

水稻产后加工及综合利用

Rice post-harvest processing and comprehensive utilization



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从事粮食工程技术的教学与研究工作

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2021年全国粮食行业青年拔尖人才

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Youth award of Scientific and Technological of CGOA

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01

稻谷的分类及籽粒形态结构

Classification of rice grains and morphological structure of the seeds

1.1 稻谷的分类

Classification of rice grains

在中国，稻谷按照粒形和粒质可分为：粳稻、籼稻、糯稻

In China, Rice grains can be classified according to grain shape and grain quality: japonica, indica, and glutinous rice

粳稻：稻粒呈椭圆形或卵形，米粒强度大

Japonica:rice grains are oval or ovate in shape,High rice grain strength

籼稻：稻粒呈细长形，米粒强度小

Indica:Rice grains are elongated in shape,Low rice grain strength

糯稻：分为粳糯和籼糯，米粒乳白色，不透明或半透明

Glutinous rice:divided into japonica glutinous and indica glutinous, the rice grains are milky white, opaque or translucent



粳稻
japonica



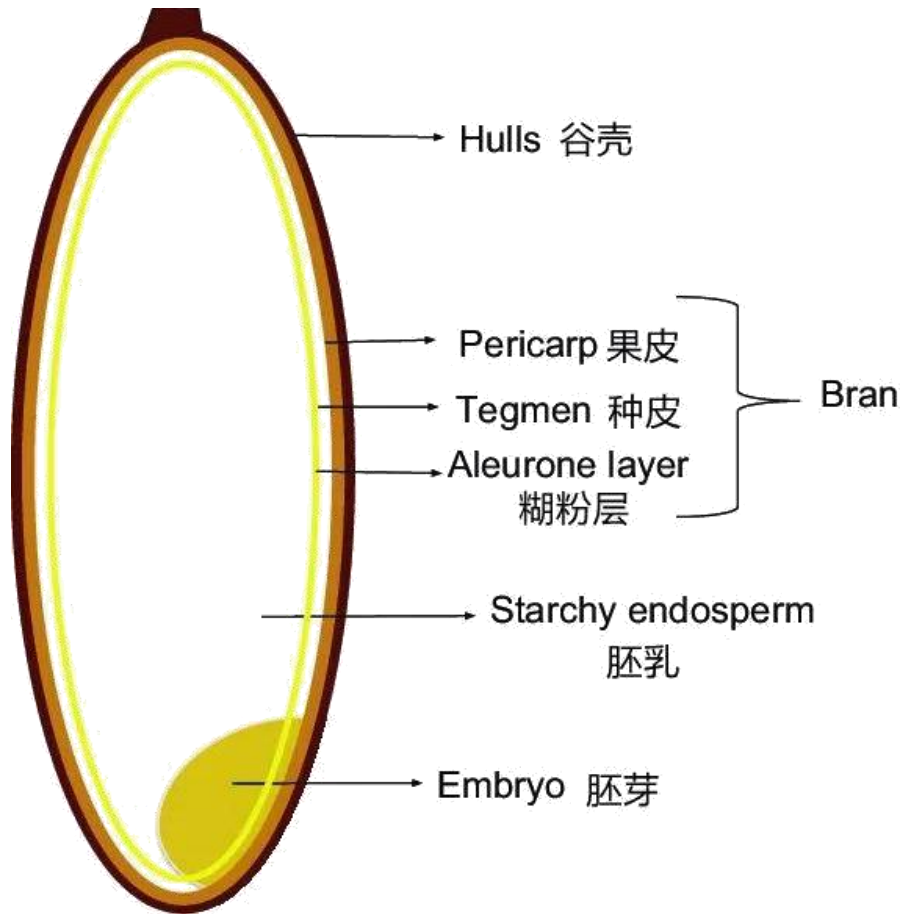
籼稻
indica



糯稻
glutinous rice

1.2 稻谷籽粒结构及组成

Structure and composition of rice grain



谷皮: 纤维素、半纤维素、矿物质、脂肪、维生素、植酸
Grain husk: cellulose, hemicellulose, minerals, fat, vitamins, phytic acid

糊粉层: 蛋白质、脂类、矿物质、维生素、营养价值较高
Aleurone layer: proteins, lipids, minerals, vitamins, high nutritional value

胚乳: 大量淀粉、少量蛋白质、维生素、矿物质
Endosperm: high amounts of starch, small amounts of protein, vitamins, minerals

胚芽: 富含优质蛋白质、脂类、矿物质、维生素B₁、维生素E
Embryo: rich in high quality proteins, lipids, minerals, vitamin B₁, vitamin E

02

稻谷初级加工

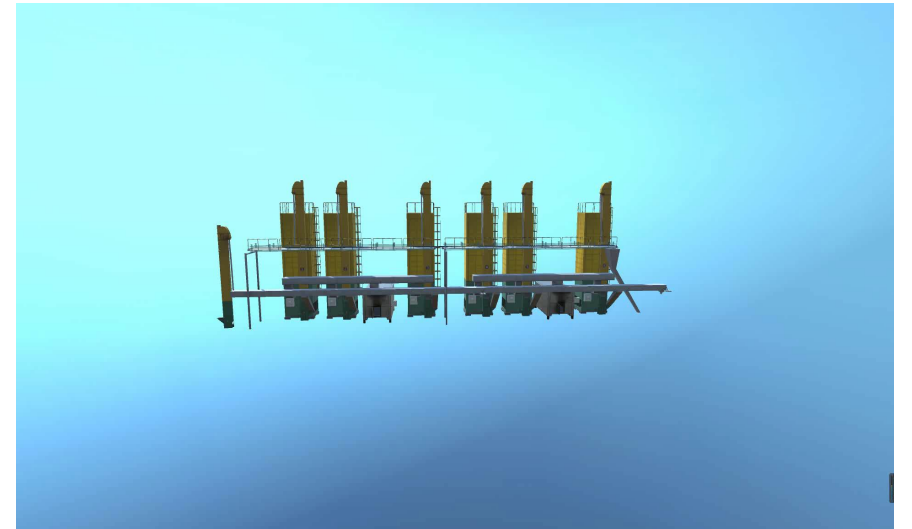
Primary processing of paddy

2.1 稻谷初级加工及其流程

Primary processing of rice and its steps

稻谷干燥：收获后稻谷水分往往偏高，通过**热风**、**太阳辐照**、**微波**等多种方式降低稻谷**水分含量**，便于后续**储藏和加工**。

The moisture content of harvested paddy rice is high, and the **moisture content** of rice can be reduced by **hot air**, **solar irradiation**, **microwave** and other ways to facilitate subsequent **storage and processing**.



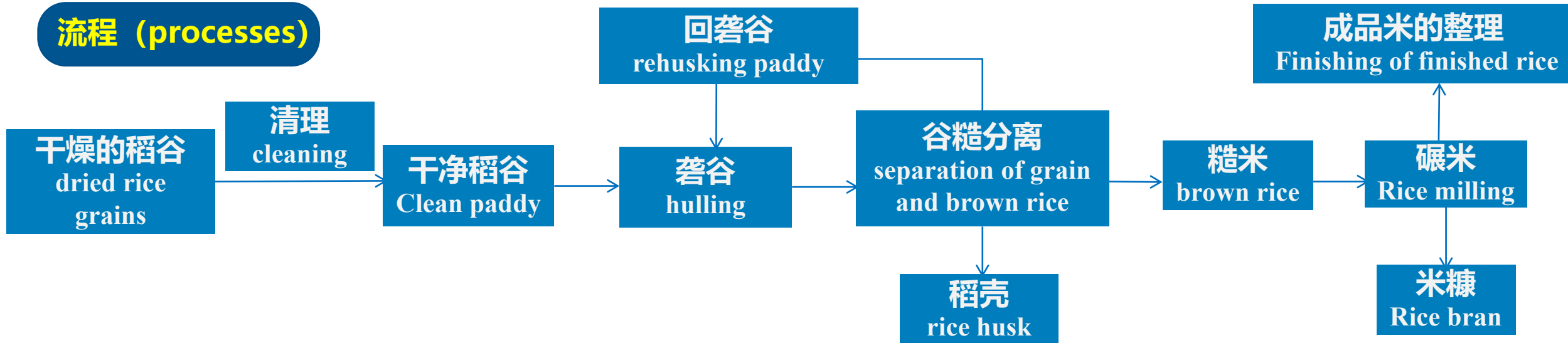
2.1 稻谷初级加工及其流程

Primary processing of rice and its steps

稻谷初加工是将原粮稻谷按**清理、砻谷、砻下物分离、碾米**的常规方法，制成符合一定质量标准的食用大米(普通大米)的加工过程。

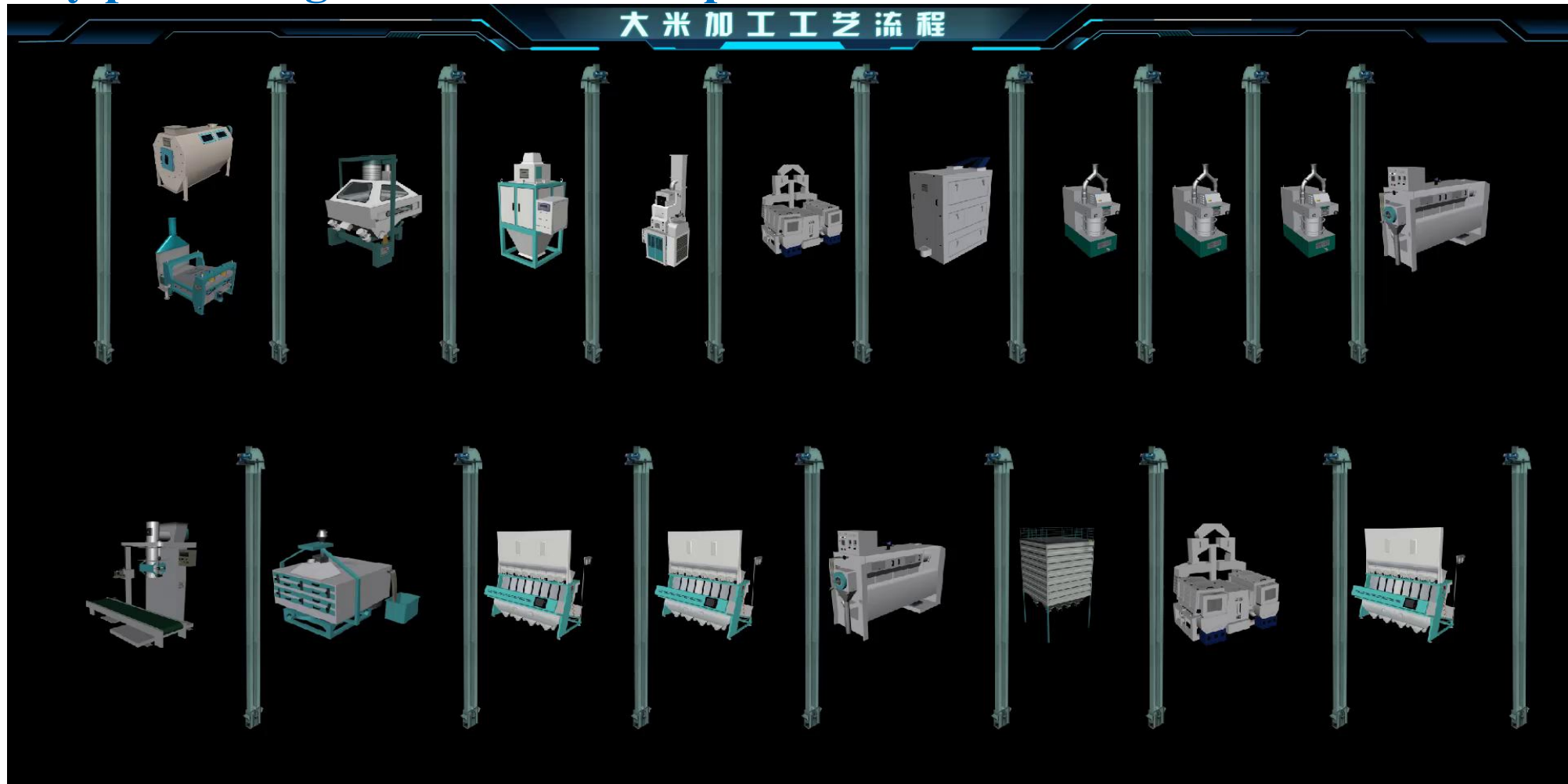
Primary processing of rice is the processing of raw grain rice according to the conventional methods of **cleaning, hulling, separation of hulled material, and rice milling**, to make edible rice (common rice) that conforms to certain quality standards.

