co., Ltd.

具体而言，本步骤中的沼液优选养猪场污水处理场发酵池发酵3个月以上的猪粪污水，例如来自东瑞食品集团股份有限公司的东源东瑞分公司的猪粪污水。

The obtained biogas slurry is stored in a 19L transparent covered bucket. After the lid is closed, it must be sealed with sealing film and stored in a dark environment with the ambient temperature kept below 25°C for no more than one month.

将获取到的沼液采用19L的透明有盖水桶盛装，盖上盖子后，需用封口膜密封处理，存放于阴暗的环境，其中环境温度保持在25°C以下，存放不超过1个月。

[n0039]

Furthermore, after obtaining the above-mentioned biogas slurry, the biogas slurry is mixed with Hogland working solution in a certain proportion to prepare duckweed culture medium.

进一步的，在获取到上述沼液后，将沼液与霍格兰工作液按比例混合制备浮萍培养液。

Specifically, the concentration of biogas slurry is preferably 1.5%-5%, and the concentration of Hogland working solution is preferably 95%-98.5%.

具体的，沼液的浓度优选1.5%-5%，霍格兰工作液的浓度优选95%-98.5%。

In this process, biogas slurry and Hogland working solution were added to a 2L culture dish and stirred thoroughly with a glass rod to make the total culture solution volume in the culture dish 1L.

其中，在2L的培养盆中分别加入沼液和霍格兰工作液，使用玻璃棒充分搅拌均匀，以使培养盆中总培养液体积为1L。

It should be noted that mixing biogas slurry and Hogland working solution in the above proportion can significantly increase the crude protein content of duckweed compared with using only Hogland basal culture medium. The nitrogen and phosphorus in biogas slurry and the potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, molybdenum and boron in Hogland working solution work synergistically to promote the growth of duckweed and the synthesis of protein.

需要说明的是，将沼液与霍格兰工作液按上述比例混合，与仅采用霍格兰基础培养液培养浮萍相比，能够显著提高浮萍的粗蛋白含量，沼液中的氮磷与霍格兰工作液中的钾、钙、镁、硫、铁、锰、锌、铜、钼和硼协同作用，共同促进浮萍的生长和蛋白质的合成。

[n0040]

In some of these embodiments, the total nitrogen content in the biogas slurry is 980 mg/L and the total phosphorus content is 90 mg/L.

在其中一些实施例中，沼液中，总氮含量为980mg/L，总磷含量为90mg/L。

[n0041]

The biogas slurry used in this implementation contains a large amount of nitrogen, phosphorus, potassium and other elements, as well as a variety of trace elements such as copper, iron, sodium, magnesium and zinc, and also a large amount of microorganisms and organic matter.

本实施中所采用的猪场沼液含有大量的氮、磷、钾等元素，以及铜、铁、钠、镁、锌等多种微量元素，同时还有大量的微生物和有机质等。

The total nitrogen content of the biogas slurry was 980 mg/L, and the total phosphorus content was 90 mg/L.

其中沼液的总氮含量为980 mg/L，总磷含量为90mg/L。

It should be noted that nitrogen is a key factor in protein synthesis during the cultivation of duckweed. The biogas slurry in this embodiment is rich in ammonia nitrogen (NH4-N) and nitrate nitrogen (NO3-N), which can be directly absorbed and utilized by the duckweed to promote the synthesis of amino acids and proteins. Phosphorus is a component of ATP, nucleic acids and phospholipids, and participates in energy metabolism and protein synthesis. Phosphate (PO43-) in the biogas slurry can promote the growth and metabolism of duckweed and enhance the efficiency of protein synthesis.

需要说明的是，在浮萍的培养过程中，氮是蛋白质合成的关键因素，本实施例的沼液中富含氨氮NH4-N和硝氮NO3-N，可以直接被浮萍吸收利用，促进氨基酸和蛋白质的合成；磷是ATP、核酸和磷脂的组成部分，参与能量代谢和蛋白质合成，沼液中的磷酸盐PO43-可以促进浮萍的生长和代谢，增强蛋白质合成的效率。

[n0042]

In some embodiments, when the biogas slurry is mixed with the Hogland working solution, the concentration of the Hogland working solution is 95%-98% and the concentration of the biogas slurry is 2%-5%.