流程 (processes)



2.1 稻谷初级加工及其流程

Primary processing of rice and its steps



2.2 稻谷的清理

Cleaning of rice grains

清理目的

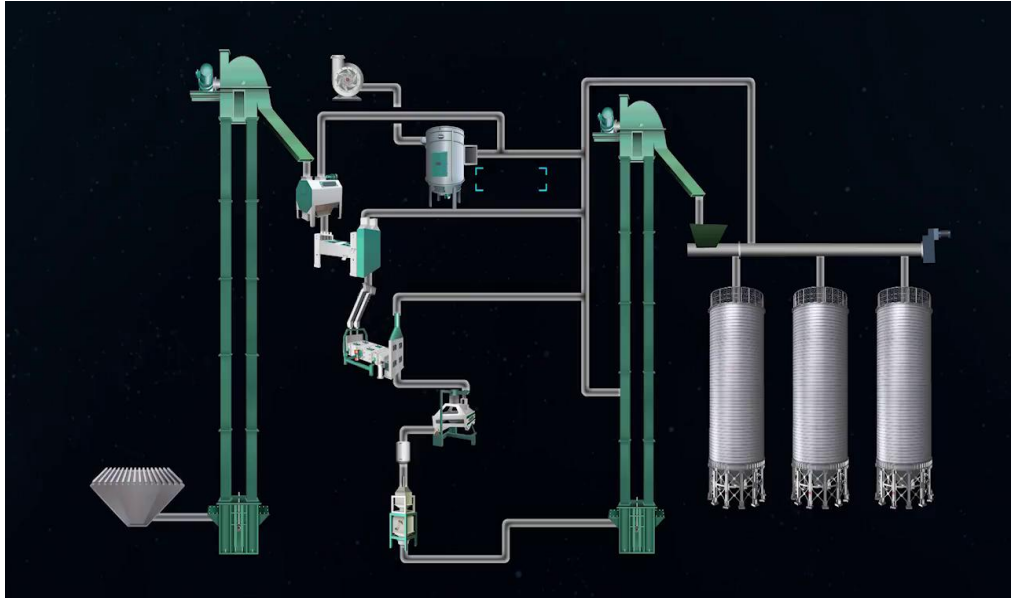
Purpose of paddy cleaning

由于收获后稻谷中含有**秸秆、砂石、灰尘**等各种杂质可能影响后续加工流程。因此需要将稻谷中的各类杂质尽可能的清除干净，做到“净谷上砻”，**保证机械加工设备的安全运行；发挥或提高设备的工艺效果；保证工艺流程的稳定性和连续性；确保成、副产品质量和车间环境卫生。**

As the post-harvest rice contains **straw, gravel, dust and other impurities** may affect the subsequent processing process. Therefore, it is necessary to remove all kinds of impurities in the paddy as much as possible, so as to achieve the "clean grain on the huller", **to ensure the safe operation of the mechanical processing equipment; play or improve the process effect of the equipment; to ensure the stability and continuity of the process; to ensure that into the quality of the product, vice product quality and environmental hygiene of the workshop.**



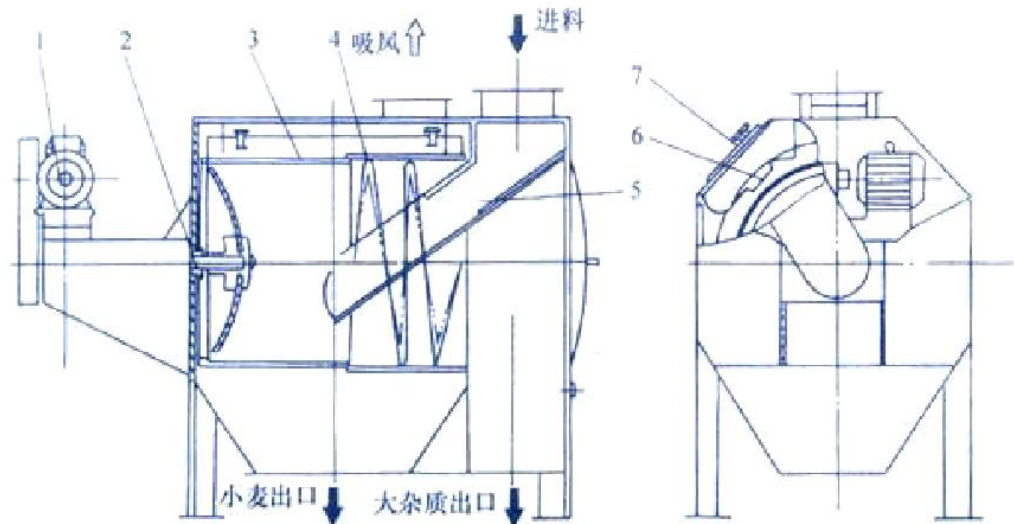
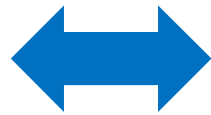
稻谷清理的工艺流程 Process flow of rice cleaning



圆筒初清筛 Cylinder primary screen

圆筒初清筛主要用以清除出大的杂质，如稻草、麻绳、纸片、土块等杂物，以保护机器设备免于损坏。根据物料性质选配适宜的筛孔，就能达到要求和分离效果。

The screen is mainly used to remove large impurities, such as straw, twine, paper, dirt and other debris, to protect the machinery and equipment from damage. According to the nature of the material, the appropriate sieve can be selected to achieve the requirements and separation effect.



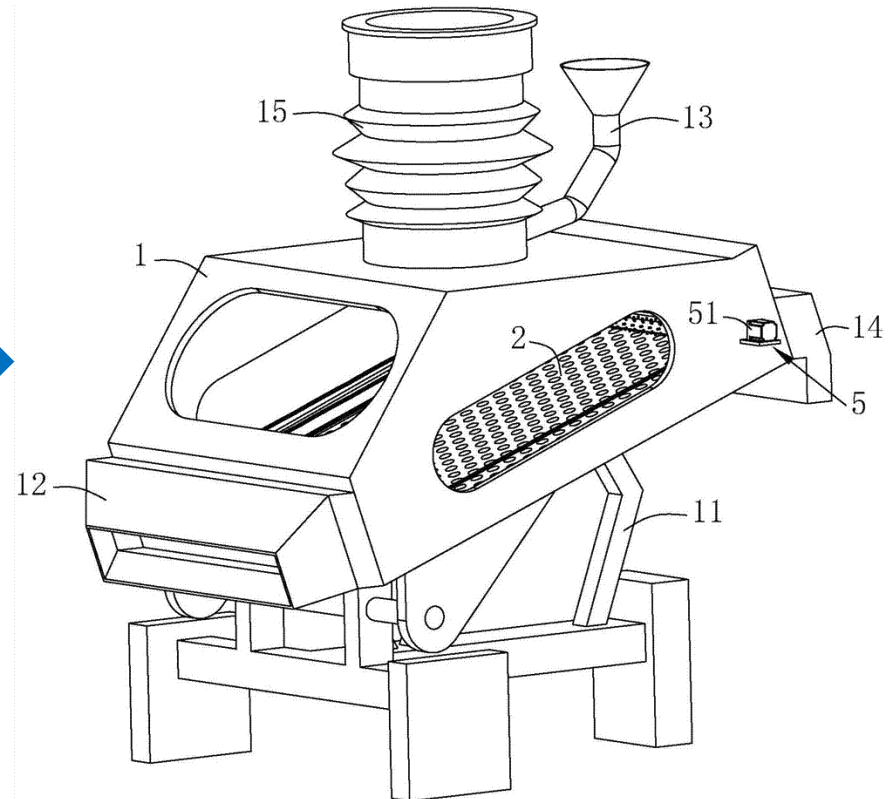
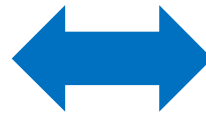
圆筒初清筛结构

1——电动机；2——传动轴；3——筛筒；4——螺旋；5——进料管；6——清理刷；7——检修门

比重去石机 specific-gravity stoner

比重去石机借助振动运动，调节气流和调节筛面倾斜度来进行粮食和砂石的分离。

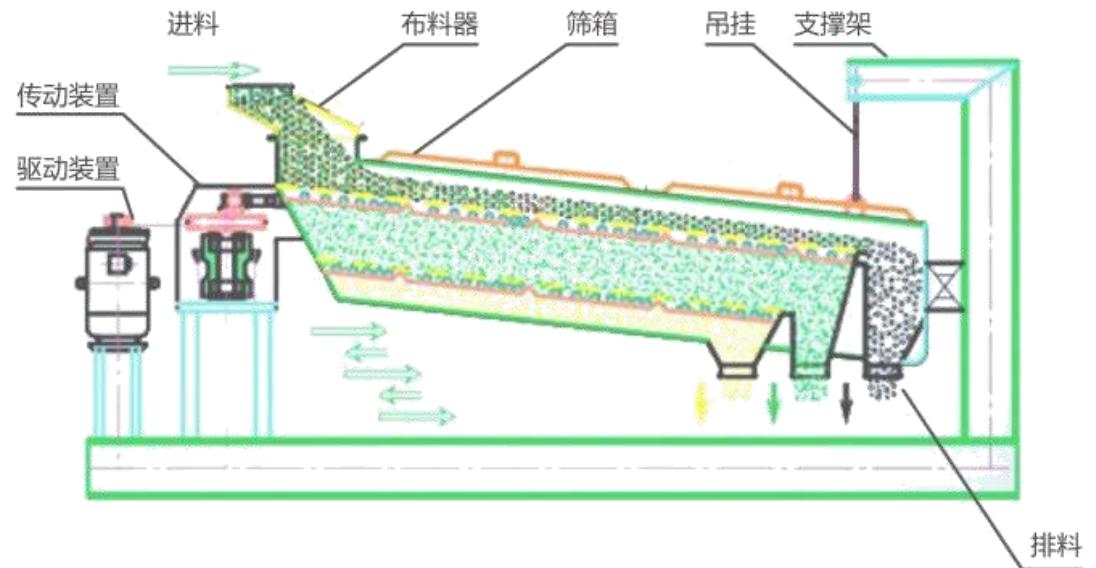
The specific gravity stone removal machine uses vibration movement to adjust the air flow and adjust the inclination of the screen surface to separate grain and sand.



平面回转筛 gyratory vibrating screen

平面回转筛采用了**平面回转运动原理**，利用平面回转振动筛**上下振动**，网下有自动清理设备将杂质与粮食分离开来。

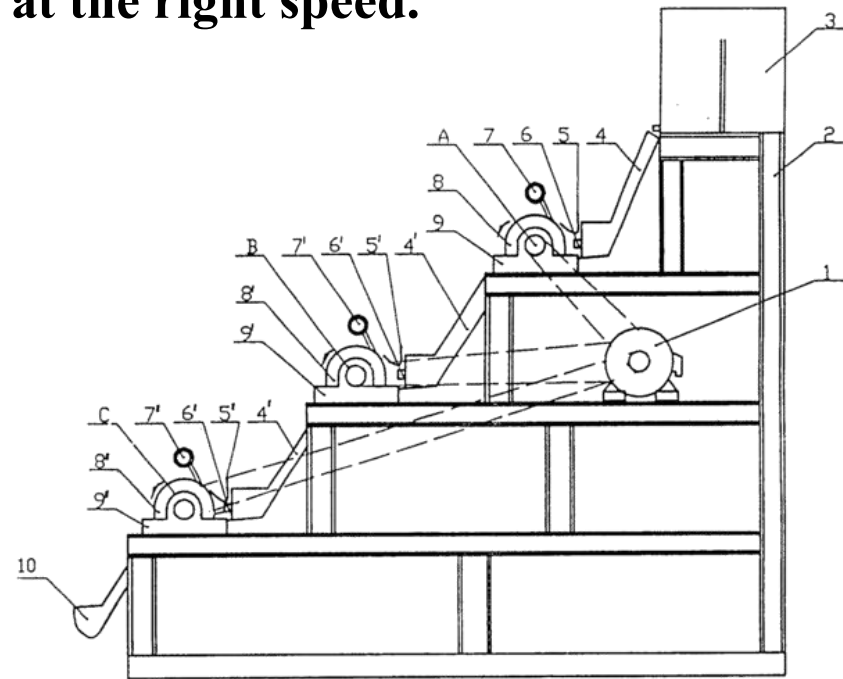
The gyratory vibrating screen adopts **the principle of flat rotary motion** and utilizes **up and down vibration** on the flat rotary vibrating screen. There is an automatic cleaning device below the screen to separate impurities from grain.



多辊式磁选机 Multi-roll magnetic separator

多辊式磁选机是根据粮食及其中混杂的**磁性**物质的不同磁性，物料以合适的速度通过一个封闭的强大磁场时将粮食和铁杂质分离开来。

The multi-roll magnetic separator is based on the different magnetic properties of the grain and the **magnetic** substances mixed in it, and the grain and **iron impurities** are separated when the material passes through a closed strong magnetic field at the right speed.

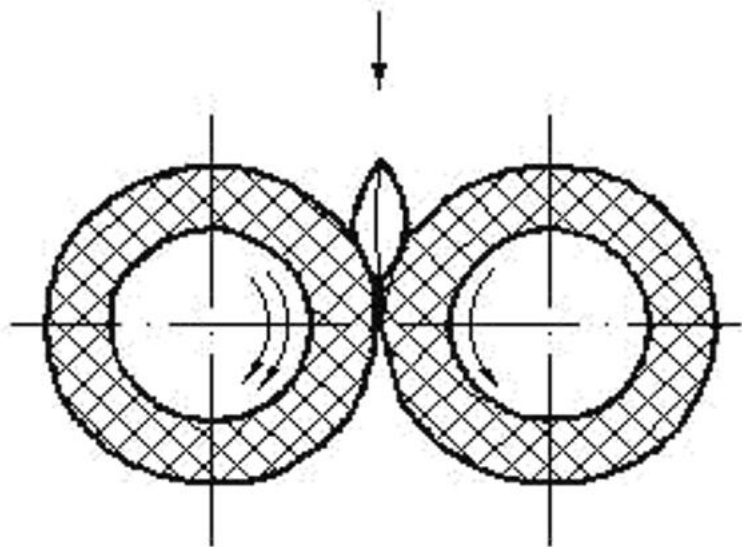


2.3 稻谷的脱壳

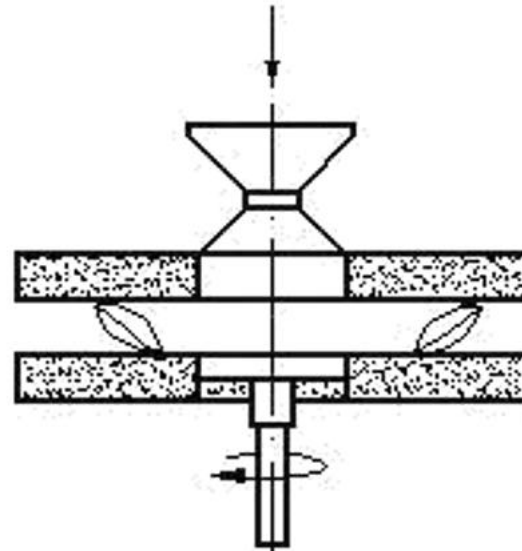
Dehulling of rice

稻谷的脱壳又称为砻谷，根据稻谷脱壳时的受力状况和脱壳方式，稻谷脱壳方法通常可分为挤压搓撕脱壳、端压搓撕脱壳和撞击脱壳三种。

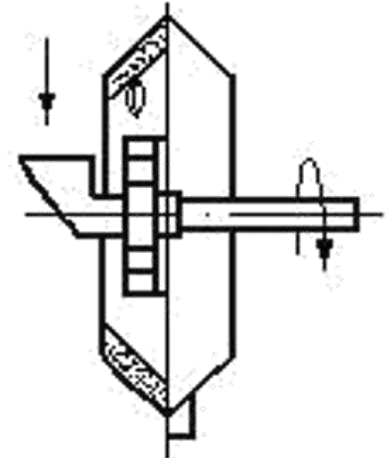
The dehulling of paddy is also called husking, according to the force condition and dehulling method when dehulling paddy, the dehulling method of paddy can be divided into three kinds, namely, extruding and rubbing, end pressing and rubbing, and knocking dehulling.



挤压搓撕脱壳



端压搓撕脱壳



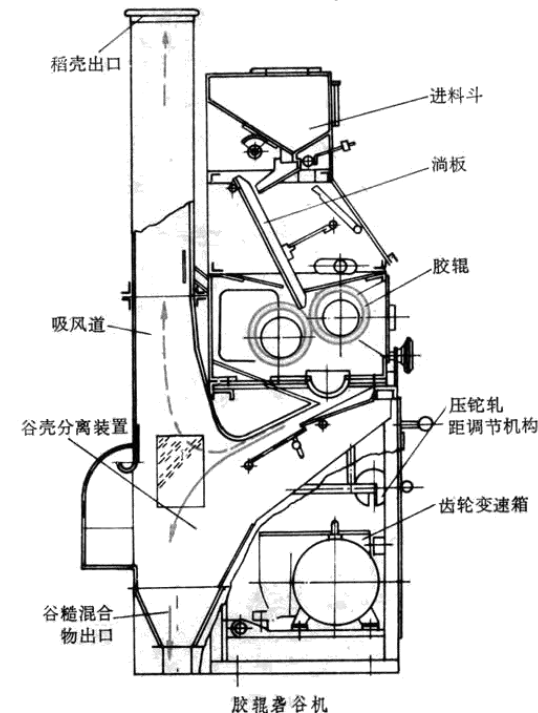
撞击脱壳

稻谷脱壳设备 Paddy hulling equipment

根据三种脱壳方法及原理，常见的砻谷机设备分为胶辊砻谷机、砂盘砻谷机和离心砻谷机，其中最常用的为胶辊砻谷机。

According to the three hulling methods and principles, common hulling equipment is divided into rubber roller huller, sand disk huller and centrifugal huller, the most commonly used is the rubber roller huller.

胶辊式砻谷机
rubber roller huller



2.4 谷糙分离

paddy separation

2.4.1 谷糙分离的基本方法与原理

The basic method and principle of grain-roughness separation

① 筛选法 screening method

筛选法是利用稻谷和糙米间粒度的差异及其自动分级特性，配备以合适的筛孔，借助筛面的运动进行谷糙分离的方法。

The screening method is to use the difference in particle size between rice and brown rice and its automatic grading characteristics, equipped with a suitable sieve, and the method of separating rice from brown rice by means of the movement of the sieve surface.

常用的设备：**谷糙分离平转筛**

Commonly used equipment : **Valley rough separation rotary sieve**



②比重分离法 specific gravity separation method

比重分离法是利用稻谷和糙米比重的不同及自动分级特性，借助双向倾斜并往复振动的筛面使稻谷上浮、糙米下沉。

The specific gravity separation method is based on the difference in specific gravity between rice and brown rice and its automatic grading characteristics. With the help of a two-way inclined and reciprocating vibrating screen surface, the rice floats up and the brown rice sinks.

常用设备：**重力谷糙分离机**

Commonly used equipment:**gravity valley rough separator.**



③弹性分离法Elastic separation method

弹性分离法是利用稻谷和糙米的弹性差异和自动分级特性进行谷糙分离的方法。

Elastic separation method is a method of separating rice from brown rice by using the elastic difference and automatic grading characteristics of rice and brown rice.

常用设备：**撞击谷糙分离机**

Commonly used equipment:**gravity valley rough separator**



2.4.2 谷糙分离设备 Grain rough separation equipment

① 谷糙分离平转筛 Valley rough separation rotary sieve

(1) 优点: 产量大、结构简单、操作方便

(1) Advantage: Large output, simple structure and convenient operation.



(2) 主要工艺指标 main process indicators

- 回砻谷中含糙米量 $\leq 10\%$ 。
- The content of brown rice in rice hulling is **less than 10%**.
- 净糙含谷粒数 ≤ 40 粒·kg⁻¹。
- Grain number of net rough is **less than 40 grains·kg⁻¹**
- 回筛物料流量为净糙流量的**40% ~ 50%**。
- The material flow rate of rescreening is **40% ~ 50%** of the net rough flow rate.



②重力谷糙分离机 gravity type paddy separator

(1)最大特点：对品种混杂严重、粒度均匀性差的稻谷原料的加工有较强的适应性，谷糙分离效率高，操作管理简单等。

(1)Most important feature: It has strong adaptability to the processing of rice raw materials with serious mixture of varieties and poor particle size uniformity, **high separation efficiency** of grain and rough, **simple** operation and management, etc.



(2) **工艺指标** process indexes

- **回砻谷中含糙米量 $\leq 10\%$ 。**
- **The content of brown rice in rice hulling is **less than 10%**.**
- **净糙含谷粒数 ≤ 30 粒·kg⁻¹。**
- **Grain number of net rough is **less than 40 grains·kg⁻¹****
- **回机物料流量与净糙流量之比 $\leq 40\%$ 。**
- **The ratio of material flow to net roughness flow is **less than 40%**.**



③谷糙分离机 grain rough separator---**撞击谷糙分离机 Impinging Grain Rough Separator**

采用高速旋转的**撞击器**将谷物投入撞击室，通过撞击和摩擦的作用，使谷物的外壳与**糠层**分离。分离后的糠层会通过**气流或振动筛**分离出去，而去壳后的谷物则会通过出料口排出。

The Impact Dehuller, utilizing high-speed rotating **impactors**, is employed to introduce grains into the impact chamber, where the hulls and **bran layers** are separated from the grains through the combined action of impact and friction. The separated bran layer is subsequently removed through either **air flow or vibrating screens**, while the dehulled grains are discharged through the outlet.



2.4.3 谷糙分离工艺效果的评定指标

Evaluation indicators of the effect of grain-roughness separation process

① 糙米纯度 Purity of brown rice

糙米纯度通常是用糙米含谷率表示，即经谷糙分离设备一次分离后选出的净糙中含稻谷的质量百分比。

The purity of brown rice is usually expressed by the grain content of brown rice, that is, the mass percentage of rice in the net brown selected by the rice-roughness separation equipment after one separation.

② 选糙率 Percentage of machine-selected brown rice

定义：单位时间内选出的糙米质量与进机物料中糙米质量的百分比。

Definition: The percentage of brown rice mass selected per unit time to the brown rice mass in the incoming material.

③回砻谷纯度Purity of rice husk

定义：回砻谷中含糙米质量的百分比

Definition: The percentage of brown rice mass in rice husk.

④稻谷提取率Extraction rate of rice

定义：单位时间内提出稻谷的质量与进机物料中稻谷质量的百分比

Definition: The percentage of the quality of rice and the quality of rice in the material entering the machine is put forward per unit time

2.5碾米Milling rice

2.5.1碾米的基本方法The basic method of rice milling

物理碾米法（各国普遍采用） Physical milling method（Widely used in various countries）

①擦离碾白Rubbing off whitening

依靠强烈的摩擦擦离作用使糙米碾白，适宜于籽粒强度较大、皮层柔软的糙米。

Brown rice is whitened by strong friction and friction. It is suitable for brown rice with strong grain strength and soft cortex.

②碾削碾白Grinding Whitening

借助高速旋转的金刚砂碾辊表面密集的坚硬锐利金刚砂粒的砂刃，对糙米皮层不断地施加碾削作用，使皮层破裂、脱落，糙米得到碾白。适宜于籽粒结构强度较差、表面较硬的糙米。

With the help of high-speed rotating emery grinding roller surface dense hard sharp emery grit sand blade, the brown rice cortex is constantly applied to the grinding effect, so that the cortex rupture, shedding, brown rice is whitened. It is suitable for brown rice with poor grain structure strength and hard surface.

2.5.2 碾米的基本原理 The basic principle of rice milling

① 碰撞 Collision

碰撞运动是米粒在碾白室内的基本运动之一，有米粒与碾辊的碰撞、米粒与米粒的碰撞、米粒与碾白室外壁的碰撞。

Collision movement is one of the basic movements of rice grains in the whitening room. There are collisions between rice grains and rollers, collisions between rice grains and rice grains, collisions between rice grains and whitening outdoor walls.

② 碾白压力 Bleaching pressure

碰撞运动在碾白室内建立起的压力，称为碾白压力。根据物理碾白方式分为摩擦碾白压力和碾削碾白压力。

The pressure established by the collision motion in the whitening chamber is called the whitening pressure. It is divided into friction whitening pressure and grinding whitening pressure according to the physical whitening method.

③翻滚Rolling

米粒在碾白室内的翻滚运动，是米粒进行均匀碾白的重要条件

The rolling movement of rice grains in the whitening chamber is an important condition for uniform whitening of rice grains.

④轴向输送 Axial conveying

轴向输送是保证米粒碾白运动连续不断的必要条件

Axial conveying is a necessary condition to ensure the continuous movement of rice milling.

2.5.3米粒群体在碾白室内的运动状态 The movement state of rice grain group in the whitening chamber

①米粒处于运动状态中 Rice grains are in **motion**.

②流动的米粒充满整个碾白室，其体积与碾白室的体积相同。

The flowing rice grain **fills the whole milling chamber**, and its volume is the same as that of the milling chamber.

③流动的米粒之间的距离具有可压缩性 The distance between the flowing rice grains is **compressible**.

④流动的米粒具有黏滞性。 The flowing rice grain has **viscosity**.

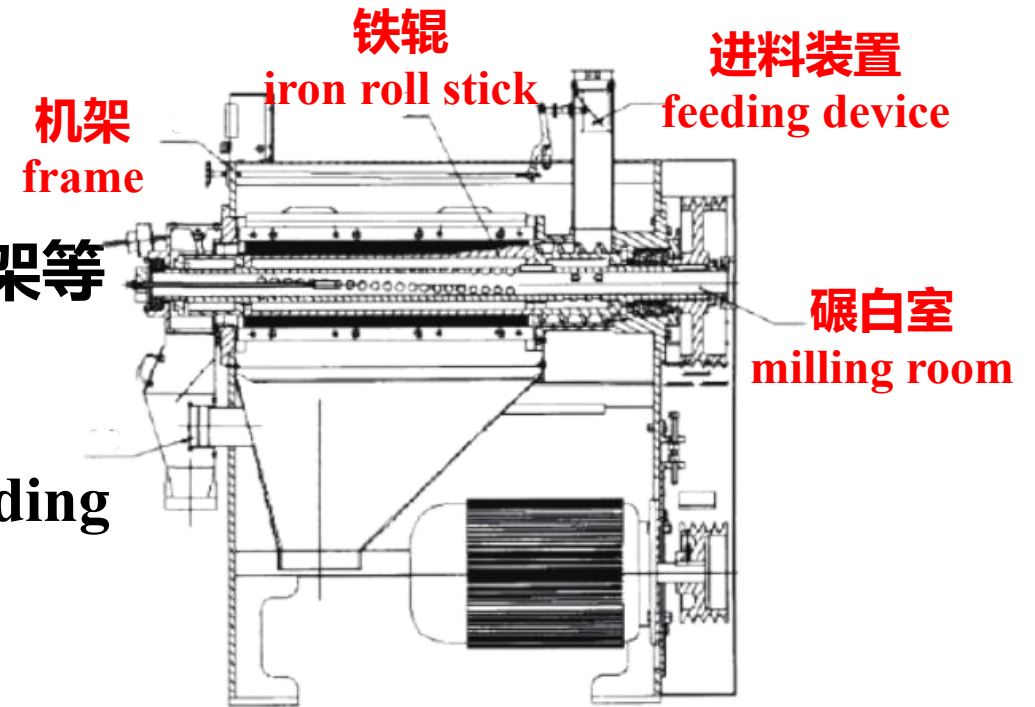
2.5.4 典型碾米设备 Typical rice milling equipment

摩擦擦离型碾米机 Frictional erasing rice mill

① 铁辊碾米机 Iron roller rice mill

铁辊碾米机主要由进料装置、碾白室、铁辊和机架等部分组成。

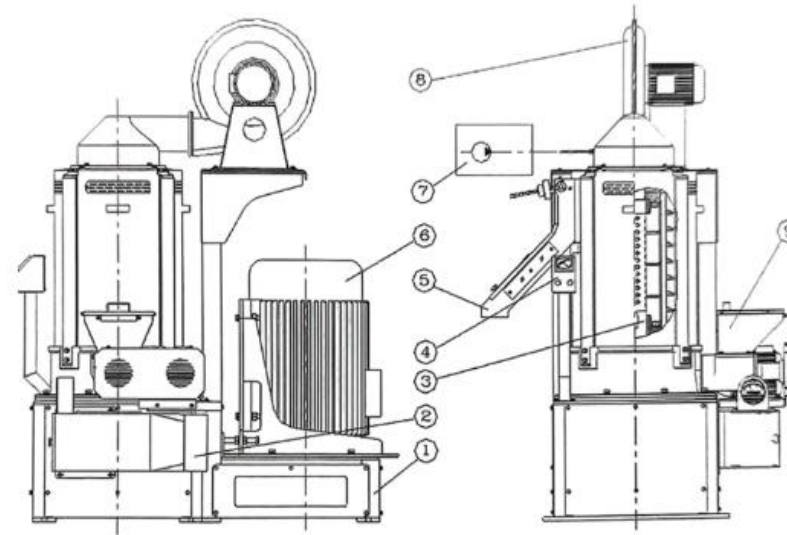
The iron roller rice mill is mainly composed of feeding device, milling room, iron roll stick and frame.



②铁辊喷风碾米机 Iron roller air-blast rice mill

如NP·13.6型丰收1号铁辊碾米机，主要由进料装置、碾白室、喷风装置、糠粞收集装置、传动装置及机架等部分组成。

For example, NP·13.6 Fengshou No.1 iron roller rice mill is mainly composed of feeding device, milling room, air jet device, chaff collecting device, transmission device and frame.