在其中一些实施例中，在将沼液与霍格兰工作液混合时，霍格兰工作液的浓度为95%-98%，沼液的浓度为2%-5%。

[n0043]

It should be noted that the effect of improving duckweed protein is optimal when the concentration of biogas slurry is 2%-5% and the concentration of Hogland working solution is 95-98%. Compared with duckweed culture using only Hogland culture solution, the crude protein content of duckweed can be significantly increased.

需要说明的是，当沼液的浓度为2%-5%，霍格兰工作液的浓度为95-98%时，对于浮萍蛋白的提高效果最优，与仅采用霍格兰培养液进行浮萍培养相比，浮萍的粗蛋白含量能够显著提高。

For sparse-veined duckweed, a biogas slurry concentration of 2%-4% is more effective; for sparse-rooted duckweed, a biogas slurry concentration of 3%-5% is more effective.

其中，对于稀脉浮萍而言，沼液浓度为2%-4%时效果更好；对于少根紫萍而言，沼液浓度为3%-5%时效果更好。

[n0044]

S300. After purifying the duckweed, put it into the duckweed culture medium and place it in an incubator with preset culture conditions to culture, and obtain the cultured duckweed.

S300、将纯化后的浮萍投萍至浮萍培养液后，置于预设培养条件的培养箱中进行培养，得到培养后的浮萍。

[n0045]

In this step, the purified duckweed is added to the duckweed culture solution so that the biogas slurry and Hogland working solution can work together on the duckweed.

本步骤中，将经过纯化处理后的浮萍投入浮萍培养液中，以使沼液和霍格兰工作液能够共同作用在浮萍上。

It should be noted that the incubator needs to be sprayed with 75% medical alcohol for disinfection before it is used, followed by ultraviolet disinfection for 24 hours.

其中，需要说明的是，培养箱在正式使用前，需要用75%的医用酒精进行喷洒消毒，随后用紫外消毒24小时。

[n0046]

In some embodiments, after the purified duckweed is added to the duckweed culture solution, it is placed in an incubator with preset culture conditions for cultivation to obtain cultured duckweed. The process includes: obtaining the purified duckweed, removing impurities and drying the leaves and roots in sequence to obtain duckweed to be cultivated; placing the duckweed to be cultivated into a culture pot containing the culture solution, wherein the leaf surface of the duckweed to be cultivated is facing upward; placing the culture pot in an incubator and cultivating it for 5 days according to preset culture conditions to obtain cultured duckweed.

在其中一些实施例中，将纯化后的浮萍投萍至浮萍培养液后，置于预设培养条件的培养箱中进行培养，得到培养后的浮萍，包括：获取纯化后的浮萍，依次进行除杂和吸干叶片及根系上的水分，得到

待培养浮萍；将待培养浮萍投入放置培养液的培养盆中；其中，待培养浮萍的叶片表面朝上；将培养盆置于培养箱中，按照预设培养条件培养5天，得到培养后的浮萍。

[n0047]

Specifically, during the duckweed cultivation process, the duckweed purified for one week is scooped out of the water with a net smaller than 1mm, and the leaves and roots are rinsed with tap water to remove debris, especially algae, to prevent algae from competing with the duckweed for nutrients.

具体的，在浮萍培养过程中，将纯化1周的浮萍用小于1mm的抄网从水中捞出，用自来水冲洗干净叶片和根系上的杂物，尤其是藻类，以防止藻类与浮萍竞争营养物质。

Then, use absorbent paper to dry the leaves and roots.

随后，用吸水纸吸干叶片及根系上的水分。

Furthermore, weigh 2g of fresh duckweed and put it into nutrient solutions of different concentrations of biogas slurry, so that the surface of the duckweed leaves faces upward and is evenly distributed.

进一步的，称取2g新鲜浮萍，投入不同浓度沼液的营养液中，使浮萍的叶片表面朝上并均匀分布。

All duckweed was cultured in an incubator for 5 days to obtain cultured duckweed.

其中，所有浮萍于培养箱中培养5天，从而得到培养后的浮萍。

[n0048]

In some embodiments, when the duckweed to be cultivated is placed into a culture dish containing the culture medium, the surface area of the duckweed covering the culture medium is greater than 60%.

在其中一些实施例中，在将待培养浮萍投入放置培养液的培养盆中时，浮萍覆盖在培养液的表面面积大于60%。

[n0049]

It should be noted that, in order to enable duckweed to grow rapidly, this embodiment preferably covers 60% of the surface of the duckweed culture solution with duckweed. Since duckweed will only grow rapidly after reaching a certain initial amount, a large initial coverage area of duckweed can block light from reaching the underwater environment, inhibit the growth of algae in the water, and prevent algae from competing with duckweed for sunlight and growth space.