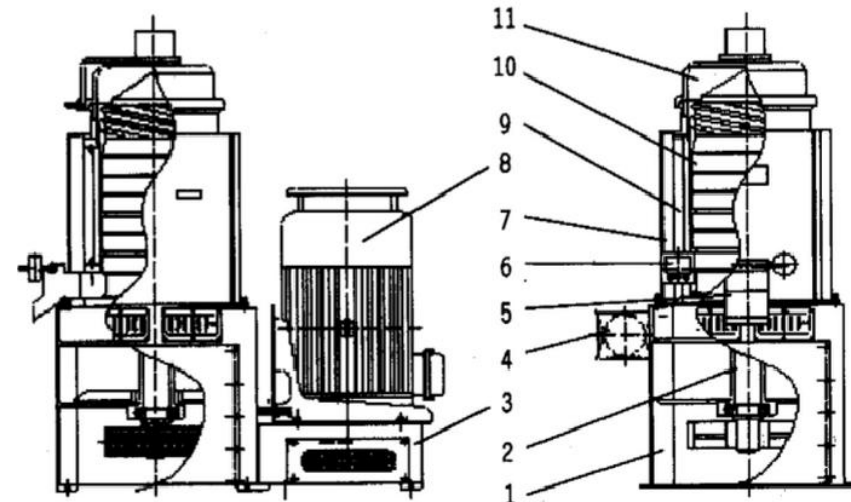


1机架 2吸糠装置 3碾白室 4电器控制 5出料口
6主驱动 7加湿系统 8喷风风机 9进料装置

碾削型碾米机 Milling type rice miller

例如，DSRD型立式砂辊碾米机主要由碾白辊、出料嘴、电流计、排料装置、传动装置等部分组成。

For example, DSRD vertical sand roller rice mill is mainly composed of whitening roller, extrusion nozzle, galvanometer, discharge device, transmission device and other parts.



1. 机架 2. 轴承座 3. 电机座 4. 出料嘴 5. 吸风管 6. 电流计 7. 罩壳
8. 电机 9. 竖梁 10. 碾白辊 11. 分料器

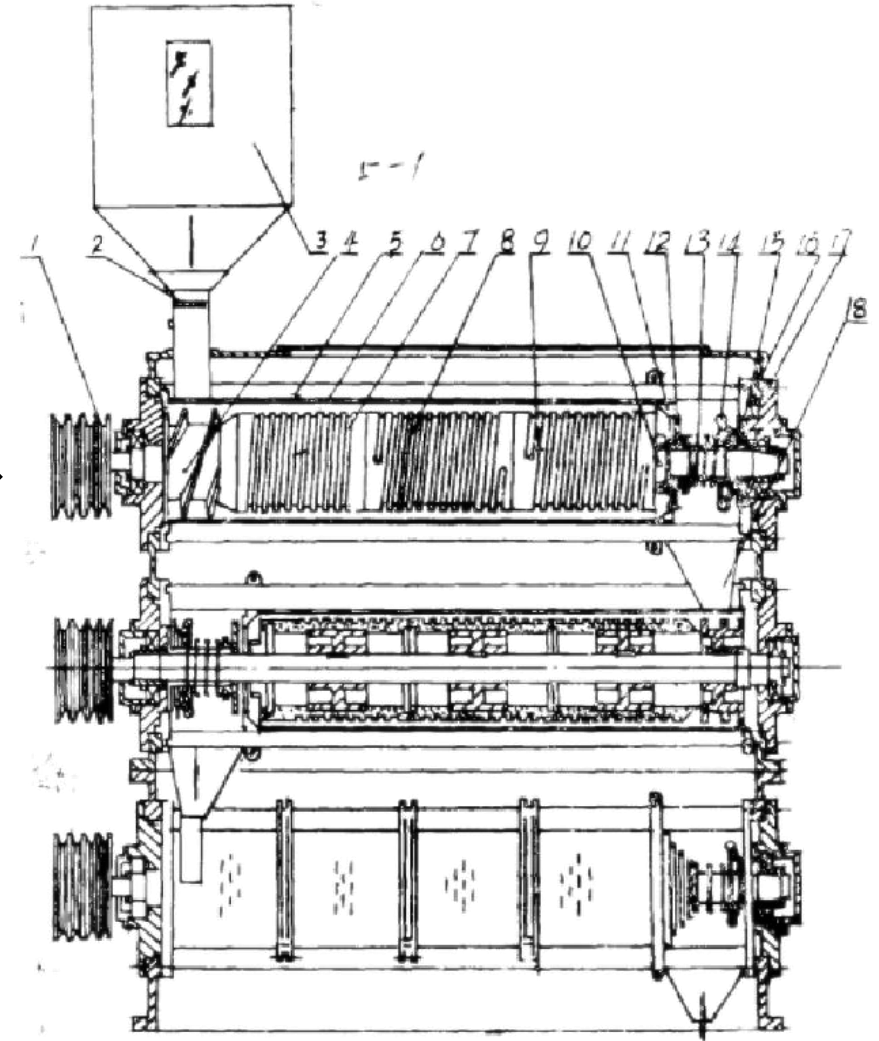
混合型碾米机 Mixed rice milling machine

螺旋槽砂辊碾米机

spiral groove sand roller rice mill

螺旋槽砂辊碾米机的主要由进料装置、碾白室、擦米室、传动装置、机架等组成。

The NS-type spiral groove sand roller rice mill is mainly composed of a feed device, a whitening chamber, a rice wiping chamber, a transmission device, and a frame.



1. 传动装置 2. 流量调节装置 3. 储料斗 4. 输送机 5. 横梁 6. 米筛 7、8、9. 砂辊 10. 拔米器
11. 排米口 12. 压力门 13. 弹簧 14. 手轮 15. 螺母 16. 套筒 17. 机体 18. 接料斗

2.6成品米的处理 Processing of finished rice

2.6.1擦米 Rubbing rice

擦米的主要作用是擦除粘附在米粒表面上的糠粉，使米粒表面光洁，提高成品的外观色泽，同时也利于大米的贮藏和米糠的回收利用。

The main function of wiping rice is to wipe off the bran powder adhered to the surface of rice grains, so that the surface of rice grains is smooth and clean, and the appearance and color of finished products are improved. At the same time, it is also conducive to the storage of rice and the recycling of rice bran.

2.6.2凉米 Cool rice

凉米的目的是为了降低米温，以利于贮藏。目前，使用较多的凉米专用设备是流化床，它不但可以降低米温，而且还兼有去湿、吸除糠粉等作用。

The purpose of cool rice is to reduce the temperature of rice to facilitate storage. At present, the most widely used special equipment for cold rice is fluidized bed, which can not only reduce the temperature of rice, but also have the functions of dehumidifying and absorbing bran powder.

2.6.3 白米分级 White rice grading

将白米分成不同含碎等级的工序称为白米分级。白米分级目的主要是根据成品的质量要求，分离出超过标准的碎米。

The process of dividing white rice into different crushing grades is called white rice grading. The purpose of grading white rice is mainly to separate broken rice that exceeds the standard according to the quality requirements of the finished product.

① MMJP-1型白米分级平转筛 white rice grading rotary sieve

MMJP-1型白米分级平转筛的结构主要由进料斗、筛体、偏心回转机构、传动调速机构和机架等部分组成。

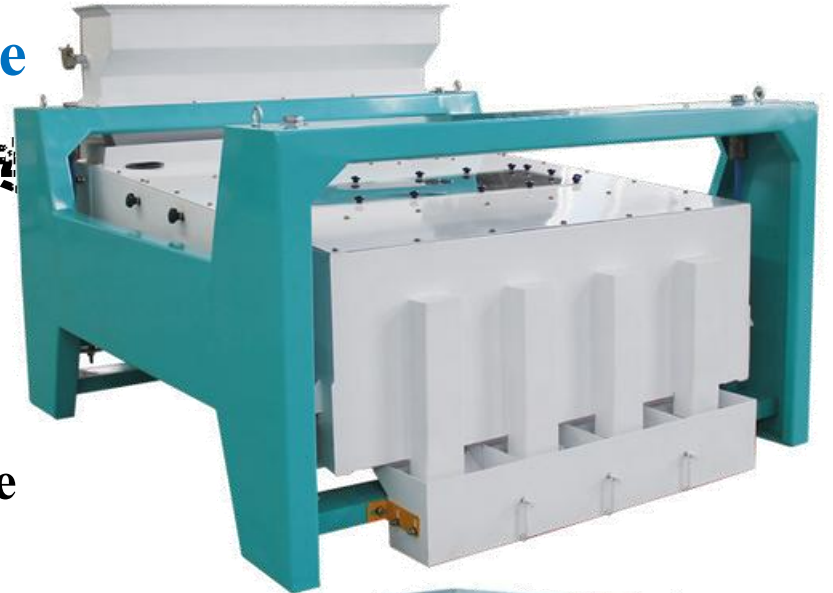
The structure of **MMJP-1 type** white rice grading rotary screen is mainly composed of feed hopper, screen body, eccentric rotary mechanism, transmission speed regulation mechanism and frame.



②MMJM型白米分级平转筛white rice grading rotary sieve

MMJM型白米分级平转筛，由进料机构、吸糠装置、传动机构、筛体、机架和悬挂装置等组成。

The **MMJM** white rice grading rotary sieve is composed of feeding mechanism, suction device, transmission mechanism, sieve body, frame and suspension device.



③国际先进设备展示International advanced equipment display

例如，日本佐竹的白米分级机

For example, Japan Sasaki white rice classifier



2.6.4抛光 Polishing

将符合一定精度的白米，经着水、润湿后，送入白米抛光机内，在一定温度下，米粒表面的淀粉胶质化，使得米粒晶莹光洁、不粘附糠粉、不脱落米粉，从而改善其贮存性能，提高其商品价值。

The white rice conforming to a certain precision is put into the white rice polishing machine after watering and wetting. At a certain temperature, the starch on the surface of the rice grain is gelatinized, so that the rice grain is crystal clear, does not adhere to the bran powder, and does not fall off the rice flour, thereby improving its storage performance and increasing its commodity value.

①滴定管加水 Titration tube water

调节每分钟水滴数量控制着水量，水滴直接进入抛光室。

Adjust the number of water droplets per minute to control the amount of water, water droplets directly into the polishing chamber.

② 压缩空气喷雾 Compressed air spray

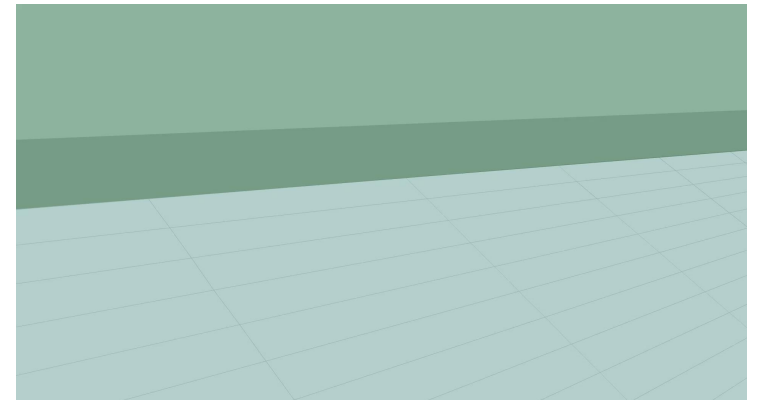
通过空气压缩机产生的高压(0.2 ~ 0.4MPa)气流，将水雾化，米粒通过雾化区得以着水、湿润。着水量由流量计控制。

Through the high-pressure (0.2 ~ 0.4MPa) air flow generated by the air compressor, the water is atomized, and the rice grain is wetted and wetted through the atomization zone. The amount of water is controlled by the flowmeter.

③ 水泵喷雾 Water pump spray

采用电动水泵，使水通过喷嘴形成雾状，米粒通过雾化区被着水、湿润。

The electric water pump is used to make the water form a mist through the nozzle, and the rice grain is wetted and wetted through the atomization area.



供水量检测

④ 喷风加水 Spraying water

由流量计控制的水通过喷风风机产生的高压气流形成雾化，与空气一同进入抛光室，对米粒表面进行湿润。

The water controlled by the flowmeter is atomized by the high-pressure airflow generated by the jet fan, and enters the polishing chamber together with the air to wet the surface of the rice grains.

⑤ 超声波雾化 Ultrasonic atomization

由超声波雾化器将水雾化，然后送至抛光机的进料斗内，借此将通过进料斗的米粒着水、湿润。

The water is atomized by an ultrasonic atomizer and then sent to the feed hopper of the polishing machine, so that the rice grains passing through the feed hopper are watered and moistened.

⑥MPGF型白米抛光机MPGF white rice polishing machine

MPGF型白米抛光机它主要由雾化装置、进 料装置、抛光室、喷风系统等组成。

The MPGF white rice polishing machine is mainly composed of atomization device, feeding device, polishing chamber, air jet system and so on.

⑦MPGT型白米抛光机MPGT white rice polishing machine

MPGT型白米抛光机为铁辊喷风抛光机，由进料斗、喷雾装置、抛光室、喷风风机及机体等部分组成。

The MPGT white rice polishing machine is an iron roller jet polishing machine, which is composed of a feed hopper, a spray device, a polishing chamber, a jet fan and a body.



⑧ BSPA型白米抛光机 BSPA white rice polishing machine

由加湿、抛光、供水三大系统组成。

It consists of three systems : humidification, polishing and water supply.



日本佐竹的大米抛光机

Japanese Sasaki rice polishing machine

2.6.5色选 Color selection

①色选基本原理 Basic principle of color selection

利用物料之间的色泽差异进行分选的

Sorting by using the same color difference of materials.

②MMS·24A型色选机 MMS · 24A color sorter

MMS·24A型色选机由进料斗、振动喂料器、通道、光电箱、出料斗、流量计、斗式提升机和电控箱等部分组成。

MMS·24A color sorter is composed of feeder hopper, vibrating feeder, channel, photoelectric box, discharge hopper, flow meter, bucket elevator and electric control box.



2.7加工成品米的质量评定

Quality assessment of processed rice



中国现行大米国家标准 (**GB/T 1354-2018**) 将大米按食用品质分为：大米 (籼米、粳米、籼糯米、粳糯米) ;优质大米 (优质籼米、优质粳米)

China's current national standard for rice (**GB/T 1354-2018**) categorizes rice according to its edible quality into: rice (indica, japonica, indica glutinous rice, japonica glutinous rice); high-quality rice (high-quality indica rice, high-quality japonica rice)

在大米 (籼米、粳米、籼糯米、粳糯米) 的质量标准中，将碎米、加工精度和不完善粒含量作为定级指标，细分为：一级、二级、三级。In the quality standard of rice (indica rice, japonica rice, indica glutinous rice, japonica glutinous rice), the broken rice, processing accuracy and imperfect grain content as a grading index, subdivided into: Grade 1, Grade 2, Grade 3

从优到良的顺序依次是：优质大米 > 大米；一级 > 二级 > 三级

The order from good to excellent is: high quality rice > rice; Grade 1 > Grade 2 > Grade 3

标准一级米：基本上除净了糙米皮层、糊粉层和胚，所以淀粉含量在几类大米中最高，粗纤维素、灰分含量则最低。不过一等米胀性好、出饭率高，食用口感好，消化吸收率也最高。

Standard Grade 1 rice: basically, the brown rice cortex, the dextrin layer and the embryo are removed, so the starch content is the highest among several types of rice, while the crude cellulose and ash content are the lowest. However, first-class rice has good distensibility, high rice production rate, good eating taste, and the highest digestive absorption rate.

表 1 大米质量指标

品种	籼米			粳米			籼糯米		粳糯米		
	一级	二级	三级	一级	二级	三级	一级	二级	一级	二级	
碎米	总量/%	≤ 15.0	20.0	30.0	10.0	15.0	20.0	15.0	25.0	10.0	15.0
	其中:小碎米含量/%	≤ 1.0	1.5	2.0	1.0	1.5	2.0	2.0	2.5	1.5	2.0
加工精度	精碾	精碾	适碾	精碾	精碾	适碾	精碾	适碾	精碾	适碾	
不完善粒含量/%	≤ 3.0	4.0	6.0	3.0	4.0	6.0	4.0	6.0	4.0	6.0	
水分含量/%	≤ 14.5				15.5			14.5		15.5	
杂质	总量/%						0.25				
	其中:无机杂质含量/%						0.02				
黄粒米含量/%						1.0					
互混率/%						5.0					
色泽、气味	正常										

标准二级米：加工精度次于特等米，食用品质、出饭率和消化吸收率略低于特等米。但维生素、矿物质、脂肪、蛋白质含量均高于一等米。

Standard Grade 2 rice: Processing precision is second to that of special-grade rice, and its eating quality, rice production rate and digestive absorption rate are slightly lower than that of special-grade rice. However, the content of vitamins, minerals, fats and proteins are higher than that of first-class rice.

表 1 大米质量指标

品种	籼米			粳米			籼糯米		粳糯米		
	一级	二级	三级	一级	二级	三级	一级	二级	一级	二级	
碎米	总量/%	≤ 15.0	20.0	30.0	10.0	15.0	20.0	15.0	25.0	10.0	15.0
	其中：小碎米含量/%	≤ 1.0	1.5	2.0	1.0	1.5	2.0	2.0	2.5	1.5	2.0
加工精度	精碾	精碾	适碾	精碾	精碾	适碾	精碾	适碾	精碾	适碾	
不完善粒含量/%	≤ 3.0	4.0	6.0	3.0	4.0	6.0	4.0	6.0	4.0	6.0	
水分含量/%	≤ 14.5				15.5			14.5		15.5	
杂质	总量/%							0.25			
	其中：无机杂质含量/%							0.02			
黄粒米含量/%	≤ 1.0										
互混率/%	≤ 5.0										
色泽、气味	正常										

标准三级米：为粮店日常供应大米。这类大米尽管淀粉含量较一等米和标准二等米为低，出饭率和消化吸收率也较低，但粗纤维素、灰分含量高，维生素B和尼克酸含量能满足人体需要，唯有维生素B2和钙含量达不到营养标准。

Standard Grade 3 Rice: This is the daily supply of rice for grain stores. Although the starch content of this type of rice is lower than that of first-grade rice and standard second-grade rice, and the rate of rice production and digestive absorption rate are also lower, the crude cellulose and ash content is high, and the content of vitamin B and niacin meets the needs of the human body, except that the content of vitamin B2 and calcium fails to meet the nutritional standards.

标准四级米：因保留了大量皮层和糊粉层，所以维生素和矿物质含量最高，但因为含有较多粗纤维和灰分，其出饭率和食用品质都不及上述三个等级大米。所以标准四等米一般不加工。

Standard Grade 4 Rice: It has the highest vitamin and mineral content because it retains a large number of cortexes and dextrans, but because it contains more crude fiber and ash, its rice yield and eating quality are not as good as the three grades of rice mentioned above. So standard fourth grade rice is generally not processed.

加工大米精度的检测



①看黄粒米 Observe the presence condition of yellow grain rice

米粒变黄是由于大米中某些营养成分在一定条件下发生了化学反应，或者是大米粒中微生物引起的。这些黄粒香味和食味都较差，所以选购时，必须观察黄粒米的多少。另外，米粒中含有“死青”粒较多米的质量也较差。中国国家标准GB/T1354-2018规定，黄米粒的含量不超过1%。

The yellow of rice grains is due to the chemical reaction of some nutrients in rice under certain conditions, or it is caused by microorganisms in rice grains. These yellow grain flavor and taste are poor, so when purchasing, we must observe the number of yellow grain rice. In addition, the quality of rice containing more "dead green" grains is also poor. According to the national standard GB/T1354-2018, the content of yellow rice grains is not more than 1%.



②看硬度Hardness of rice

大米的硬度主要是由蛋白质含量决定的，硬度越强，蛋白质含量越高，透明度越高。反之，蛋白质含量较低的米含水量高，或是用不成熟的稻制的米，透明度差，米的腹部不透明，白斑(腹白)较大。一般新米比陈米硬，水分低的米也硬。

The hardness of rice is mainly determined by the protein content, the stronger the hardness, the higher the protein content, the higher the transparency. On the contrary, the lower protein content of the rice with high water content, or with immature rice, poor transparency, the rice belly opaque, white spots (belly white) larger . Generally, new rice is harder than old rice, and rice with low water content is also hard.

③看杂质 Observe the presence condition of impurities

杂质除了米粒之外的其他物，大米杂质 包括通包括有机杂质和无机杂质。糠粉:经过1.0mm圆孔筛的筛下物，以及粘附在筛层上的粉状物。无机杂质如沙石、煤渣、砖瓦块和金属物等。有机杂质 如带壳的籽粒、无使用价值的米粒及异种粮粒等物质。根据是国标要求杂质总量不超过0.25%，其中无机杂质含量不超过0.02%。

Impurities other than rice grains, rice impurities including through including organic impurities and inorganic impurities. Bran powder: The sieve under the 1.0mm round hole sieve, as well as the powder adhering to the sieve layer. Inorganic impurities such as sand and gravel, cinders, masonry blocks and metal objects. Organic impurities such as shelled seeds, rice grains without use value and heterogeneous grain particles and other substances. According to the national standard, the total amount of impurities should not exceed 0.25%, of which the content of inorganic impurities should not exceed 0.02%.



④看碎米 Amount of broken rice in rice

碎米不会影响大米口感，但影响卖像。碎米率也是影响大米分级的重要指标。

Broken rice does not affect the taste of the rice, but it affects the selling image. The rate of broken rice is also an important indicator that affects the grading of rice.



碎米含量检测视频

⑤看水分moisture content

大米水分过高时，大米会容易发霉长虫；当大米水分过低时，米粒变得很脆，煮出来的米饭偏烂。在国家标准GB/T 1354-2018《大米》中，明确规定了各种大米的水分含量要求。其中籼米、籼糯米的水分要不超过14.5%；粳米及粳糯米的水分不能超过15.5%的上限。安全含量在13.5%的大米较易在南方保存。一般来说，泰国米水份含量较低，国产米较高，可通过低温烘干的方法降低。

When the moisture content of rice is too high, the rice will be prone to mold and insects; when the rice moisture is too low, the grains of rice become brittle, and the cooked rice is rotten. In the national standard GB/T 1354-2018 "Rice", the moisture content requirements of various types of rice are clearly stipulated. Among them, the moisture of indica rice and indica glutinous rice should be no more than 14.5%; the moisture of japonica rice and japonica glutinous rice cannot exceed the upper limit of 15.5%. Rice with a safe content of 13.5% is easier to preserve in the south. Generally speaking, the moisture content of Thai rice is lower and that of domestic rice is higher, which can be reduced by low-temperature drying.

⑥腹白 White belly

“腹白”大米腹部常有不透明的白斑，腹白的米蛋白含量较低，含淀粉较多，一般水分也较高一般粳米（广南八宝香、云禾米、秋田小町）腹白很少，籼米的腹白则多；如云香米。

Abdominal whiterice abdomen is often opaque white spots, abdominal white rice protein content is low, containing more starch, generally higher moisture general round-grained rice (Guangnan Baoxiang, Yunhao rice, Akita Komachi) abdominal white is very little, indica rice abdominal white is more; such as Yunxiang rice.



⑦ 爆腰 Popping rate of rice

爆腰：米粒表面出现横裂纹的米称为爆腰。裂纹越多，质量越差。爆腰米食用时外烂里生，营养价值低。选米时要注意，米粒上有条或多条横裂纹，就是爆腰米。用这种米做成的饭会“夹生”，不仅难吃，而且营养价值低。

Exploding waist: Rice with horizontal cracks on the surface is called "exploding waist". The more cracks there are, the poorer the quality. When consumed, exploding waist rice is soft on the outside but uncooked on the inside, with low nutritional value. When selecting rice, it is important to note if there are one or multiple horizontal cracks on the rice grains, as this indicates exploding waist rice. Rice made from this type of rice will be undercooked, not only unpleasant to eat but also low in nutritional value.



⑧看新陈 Checking for staleness

大米陈化现象较重，陈米的色泽变暗，粘性降低，失去大米原有的香味。所以要认真观察米粒颜色，表面呈灰粉状或有白道沟纹的米是陈米，其量越多则说明大米越陈旧。同时，捧起大米闻一闻气味是否正常，如有发霉的气味说明是陈米。另外，看米粒中是否有虫蚀粒，如果有也说明是陈米。

The phenomenon of rice becoming stale is more pronounced, with the color of stale rice becoming darker, stickiness decreasing, and losing the original fragrance of rice. Therefore, it is important to carefully observe the color of the rice grains. Rice that appears grayish or has white grooves on the surface is stale rice, and the more of it there is, the older the rice is. At the same time, pick up the rice and smell it to see if the odor is normal. If there is a musty smell, it indicates that the rice is stale. Additionally, check if there are any grains damaged by insects in the rice. If there are, it also indicates that the rice is stale.



陈米 Stale rice



新米 fresh rice

03

稻米精深加工

Refining and deep processing of rice

3.1 特种大米加工 Special rice processing

① 蒸谷米加工 Steamed rice processing

蒸谷米起源于印度，具有**营养价值高**、米糠出油高、胀性好、出饭率高、**贮藏中少受虫害**等优点。但同时其米色较深，常带有异味，粘性差，不适合煮稀饭，且加工成本较高。

Steamed grain rice originated in India, has the advantages of **high nutritional value**, high oil from rice bran, good flatulence, high rate of rice, **less insect damage in storage**. But at the same time its rice color is darker, often with odor, viscosity is poor, not suitable for cooking thin rice, and processing cost is higher.



蒸谷米的原料要求与精选

Requirements and selection of raw materials for steamed grain rice

选择组织较松、质地较脆、出米率低、粒形细长，以**籼稻**为宜，并去石，除稗、不完善粒、虫害、病斑等。

Select the looser tissue, brittle texture, low rice yield, grain shape, long and thin, preferably **indica rice**, and de-stoning, in addition to tares, imperfect grains, insect pests, disease spots, etc.



蒸谷米的生产工艺

Production process of steamed grain rice

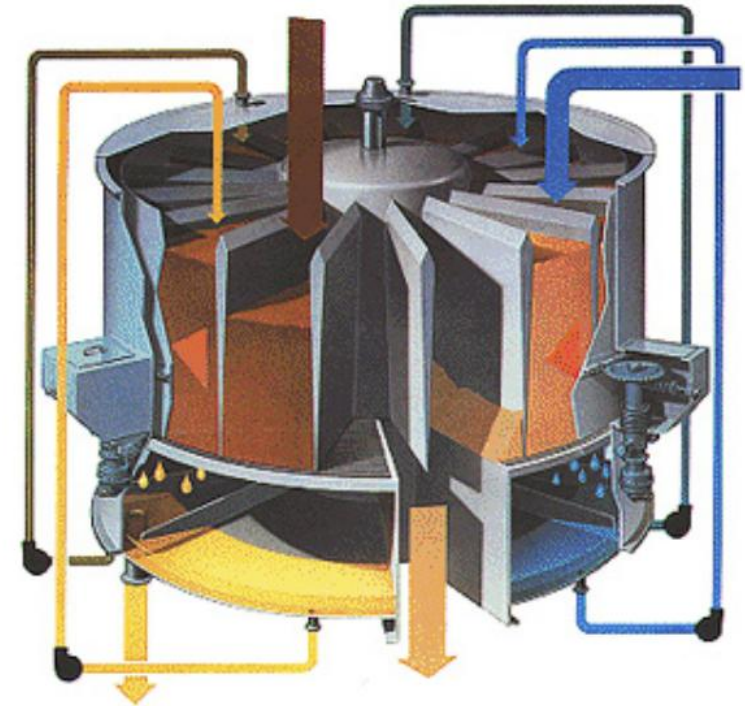
原料稻谷 → 清理精选 → **浸泡** → **蒸煮** → **干燥** → **冷却** → 砻谷 → 碾米 → 整理 → 成品

Raw rice → cleaning and selecting → **soaking** → **boiling** → **drying** → **cooling** → hulling → rice milling → finishing → finished product

浸泡

soaking

- 要求：水温略低于米淀粉糊化温度约**70°C**
- 含水量34~36%
- 时间要迅速以免发酵（**2~3小时**）
- 设备：传统：陶制小罐，水泥池
- 现代：罐注式浸泡器，平转式浸泡器
- Requirements: water temperature slightly lower than the rice starch paste temperature of about **70 °C**
- Water content 34~36%
- Time to be quick to avoid fermentation (**2 to 3 hours**)
- Equipment: Traditional: small earthenware pots, concrete pools
- Modern: tank-infused soakers, flat-turn soakers



平转式浸泡器
flat-turn soakers

蒸煮：增加碾米出率，改进储藏特性和食用品质

Steaming: increases milling yield, improves storage characteristics and eating quality

- 要求：温度高于糊化温度，提供足够水分使所有淀粉糊化含水量**34~36%**
- 设备：蒸汽绞龙，常压蒸煮筒，立式蒸煮器，卧式蒸煮干燥器等
- Requirements: Temperature higher than pasting temperature, provide enough water to make all starch paste **water content of 34~36**
- Equipments: steam winch, atmospheric pressure cooking cylinder, vertical cooker, horizontal cooking drier, etc.