需要说明的是，为了能够使浮萍迅速生长，本实施例优选将浮萍覆盖在浮萍培养液表面的60%，由于浮萍在达到一定初始量后才会迅速生长，浮萍初始覆盖面积大可遮挡光线照射水下，抑制水中水藻滋生，防止水藻滋生后与浮萍竞争阳光和生长空间。

In this embodiment, by covering the surface of the culture medium with duckweed by 60% or more, the amount of light reaching the bottom of the water can be effectively reduced, thereby inhibiting the growth of algae.

本实施例中，通过将浮萍覆盖在培养液表面60%及以上，可以有效减少光线照射水底，从而抑制水藻的滋生。

[n0050]

In some of these embodiments, preset culture conditions include: a light duration of 16 hours, a dark duration of 8 hours, a light intensity of 6000 LUX, a temperature of 25°C, and a humidity of 75%.

在其中一些实施例中，预设培养条件，包括：光照时长为16h、黑暗时长为8h、光照强度为6000LUX、温度为25°C和湿度为75%。

[n0051]

In this embodiment, the incubator's incubation conditions need to be set as follows: light duration of 16 hours (6:00-22:00), darkness duration of 8 hours, light intensity of 6000 LUX, temperature of 25°C, and humidity of 75%.

本实施例中，需要将培养箱的培养条件设置为光照时长为16h（6：00-22：00），黑暗时长8h，光照强度为6000LUX，设定温度为25°C，设定湿度为75%。

The purification and formal cultivation of duckweed are both achieved under the above conditions, without the need to set different purification or cultivation conditions.

其中，浮萍纯化和浮萍的正式培养均在上述条件下实现，无需额外设置不同的纯化或培养条件。

[n0052]

It should be noted that, for the determination of protein content after duckweed culture, this application uses a semi-automatic Kjeldahl nitrogen analyzer to determine the crude protein content of duckweed.

需要说明的是，对于浮萍培养后的蛋白含量测定，本申请使用半自动凯氏定氮仪测定浮萍粗蛋白含量。

Before the measurement, the duckweed must be collected and dried.

其中，在测定之前，需先进行浮萍的收集与烘干处理。

Specifically, after 5 days of duckweed cultivation, use a net with a mesh size of less than 1 mm to scoop the duckweed out of the water and rinse the leaves and roots with tap water to remove debris, especially algae.

具体的，在浮萍培养5天后，用孔径小于1mm的抄网将浮萍从水中捞出，采用自来水冲洗干净叶片和根系上的杂物，尤其是藻类。

Then, use absorbent paper to dry the leaves and roots, wrap them in A4 paper to ensure that the duckweed has enough surface area to be heated, and mark them.

随后，用吸水纸吸干叶片及根系上的水分，用A4纸包裹起来，确保浮萍有足够的受热面积，做好标记。

Furthermore, all the collected duckweed was dried using a blower dryer at a temperature of 105°C for 36 hours.

进一步的，将收集到的所有浮萍用鼓风干燥机烘干，烘干温度为105°C，烘干时长为36h。

[n0053]

The determination of duckweed protein will be explained in detail below:

下面将针对浮萍蛋白的测定进行详细说明：

[0078]

1. Consumables preparation: absorbent paper; marker pen; mortar and pestle; balance; weighing paper; test tubes; sealing film; 5 mL pipette and tip; other pipettes and tips; 100 ml graduated cylinder; 150 ml conical flask; plastic dropper.

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1. 耗材准备：吸水纸；记号笔；研钵；天平；称量纸；试管；封口膜，5 mL移液枪及枪头，其他移液枪及枪头，100 ml量筒，150 ml锥形瓶，塑料滴管。

[n0054]

2. Reagents: concentrated sulfuric acid, H2O2, distilled water, NaOH solution (10 mol/L), H3BO3 (boric acid, 20 g/L), methyl red-bromocresol green indicator, 0.02 mol/L sulfuric acid.

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2. 试剂：浓硫酸，H2O2，蒸馏水，NaOH溶液（10 mol/L），H3BO3(硼酸，20 g/L)，甲基红-溴甲酚绿指示剂，0.02 mol/L的硫酸。

[n0055]

3. Sample preparation:

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3. 准备样品：

[0081]

Sample crushing: After the duckweed sample is completely dried, take it out and grind it into powder with a mortar and pestle. Weigh 0.5 g of the powder sample (accurate to 0.0002 g) and place it in a dry digestion tube.

样品粉碎：待浮萍样品完全烘干，取出，用研钵磨碎成粉末，称取0.5 g粉末样品（精确至0.0002 g），放于干燥的消煮管中。

[0082]

4. Digestion:

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4. 消煮：

[0083]

Label the digestion tubes and add 5 mL of concentrated sulfuric acid in sequence;

消煮管做好标记并排序加入5 mL浓硫酸；

[0084]

Mix well: Mix the sample with concentrated sulfuric acid;

混匀：将样品与浓硫酸混匀；

[0085]

Sealing: Seal the tube opening with plastic wrap to prevent concentrated sulfuric acid from evaporating;

封口：用保鲜膜将管口封住，防止浓硫酸挥发；

[0086]

Overnight: Let stand for more than 6 hours, add concentrated sulfuric acid the afternoon before, and continue to the next step the next morning;

过夜：放置6 h以上，前一天下午加浓硫酸，第二天上午继续下一步；

[0087]

Add H2O2: Use a 5 mL pipette to add 5 mL of H2O2 to each test tube. After adding, shake to allow the reaction to complete and the solution to become colorless or clear.

加H2O2:用5 mL移液枪，向每个试管中加入5 mL的H2O2，加完之后摇晃使完全反应，变为无色或清亮；

[0088]

Digestion: Place the digestion tube on the digestion oven (turn on the water tap and power), the digestion temperature is 370°C, and the digestion time is 10 minutes. After the first digestion, remove it and place it in a fume hood to cool for about 10 minutes. Then replace it with another sample and digest the two samples alternately. Add H2O2 before each digestion. There is no limit to the number of digestion times. The liquid is ready after the digestion is clear.

消煮：将消煮管放在消煮炉上（开水龙头，电源），消煮温度为370°C，消煮10分钟；第一次消煮完后，拿下来放通风橱冷却约10分钟，换另一板样品，两板交叉消煮；消煮前都要加H2O2；消煮次数不限，待消煮后液体澄清即可。

[n0056]

Ventilation: After sterilization, ventilate in a fume hood for 4 hours;

通风：消煮后，在通风橱通风4 h；

[0090]

Volume adjustment: After digestion, bring the volume to 100 mL with distilled water.

定容：消煮完后，用蒸馏水定容至100 mL。

[n0057]

Note: H2O2 should be added along the tube wall, and a blank control should be set up.

注意：H2O2要沿着管壁加入，要设置空白对照。

[n0058]

5. Nitrogen determination:

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5. 定氮：

[0093]

Sampling: Take 10 mL of the final volume of sample into a new test tube, ready for instrumentation;

取样：取定容后的样品10 mL于新的试管中，待上机；

[0094]

Titration bottle: Take 10 ml of H3BO3 (boric acid) into a 150 mL Erlenmeyer flask, and add 2 drops of methyl red-bromocresol green indicator;

滴定瓶：取10 ml H3BO3(硼酸)于150 mL的锥形瓶中，再加入2滴甲基红-溴甲酚绿指示剂；

[0095]

Clean the machine before and after use: Set the program to 100 mL water, 0 mL boric acid, 0 mL alkali, and 10 mL water; rinse once with ultrapure water.

使用前和后要清洗机器：程序设置水100 mL，硼酸0，碱0，水10；用超纯水清洗一次；

[0096]

Procedure for use: 10 mL water, 0 mL boric acid, 10 mL alkali;

使用时的程序：水10 mL，硼酸0，碱10 mL；

[0097]

Powering on: Turn on the two switches on the right and left sides of the machine ------- Drain wastewater and vent air ------- Place the sample ------- Place the titration bottle ------ (Automatic - Start - Confirm)

开机：打开机器的右边、左边两个开关-------排废水，排气-------放样品---放滴定瓶-----（自动-启动-确定）

[0098]

Titration: After the machine has finished running, remove the conical flask and titrate with 0.02 mol/L sulfuric acid until a transparent red color is obtained (record the volume of sulfuric acid added).