蒸煮筒
cooking cylinder

干燥与冷却:

使稻谷含水量降到**14%**的安全水分以便贮存和加工

Drying & Cooling:

Reducing the moisture content of rice to a safe level of **14%** for storage and processing

- **第一次高温快速干燥至**20%****
- **第二次低温慢速干燥**
- **设备: 沸腾床干燥机、喷床干燥机、流化槽干燥机、滚筒干燥机等**
- **The first high-temperature rapid drying to **20%****
- **The second low-temperature slow drying**
- **Equipment: boiling bed dryer, spray bed dryer, fluidized tank dryer, drum dryer, etc.**



沸腾床干燥机
boiling bed dryer

②免淘米加工 No-polishing rice processing

- 普通大米：含较多米糠及米糠油，易氧化，煮饭前淘洗，耗水、耗时，损失营养。
- 免淘米：米质纯净，外观晶莹透亮
- Ordinary rice: contains more rice bran and rice bran oil, easy to oxidize, washing before cooking, water consumption, time-consuming, loss of nutrition.
- No-tanning rice: rice quality is pure, appearance is crystal clear and bright.



国内生产免淘米的方法

Domestic production of no-polish rice

(一) 渗水法：又称水磨米

(i) Percolation: also known as water-milled rice

糙米 → 碾白 → 擦米 → **渗水碾磨** → 冷却 → 分级 → 免淘米

Brown rice → polishing → polishing rice → **seepage milling** → cooling → grading → no-polishing rice

(二) 膜化法

(ii) Membranization

标一米 → 精选除杂 → 碾白 → **去糠上光** → 分级 → 免淘米

Standard one rice → selecting and removing impurities → polishing → **removing chaff and polishing** → grading → no-polishing rice

上光剂
glazing agent



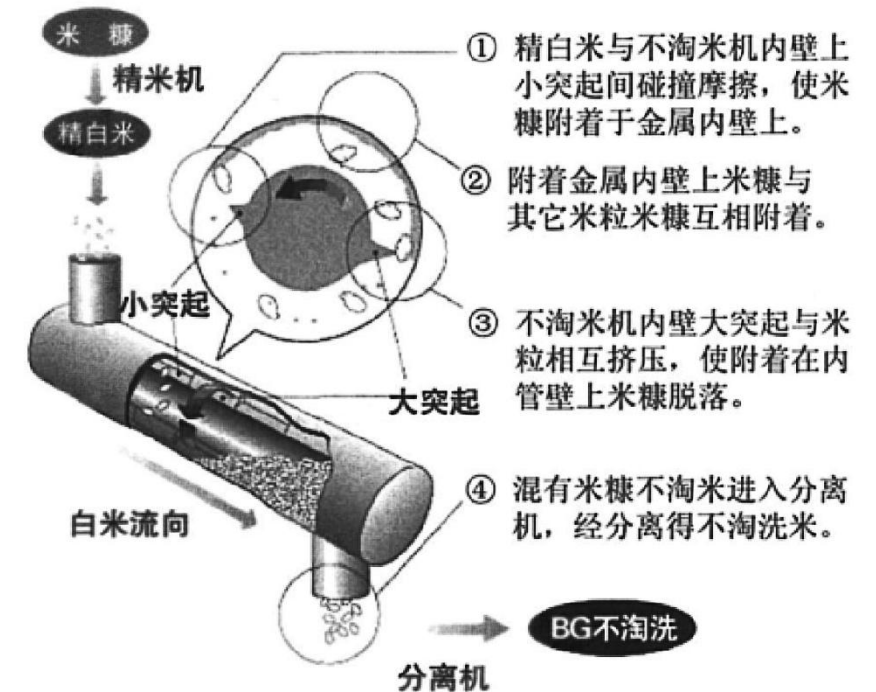
免淘米加工关键设备

Key equipment for no-polish rice processing

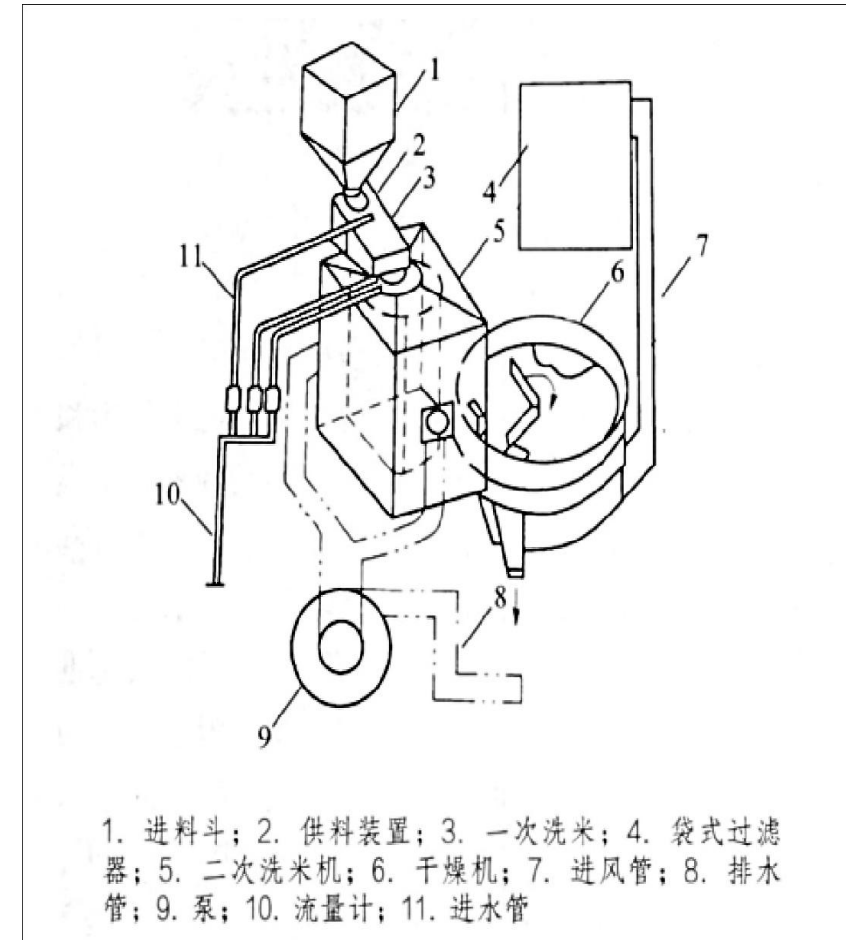
1999年日本碾米工业协会将不淘洗米的生产分为**特殊型**、**湿法型**、**干法型**三大类。

In 1999, the Japan Rice Millers Association categorized the production of unpolished rice into three main types: **special**, **wet**, and **dry**.

- **特殊型**：典型产品是**BG无洗米装置**，该装置生产的不淘洗米商品名称为BG米或BG无洗米。
- **Special type**: The typical product is **the BG unwashed rice unit**, which produces unwashed rice under the trade name of BG rice or BG unwashed rice.

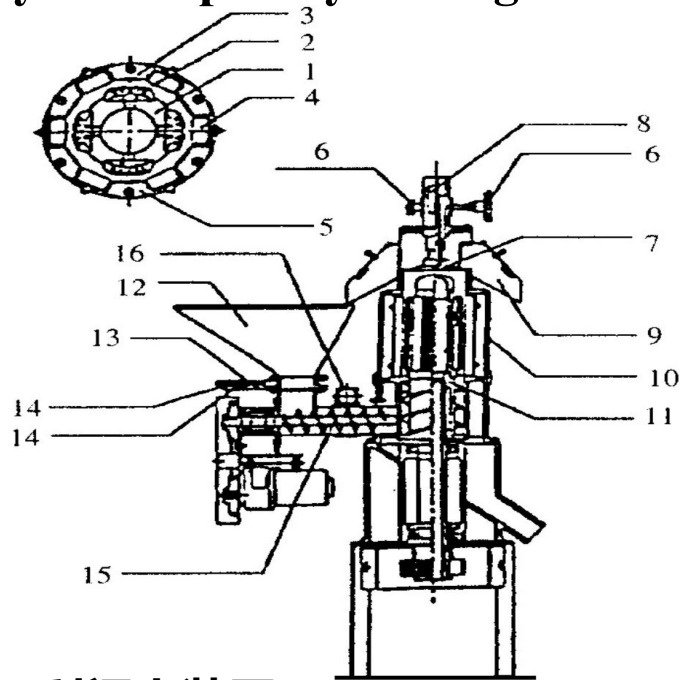


- **湿法型：典型产品是超级吉福米装置。白米经供料装置进入一次洗米机，边搅拌边水洗，然后进入二次洗米机，将米粒表面的糠粉及残留的糊粉层洗去，同时进行离心分离、脱水。**
- **Wet type: Typical product is Super Jiffy Rice Unit. White rice enters the primary rice washer through the feeding device, and is washed with water while stirring, and then enters the secondary rice washer, which washes away the bran powder and residual paste powder layer on the surface of rice grains, and at the same time centrifugally separates and dehydrates the rice.**

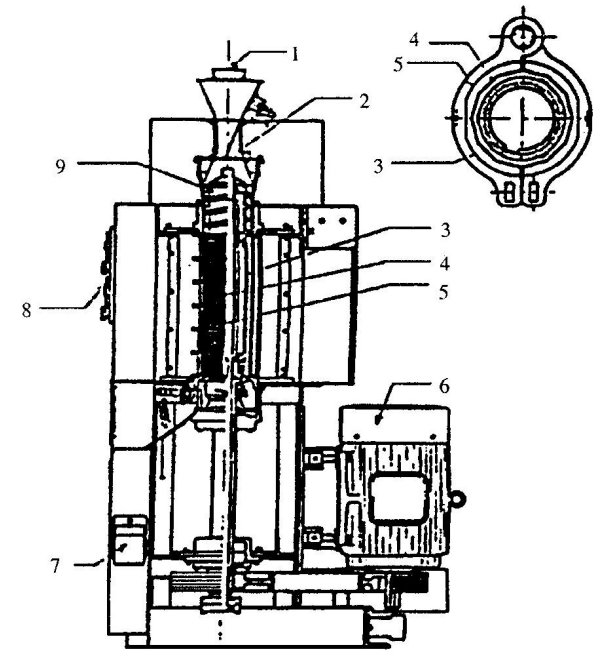


超级吉福米装置
Super Jiffy Rice Device

- 干法型典型产品是两种，即**利福来装置**和**卡比卡装置**。前者白度上升1%~2%，不产生碎米；后者是山木制作所于1995年研制成功并迅速普及日本。
- Typical products of the dry type are two kinds, namely, **the Riflame unit** and **the Kabika unit**. The former increases whiteness by 1 to 2 percent and does not produce broken rice; the latter was successfully developed by Yamagi Manufacturing in 1995 and rapidly popularized in Japan.



利福来装置 the Riflame unit



卡比卡装置 the Kabika unit

③ 营养强化米加工 Nutritionally fortified rice processing

◆ 满足人们的营养需求，维持膳食平衡。

Meet people's nutritional needs and maintain dietary balance.

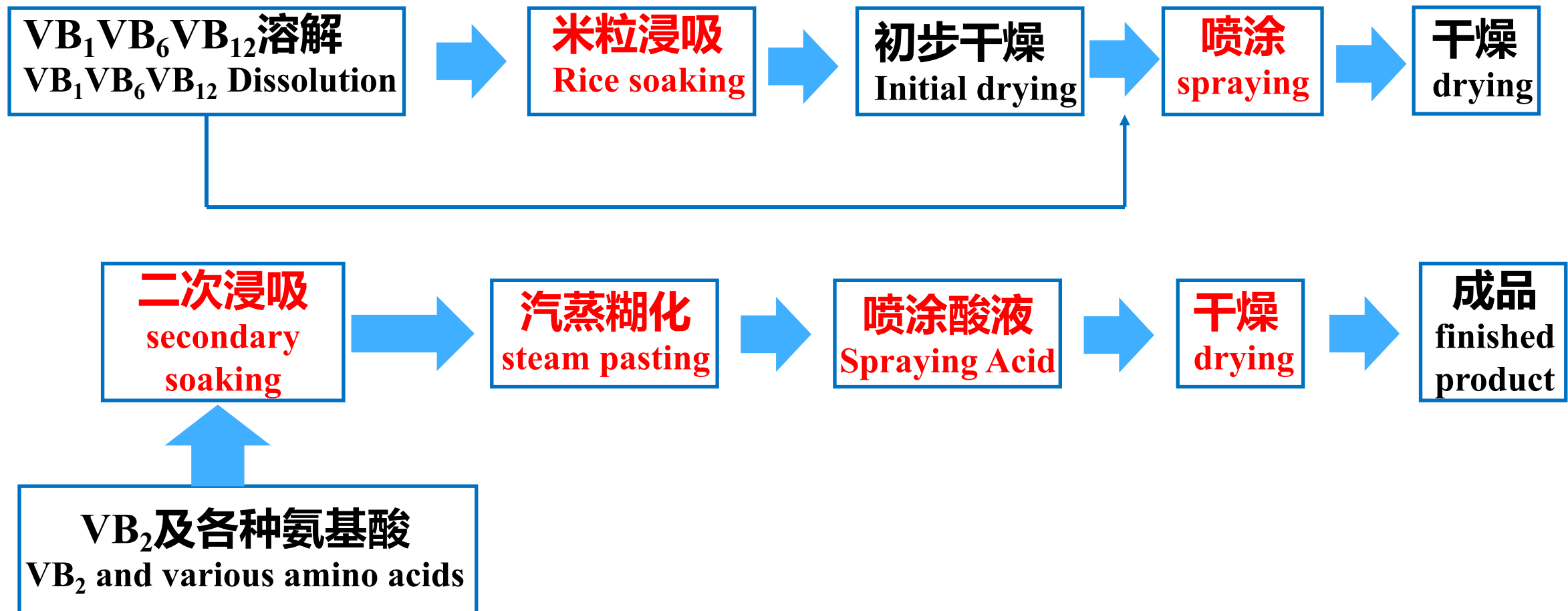
◆ 通过营养强化，改善和提高大米的品质，对改善人民的膳食结构，提高人民的健康水平，具有重要意义。

Improving and enhancing the quality of rice through nutritional fortification is of great significance in improving the dietary structure of the people and enhancing their health.