滴定：机器运行完后，拿出锥形瓶，用0.02 mol/L的硫酸滴定至透明红色（记录加入硫酸的体积）

[0099]

Result Calculation: Calculate the result according to the following formula.

结果计算：按照下列公式计算结果。

The crude protein in the sample is expressed as a mass fraction ω, and the value is expressed as a mass percentage (%).

试样中粗蛋白质以质量分数ω计，数值以质量百分数（%）表示。

[n0059]

In the formula :

 式中：

[0101]

V2 - The volume of standard hydrochloric acid solution consumed in the titration of the sample, in milliliters (mL);

V2-滴定试样所消耗盐酸标准滴定溶液的体积，单位为毫升 (mL)；

[0102]

V1 - The volume of standard hydrochloric acid solution consumed in the titration of the blank, in milliliters (mL);

V1-滴定空白所消耗盐酸标准滴定溶液的体积，单位为毫升 (mL)；

[0103]

The concentration of c-hydrochloric acid standard titration solution is expressed in moles per liter (mol/L).

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c-盐酸标准滴定溶液的浓度，单位为摩尔每升 (mol/L)；

[0104]

m - Sample mass, in grams (g);

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m-试样质量，单位为克 (g)；

[0105]

V - Total volume of the sample digestion solution, in milliliters (mL);

V-试样消煮液总体积，单位为毫升 (mL)；

[0106]

V' - Volume of digested liquid used for distillation, in milliliters (mL);

V'-蒸馏用消煮液体积，单位为毫升 (mL)；

[0107]

The molar mass of 14-nitrogen, expressed in grams per mole (g/mol);

14-氮的摩尔质量，单位为克每摩尔 (g/mol)；

[0108]

6.25 - Average coefficient for converting nitrogen to crude protein;

6.25-氮换算成粗蛋白的平均系数；

[0109]

Two parallel samples were taken for each test, and their arithmetic mean was used as the test result. The result was expressed to two decimal places.

每个试样取两个平行样进行测定，以其算术平均值为测定结果，计算结果表示至小数点后两位。

[n0060]

The following five examples, specifically for *Lemna minor* and *Lemna minor*, will further illustrate the method of this application.

下面将分别针对稀脉浮萍和少根浮萍提供五组实施例对本申请的方法进一步进行说明。

[n0061]

1. Sparse-veined duckweed;

1、稀脉浮萍；

[0112]

Example 1

实施例1

[0113]

(1) Obtain rare vein duckweed, rinse off the debris on the leaves and roots, put it in a culture pot, add Hogland working solution, and culture in an incubator for 1 week to obtain purified rare vein duckweed.

（1）获取稀脉浮萍，冲洗掉叶片及根系上的杂物后，放入培养盆中加入霍格兰工作液，于培养箱中培养1周，得到纯化后的稀脉浮萍；

[0114]

(2) The first duckweed culture medium was obtained by mixing Hogland working solution (98.5%) and biogas slurry (1.5%).

（2）按照霍格兰工作液98.5%和沼液1.5%的比例混合，得到第一浮萍培养液；

[0115]

(3) After rinsing the purified duckweed to remove debris from the leaves and roots, dry the water and put the duckweed into the first duckweed culture solution, so that the surface of

the duckweed leaves is facing upward and evenly distributed, and the duckweed must cover 60% of the surface of the first duckweed culture solution. Then, culture it in an incubator for 5 days to obtain the first duckweed.

（3）将纯化后的稀脉浮萍冲洗掉叶片和根系上的杂物后，吸干水分，投萍至第一浮萍培养液中，使稀脉浮萍的叶片表面朝上并均匀分布，且稀脉浮萍须覆盖第一浮萍培养液表面60%，并于培养箱中培养5天，得到第一稀脉浮萍。

[n0062]

Example 2

实施例2

[0117]

Unlike Example 1, in Example 2, the proportions of Hogland working fluid and biogas slurry were 98% and 2%, respectively, thereby cultivating the second rare vein duckweed.

与实施例1不同的是，实施例2中的霍格兰工作液和沼液的占比分别为98%和2%，由此培育得到第二稀脉浮萍。

[n0063]

Example 3

实施例3

[0119]

Unlike Example 1, in Example 3, the proportions of Hogland working fluid and biogas slurry were 97% and 3%, respectively, thereby cultivating the third rare vein duckweed.