直接浸渍法生产复合营养强化米:

Direct impregnation method for the production of complex nutrient-fortified rice:



涂膜法工艺:

米粒→干燥→**真空浸吸**→冷却→**汽蒸糊化**→冷却→分粒→**干燥**→**一次涂膜**→

1.2公斤果胶3公斤马铃薯淀粉溶于10公斤50°C的水中

汽蒸→冷却→分粒→干燥→**二次涂膜**→汽蒸→冷却→分粒→干燥→

先用1%阿拉伯胶润滑米粒表面
再与1.5公斤马铃薯淀粉及1公斤蔗糖脂肪酸脂液混合

三次涂膜→干燥→强化米

5公斤火棉胶+5公斤乙醚

翻译见下页

Coating method process:

Rice grains → drying → **vacuum immersion** → cooling → **vaporization and pasting**
→ cooling → granulation → **drying** → **first coating** →



1.2 kg pectin 3 kg potato starch dissolved in 10 kg water at 50°C

Vaporization → cooling → partitioning → drying → **second coating** → vaporization
→ cooling → partitioning → drying



Lubricate the surface of rice grains with 1% gum Arabic.
Then mix with 1.5kg potato starch and 1kg sucrose fatty acid fat solution.

third coating → drying → reinforced meters



5 kilograms of fire-wool glue + 5 kilograms of ether

强烈型强化法:

Strong-type reinforcement method:

- **特点:** 比浸吸法和涂膜法**工艺简单**,所需设备少,投资省,便于推广。
- **Characteristics:** It is **simpler** than the leaching and suction method and the coating method, requires less equipment, saves investment, and is easy to be popularized.
- **工艺流程:**
- **Process Flow:**

赖氨酸、维生素B₁、B₂
Lysine, Vitamin B₁, B₂

Ca、P、Fe、食用胶
Ca, P, Fe, edible gums

不淘洗米 → 强化机 → 缓苏仓 → 强化机 → 缓苏仓 → 筛选 → 强化米

Unpolished rice → fortification machine → slow soak bin → fortification machine → slow soak bin
→ screening → fortified rice



挤压营养强化法：一种与人造米生产工艺相结合的营养强化工艺

Extruded Nutritional Enrichment: A Nutritional Enrichment Process Integrated with Artificial Rice Production Processes

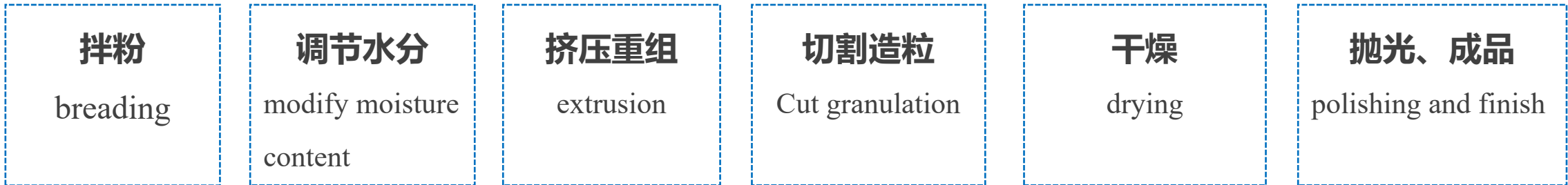
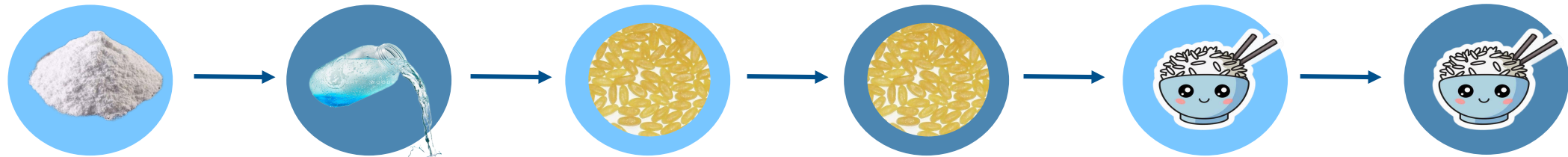
- ◆ 以**碎米**为原料，微粉碎后与营养强化剂预混料充分混合，通入蒸汽和水进行调质后，进入挤压机重新制粒，干燥后与不淘洗米进行混配，即得到营养强化大米。
- ◆ 特点：**营养素分布均匀**，稳定性好。
- ◆ Taking **broken rice** as raw material, after micro-crushing and mixing with nutrient fortifier premix fully, passing into steam and water for tempering, then entering extruder to re-pelletize, after drying and mixing with non-towed rice, that is, to get nutrient fortified rice.
- ◆ Characteristics: **uniform distribution of nutrients**, good stability.



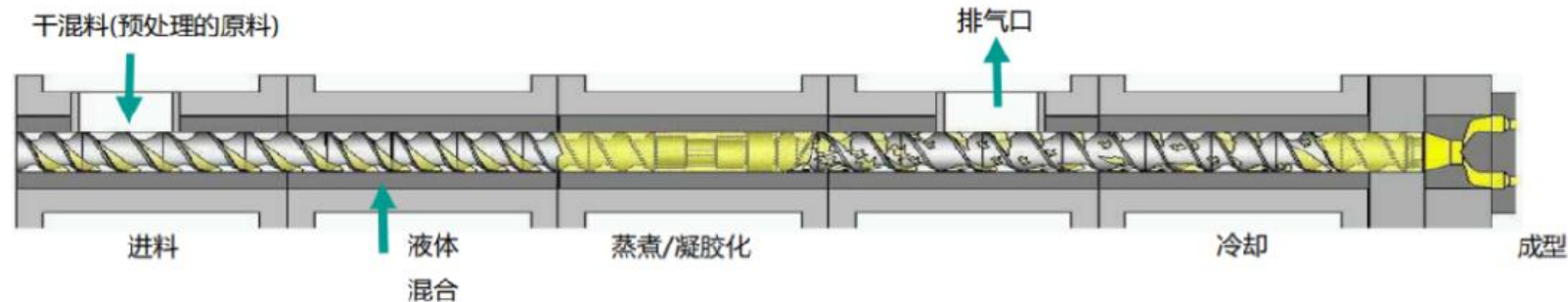
双螺杆挤出机
Twin Screw Extruder

挤压营养强化法：一种与人造米生产工艺相结合的营养强化工艺

Extruded Nutritional Enrichment: A Nutritional Enrichment Process Integrated with Artificial Rice Production Processes



挤压环节：



④留胚米加工 Retained rice processing

留胚米是指米胚保留率在**80%**以上的大米。米胚是糙米的精华部分，它含有约**22%**的蛋白质，且各种必需氨基酸的比例较合理，还含**25%**的脂肪，其中人体必需脂肪酸高达**80%**以上。



Rice with retained embryo is rice with a retention rate of **80%** or more. Rice germ is the essence of brown rice, which contains about **22%** protein, and a reasonable proportion of various essential amino acids, and also contains **25%** fat, of which more than **80%** of essential fatty acids.

④留胚米加工 Retained rice processing

胚芽米1924年在日本问世，1977年7月15日日本政府正式将胚芽米确定为正式产品。其技术关键在于碾米工艺：

Germ rice was introduced in Japan in 1924, and on July 15, 1977, the Japanese government officially identified germ rice as an official product. The key to its technology lies in the rice milling process:

必须采用多机轻碾，碾米机内压力要低。碾米机应采用砂辊碾米机，且砂辊碾米机转速不易太高，否则胚芽容易脱落。

Multiple machines must be used for light milling, and the pressure in the rice mill should be low. The rice milling machine should be a sand roller milling machine, and the speed of the sand roller milling machine is not too high, otherwise the germ is easy to fall off.



砂辊碾米机
Sand roller rice milling
machine 77

3.2 大米转化与利用 Rice transformation and utilization

① 米粉加工 Rice Vermicelli Processing

定义:

Definition:

- 广义理解米粉是以大米为原料经碾磨制成的**粉状物**;
- 但在**广东**等省区是指以大米为原料，经蒸煮糊化而制成的**条状或丝状**干湿制品。
- Rice flour is broadly understood as a **powder made** from rice by milling;
- However, in **Guangdong** and other provinces and regions, it refers to dry and wet products in the form of **strips or filaments** made from rice as raw material by steaming and pasting.



大米粉 rice flour



桂林米粉 Guilin rice noodles

米粉加工工艺 Rice Vermicelli Processing Technique:

➤ 原理：淀粉糊化形成凝胶。

Principle: Starch pastes to form a gel.

➤ 工艺流程 Process Flow:

榨粉：原料（**精白米**）→**洗涤**→**浸泡**→**磨浆**→**脱水**→**混匀**→**蒸坯**→**挤条**→**蒸煮**→**冷却**→**疏松湿榨粉成型**
→**干燥**→**干榨粉**

Squeeze the powder:

Raw material (**refined white rice**) → washing → **soaking** → **grinding** → dewatering → mixing → **steaming blanks** → extruding strips → boiling → cooling → **fluffing and wet-pressing flour molding** → **drying** → dry-pressing flour



自熟榨粉米线机

切粉：原料（精白米）→洗涤→浸泡→磨浆→脱水（上浆）→落浆蒸煮→冷却→湿米切粉
 → { **切条（连续生产）**
切割→叠粉→折片切条 } → **干燥→干切粉**
切割→卷粉

Cutting powder:

Raw material (refined white rice) → washing → soaking → milling → dewatering (sizing) → boiling → cooling → cutting wet rice into flour
 → { **Strip cutting (continuous production)**
Cutting → Stacking powder → Folding and cutting strips } → **drying → dry cut powder**
Cutting → Rolling powder



Self Cooking Vermicelli & Rice Noodle Machine

②方便米饭加工 Convenient Rice Processing

食用方式: Serving Style:

- 一种为**成品米饭**，打开包装加热或不加热即可食用，如软罐米饭。
- One type is **finished rice**, which can be eaten with or without heating when the package is opened, such as soft canned rice.
- 一种是**经过脱水干燥的米饭颗粒**，在食用时复水数分钟即可食用，包括糊化米饭、冷冻干燥米饭、膨化米饭等。
- One type of **rice granules is dehydrated and dried** and rehydrated for a few minutes before serving, including pasteurized rice, freeze-dried rice, puffed rice, and the like.



方便米饭加工工艺:

Convenient rice processing techniques:

工艺流程:

Process Flow:

糊化米饭: 大米 → 淘洗 → 浸泡 → 加抗黏剂 → 汽蒸或炊煮

Battered rice: → 冷却 → 离散 → 干燥 → 包装

Rice → washing → **soaking** → **adding anti-adhesive** → **steaming or cooking** → cooling → **discrete** → **drying** → packaging

非脱水米饭: 大米 → 淘洗 → 浸泡 → 预煮 → 定量充填、密封 → 装盘 → 蒸煮杀菌 → 蒸煮袋表面脱水 → 成品

Non-dehydrated rice: Rice → washing → soaking → pre-cooking → quantitative filling, sealing → tray loading → steaming sterilization → steaming bag surface dehydration → finished product



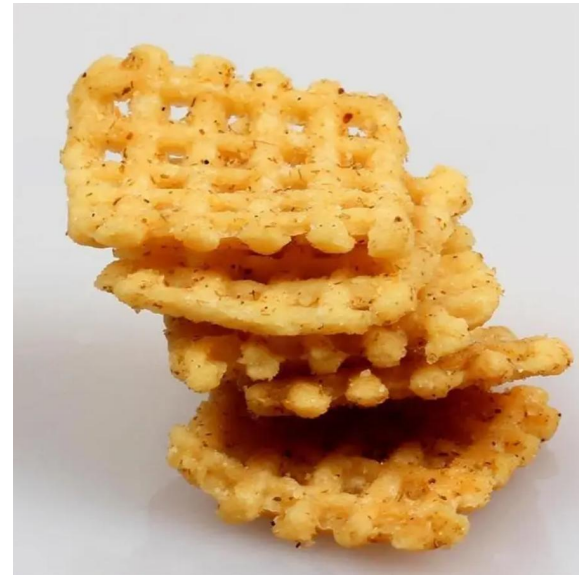
方便米饭全自动热成型
气调包装机

Instant rice automatic
thermoforming air-
conditioning packaging
machine

③大米膨化食品加工 Rice puffed food processing

膨化工艺： Puffing process:

- **直接膨化法**是指产品被挤出成型模时直接膨胀形成膨化食品的过程。
- **The direct expansion method** refers to the process of expanding the product directly when it is extruded from the mold to form expanded food products.
- **间接膨化法**是指原料从成型模被挤出的没有充分膨胀的半成品，经过精心干燥后，再进行烘烤、炸或微波等手段使其膨胀，最终成为膨化食品的工艺过程。
- **Indirect expansion method** refers to the raw materials from the molding die is extruded from the semi-finished product is not fully expanded, after careful drying, and then baking, frying or microwave and other means to make it expand, and finally become puffed food process.



膨化食品加工工艺:

Puffed food processing technology:

➤ 工艺流程:

➤ Process Flow:

直接膨化法: 进料→挤出机 (膨化) →切断→干燥→包装→膨化食品

Direct expansion method:

Feeding → **Extruder (puffing)** → **Cutting** → **Drying** →
Packaging → Puffed Foods

**间接膨化法: 进料→挤出机 (膨化) →切断→干燥→炸制→
包装→膨化食品**

Indirect expansion method:

Feeding → Extruder (puffing) → Cutting → Drying → Frying
→ Packaging → Puffed Foods



食品膨化机
Food puffer

04

稻谷副产物加工利用

Processing and utilization of rice by-products

4.1 碎米的综合利用 Comprehensive utilization of broken rice

① 生产大米淀粉 Production of rice starch

大米淀粉是由稻谷加工后提取的**纯净淀粉**，它是一种重要的食品和工业原料。

Rice is processed from rice starch extraction of pure starch, it is a kind of important foods and industrial raw materials.

碎米可以通过**研磨、浸泡和分离**等工艺步骤制成大米淀粉。

Broken rice can be processed into rice starch through grinding, soaking and separation process steps.