与实施例1不同的是，实施例3中的霍格兰工作液和沼液的占比分别为97%和3%，由此培育得到第三稀脉浮萍。

[n0064]

Example 4

实施例4

[0121]

Unlike Example 1, in Example 4, the proportions of Hogland working fluid and biogas slurry were 96% and 4%, respectively, thereby cultivating the fourth rare vein duckweed.

与实施例1不同的是，实施例4中的霍格兰工作液和沼液的占比分别为96%和4%，由此培育得到第四稀脉浮萍。

[n0065]

Example 5

实施例5

[0123]

Unlike Example 1, in Example 5, the proportions of Hogland working fluid and biogas slurry were 95% and 5%, respectively, thereby cultivating the fifth rare vein duckweed.

与实施例1不同的是，实施例5中的霍格兰工作液和沼液的占比分别为95%和5%，由此培育得到第五稀脉浮萍。

[n0066]

Comparative Example 1

对比例1

[0125]

Unlike Example 1, only Hogland working fluid was added, and no biogas slurry was added.

与实施例1不同的是，仅添加霍格兰工作液，未添加沼液。

[n0067]

Figure 2 shows the protein content detection results of the duckweed cultured in Examples 1-5 and Comparative Example 1. Specifically, in Comparative Example 1, when duckweed was cultured using only Hogland's working solution, the crude protein content in the duckweed was 24.18%, while the crude protein content of the duckweed in Examples 1-5 increased by 0.08%, 7.65%, 4.79%, 4.61%, and 3.08% respectively after adding biogas slurry.

实施例1-5与对比例1培养的稀脉浮萍蛋白含量检测结果如图2所示，具体的，对比例1中仅采用霍格兰工作液进行浮萍培养时，稀脉浮萍中的粗蛋白含量为24.18%，而添加沼液后的实施例1-5浮萍粗蛋白含量分别提高了0.08%、7.65%、4.79%、4.61%和3.08%。

Among them, when the biogas slurry concentration was 3% and 4%, the crude protein content of duckweed was significantly higher than that of duckweed in Comparative Example 1. When the biogas slurry concentration was 2%, the crude protein content of duckweed was extremely significantly higher than that of duckweed in Comparative Example 1.

其中，当沼液浓度为3%和4%时，浮萍的粗蛋白含量显著高于对比例1的浮萍蛋白含量，当沼液浓度为2%时，浮萍的粗蛋白含量极显著高于对比例1的浮萍蛋白含量。

[n0068]

2. *Lysimachia nummularia* (with few roots)

2、少根紫萍

[0128]

Example 6

实施例6

[0129]

(1) Obtain the rootless duckweed, rinse off the debris on the leaves and roots, put it in a culture pot, add Hogland working solution, and culture in an incubator for 1 week to obtain purified rootless duckweed;

（1）获取少根紫萍，冲洗掉叶片及根系上的杂物后，放入培养盆中加入霍格兰工作液，于培养箱中培养1周，得到纯化后的少根紫萍；

[0130]

(2) The first duckweed culture medium was obtained by mixing Hogland working solution (98.5%) and biogas slurry (1.5%).

（2）按照霍格兰工作液98.5%和沼液1.5%的比例混合，得到第一浮萍培养液；

[0131]

(3) After rinsing the leaves and roots of the purified duckweed to remove debris, dry the water and put the duckweed into the first duckweed culture solution, so that the surface of the duckweed leaves is facing upward and evenly distributed, and the duckweed must cover 60% of the surface of the first duckweed culture solution. Then, culture it in the incubator for 5 days to obtain the first duckweed.

（3）将纯化后的少根紫萍冲洗掉叶片和根系上的杂物后，吸干水分，投萍至第一浮萍培养液中，使少根紫萍的叶片表面朝上并均匀分布，且少根紫萍须覆盖第一浮萍培养液表面60%，并于培养箱中培养5天，得到第一少根紫萍。

[n0069]

Example 7

实施例7

[0133]

Unlike Example 6, in Example 7, the proportions of Hogland working solution and biogas slurry were 98% and 2%, respectively, thereby cultivating the second type of duckweed with few roots.

与实施例6不同的是，实施例7中的霍格兰工作液和沼液的占比分别为98%和2%，由此培育得到第二少根紫萍。

[n0070]

Example 8

实施例8

[0135]

Unlike Example 6, in Example 8, the proportions of Hogland working solution and biogas slurry were 97% and 3%, respectively, thereby cultivating the third type of duckweed with few roots.

与实施例6不同的是，实施例8中的霍格兰工作液和沼液的占比分别为97%和3%，由此培育得到第三少根紫萍。

[n0071]

Example 9

实施例9

[0137]

Unlike Example 6, in Example 9 the proportions of Hogland working solution and biogas slurry were 96% and 4%, respectively, thereby cultivating the fourth type of duckweed.

与实施例6不同的是，实施例9中的霍格兰工作液和沼液的占比分别为96%和4%，由此培育得到第四少根紫萍。

[n0072]

Example 10

实施例10

[0139]

Unlike Example 6, in Example 10, the proportions of Hogland working solution and biogas slurry were 95% and 5%, respectively, thereby cultivating the fifth type of duckweed with few roots.

与实施例6不同的是，实施例10中的霍格兰工作液和沼液的占比分别为95%和5%，由此培育得到第五少根紫萍。

[n0073]

Comparative Example 2

对比例2

[0141]

Unlike Example 6, only Hogland working fluid was added, and no biogas slurry was added.

与实施例6不同的是，仅添加霍格兰工作液，未添加沼液。

[n0074]

Figure 3 shows the protein content detection results of the duckweed cultured in Examples 6-10 and Comparative Example 2. Specifically, in Comparative Example 2, when only Hogland's working solution was used for duckweed culture, the crude protein content in duckweed was 18.13%, while the crude protein content of duckweed in Examples 6-10 after adding biogas slurry increased by 0.62%, 1.57%, 5.13%, 6.05%, and 5.37%, respectively.

实施例6-10与对比例2培养的少根紫萍蛋白含量检测结果如图3所示，具体的，对比例2中仅采用霍格兰工作液进行浮萍培养时，少根紫萍中的粗蛋白含量为18.13%，而添加沼液后的实施例6-10浮萍粗蛋白含量分别提高了0.62%、1.57%、5.13%、6.05%和5.37%。

Among them, when the biogas slurry concentration was 3% and 5%, the crude protein content of duckweed was significantly higher than that of duckweed in Comparative Example

1. When the biogas slurry concentration was 4%, the crude protein content of duckweed was extremely significantly higher than that of duckweed in Comparative Example 1.

其中，当沼液浓度为3%和5%时，浮萍的粗蛋白含量显著高于对比例1的浮萍蛋白含量，当沼液浓度为4%时，浮萍的粗蛋白含量极显著高于对比例1的浮萍蛋白含量。

[n0075]

Therefore, it can be seen that the method of this application, by adding biogas slurry to the Hogland working solution, can significantly increase the protein content of the cultured duckweed. This not only enables efficient use of biogas slurry from pig farms, saving water resources and providing an ideal way to recycle livestock wastewater and reduce sewage treatment costs, but also utilizes the nitrogen and phosphorus in the biogas slurry to promote the synthesis of duckweed protein, enhance protein synthesis efficiency, reduce the use of nutrient solution, or even completely replace nutrient solution in large-scale duckweed cultivation in production practice to obtain stable and reliable duckweed feed, thus providing a good foundation for the research on the feed application of duckweed.

由此可知，本申请的方法通过在霍格兰工作液中添加沼液，能够使得培养出的浮萍蛋白含量显著提高，不仅能够高效利用养猪场沼液，节约水资源，为养殖废水循环利用、降低污水处理费用提供一个理想途径，同时还能够利用沼液中的氮磷促进浮萍蛋白质的合成，增强蛋白质合成效率，减少营养液

使用甚至完全替代营养液在生产实践中大量养殖浮萍来获得稳定可靠的浮萍饲料，为浮萍的饲料化研究提供良好基础。

[n0076]

The above embodiments only illustrate several implementation methods of this application. The descriptions are relatively specific and detailed, but they should not be construed as limiting the scope of the invention patent.

以上实施例仅表达了本申请的几种实施方式，其描述较为具体和详细，但并不能因此而理解对发明专利范围的限制。

It should be noted that those skilled in the art can make several modifications or improvements without departing from the concept of this application, and these all fall within the scope of protection of this application.

应当指出的是，对于本领域的普通技术人员来说，在不脱离本申请构思的前提下，还可以做出若干变形或改进，这些都属于本申请的保护范围。

Therefore, the scope of protection of this patent application shall be determined by the appended claims.

因此，本申请专利的保护范围应以所附权利要求为准。