大米淀粉在食品工业中被**广泛应用于**制作面粉、糕点、粉丝、奶制品等。

Rice starch in the food industry has been widely applied in the production of flour, pastry, fans, dairy products, etc.



②生产高蛋白米粉 Production of high-protein rice flour

碎米中含有**丰富的蛋白质**，经过适当处理和加工，可以制备出**高蛋白米粉**。

Broken rice contains rich protein, and properly handling and processing, with high-protein rice flour can be prepared.

这种米粉**富含**优质蛋白质、氨基酸和其他营养物质，是一种**营养丰富**的食品原料。高蛋白米粉可用于制作高蛋白食品、膳食补充剂和婴幼儿食品等。

The rice is rich in high quality protein, amino acids and other nutrients, is a kind of nutritious food raw material. High-protein rice flour can be used to make high protein food, baby food and dietary supplements



提取大米淀粉：

Extraction of rice starch:



碾磨：将碎米进行碾磨，使其变成较为**细小的颗粒**。这可以通过传统的石磨或者机械研磨设备完成。

Grinding: Grind the crushed rice to turn it into smaller particles. This can be done by traditional stone grinding or mechanical grinding equipment.

粉碎：使用粉碎设备将碾磨后的碎米**进一步细化**，使其成为较为细小的粉末状。

Crushing: The grinding equipment is used to further refine the crushed rice to make it a relatively fine powder.

筛分：使用**筛网**对粉碎后的碎米进行筛分，去除其中的杂质和较大颗粒。这可以保证所提取的大米淀粉的纯度和质量。

Screening: Use a screen to screen the crushed rice to remove impurities and large particles. This can ensure the purity and quality of the extracted rice starch.

提取大米淀粉：

Extraction of rice starch:



水浸提取：将筛分后的碎米与适量的水混合，形成悬浮液。悬浮液中的大米淀粉会慢慢溶解到水中，形成淀粉浆。

Soaked extraction: The screened minced rice is mixed with an appropriate amount of water to form a suspension. Rice starch in the suspension will slowly dissolve in water to form starch pulp.

沉淀与分离：待淀粉浆静置一段时间后，会出现较明显的分层现象。上层为淀粉浆，下层则是其他杂质和沉淀物。将上层淀粉浆轻轻倒出，并通过过滤等方式去除杂质。

Precipitation and separation: After the starch pulp is left for a period of time, there will be a more obvious layering phenomenon. The upper layer is starch pulp, and the lower layer is other impurities and sediments. Gently pour out the upper starch pulp and remove impurities through filtration and other means.

提取大米淀粉：

Extraction of rice starch:

脱水与干燥：将得到的淀粉浆进行脱水处理，可以采用离心机或者压滤机等设备。**脱水**后得到的湿淀粉需要进行干燥处理，使其含水量降至所需标准。

Dehydration and drying: The obtained starch pulp can be dehydrated, and equipment such as centrifuge or filter press can be used. The wet starch obtained after dehydration needs to be dried to reduce its moisture content to the required standard.

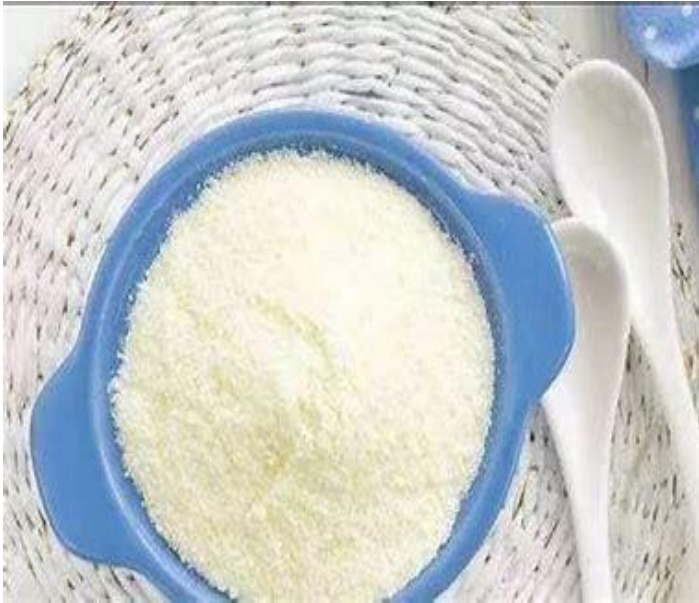
细粉加工：将干燥后的大米淀粉进行细粉加工，使其颗粒更加细腻均匀。这可以通过进一步的 **研磨、筛分**等工艺来实现。

Fine flour processing: The dried rice starch is finely processed to make its particles more delicate and even. This can be achieved through further grinding, screening and other processes.

包装与储存：对细粉加工后的大米淀粉进行包装，并确保储存条件适宜，以**保持其品质和营养成分的稳定**。

Packaging and storage: The rice starch after fine powder processing is packaged and the storage conditions are suitable to maintain the stability of its quality and nutritional content.

制备高蛋白米粉



Prepared into high-protein rice flour:

碎米净化：将碎米进行清洗，去除杂质和不洁物，确保**碎米的卫生和品质**。

Shredded rice purification: Clean the shredded rice, remove impurities and unclean things, and ensure the hygiene and quality of shredded rice.

碾磨：将清洗后的碎米进行碾磨，使其**颗粒更加细小**。可以使用碾米机或石磨等设备进行碾磨操作。

Milling: The washed broken rice is milled to make its particles smaller. Milling operations can be carried out using equipment such as rice mills or stone mills.

精选：将碾磨后的米粉进行**精选和筛选**，除去较大颗粒和杂质，以获得均匀的颗粒大小。

Selecting: The milled rice flour is selected and screened to remove larger particles and impurities to obtain a uniform particle size.

制备高蛋白米粉



Prepared into high-protein rice flour:

蒸煮：将精选后的米粉进行蒸煮处理。将其放入蒸锅中，用蒸汽进行蒸煮，使其达到适宜的**水分含量**和**口感**。

Steaming: The selected rice noodles are steamed. Put it in a steamer and steam it to achieve the right moisture content and taste.

低温干燥：将蒸煮后的米粉进行低温干燥。可以使用烘干机或其他适当的设备，**控制好温度和时间**，以保留米粉的**营养成分**和**原有风味**。

Low temperature drying: The steamed rice flour is dried at low temperature. You can use a dryer or other appropriate equipment to control the temperature and time to preserve the nutrients and original flavor of the rice flour.

制备成高蛋白米粉



Prepared into high-protein rice flour:

粉碎：将低温干燥后的米粉进行进一步的粉碎处理，使其颗粒**更加细小**，得到细腻的米粉产品。

Crushing: The rice flour after low temperature drying is further crushed to make its particles more fine, and a fine rice flour product is obtained.

包装和贮存：将制备好的高蛋白米粉进行**包装和贮存**。使用适宜的包装材料，确保产品的**卫生和品质**，并存放在干燥、阴凉的环境中，以延长其保质期。

Packaging and storage: The prepared high-protein rice flour is packaged and stored. Use suitable packaging materials to ensure the hygiene and quality of the product, and store it in a dry, cool environment to extend its shelf life.

③制备麦芽糖醇： The preparation of maltitol

麦芽糖醇是一种具有甜味且**低热量的糖醇**，广泛用于食品、药品和化妆品等行业。

Maltitol is a sweet taste and low-calorie sugar alcohols, widely used in food, medicine and cosmetics industries.

碎米中的淀粉可以通过麦芽化反应转化为麦芽糖，然后经过**氢化反应**生成麦芽糖醇。

Starch in broken rice by reaction of malt into maltose, and then generate maltitol after hydrogenation.

麦芽糖醇可用作**食品添加剂**，用于调味品、糖果、口香糖、口腔护理产品等。

Maltitol can be used as a food additive, condiments, candy, chewing gum, oral care products, etc.



制备麦芽糖醇

Preparation of maltitol:



制备麦芽糖醇 Preparation of maltitol

结晶与分离: 经过**浓缩**和**脱色**处理后, 麦芽糖醇会逐渐结晶出来。将结晶的麦芽糖醇进行分离, 可以通过离心机或过滤等方式。

Crystallization and separation: After concentration and decolorization treatment, maltitol will gradually crystallize out. The crystallized maltitol can be separated by centrifuge or filtration.

干燥与粉碎: 将得到的麦芽糖醇进行干燥处理, 使其**含水量降至所需标准**。然后, 对干燥的麦芽糖醇进行粉碎, 使其颗粒更加细腻均匀。

Drying and crushing: The obtained maltitol is dried to reduce its water content to the required standard. Then, the dried maltitol is crushed to make its particles more delicate and uniform.

包装与储存: 对粉碎后的麦芽糖醇进行包装, 并确保储存条件适宜, 以保持其品质和营养成分的稳定。

Packaging and storage: Packaging the crushed maltitol and ensuring that the storage conditions are suitable to maintain its quality and nutritional stability.

4.2米糠的综合利用 Comprehensive utilization of rice bran

4.2.1米糠的组成

Composition of rice bran

米糠是稻谷加工后的副产品，主要由外层糠皮组成。

在米糠的综合利用过程中，可以提取出米糖，其主要组成成分包括以下几种：

Rice bran is a by-product of rice processing and consists mainly of an outer layer of bran. In the comprehensive utilization process of rice bran, rice sugar can be extracted, and its main components include:

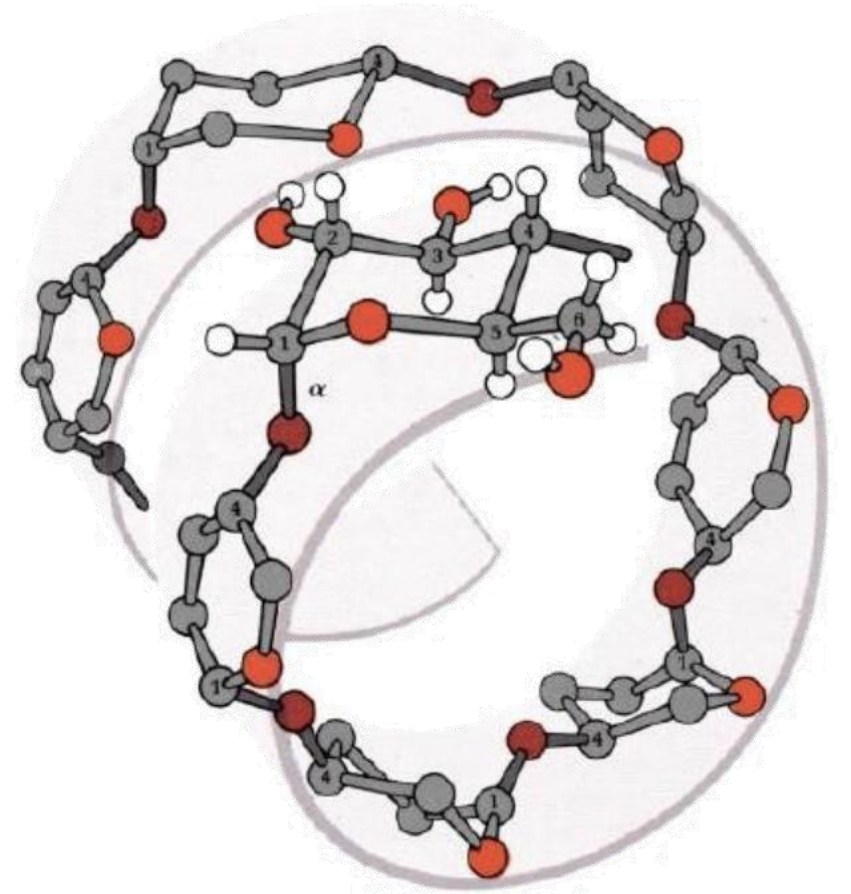


米糠的组成

Composition of rice bran

糖类：米糠主要含有多种糖类物质，其中包括葡萄糖、木糖、甘露糖等。这些糖类是**由稻谷中的淀粉在酶的作用下水解而成。**

Carbohydrates: Rice sugar mainly contains a variety of carbohydrates, including glucose, xylose, mannose, etc. These sugars are formed by the hydrolysis of starch in rice under the action of enzymes.



米糠的组成 Composition of rice bran

纤维素：米糠中含有一定量的纤维素，它是植物细胞壁的主要成分。纤维素在米糠的综合利用过程中可以进一步**转化为生物能源或用于生产纤维制品。**

Cellulose: Rice bran contains a certain amount of cellulose, which is the main component of plant cell walls. Cellulose can be further converted into bioenergy or used in the production of fiber products in the comprehensive utilization process of rice bran.

脂肪：少量的脂肪也可以存在于米糠中，这些脂肪通常是**稻谷胚芽中残留的油脂。**

Fat: A small amount of fat can also be present in rice bran, which is usually the residual oil in the rice germ.

蛋白质：虽然米糠中的蛋白质含量相对较低，但仍然存在一部分蛋白质。这些蛋白质可以用于生产饲料或进行进一步的**提取和利用。**

Protein: Although the protein content in rice bran is relatively low, there is still a part of the protein. These proteins can be used to produce feed or for further extraction and utilization.

4.2.2米糠的利用途径及现状 Utilization and current status of rice bran

米糠是稻谷加工后剩下的**外层糠皮**，其综合利用途径和现状如下：

Rice bran is the outer layer of bran left after rice processing, and its comprehensive utilization methods and status are as follows:



4.2.2米糠的利用途径及现状 Utilization and current status of rice bran

①饲料原料：米糠可以作为家禽、牲畜和水产养殖的饲料原料。由于其含有一定的蛋白质和能量，适量添加米糠可以**提供动物所需的营养**。目前，大量的米糠被用作饲料，特别是在农村地区。

Feed raw materials: rice bran can be used as feed raw materials for poultry, livestock and aquaculture. Because it contains a certain amount of protein and energy, adding rice bran in moderation can provide the nutrients that animals need. Currently, large quantities of rice bran are used as feed, especially in rural areas.

4.2.2米糠的利用途径及现状

Utilization and current status of rice bran

②**发酵制品**：米糠可以通过发酵**转化为**陈化剂、酵母、酒精等**发酵制品**。比如在米酒、米曲、米醋等的生产中，米糠被广泛应用。

Fermented products: rice bran can **be converted into fermentation products** such as aging agents, yeast, and alcohol through fermentation. For example, in the production of rice wine, rice koji, rice vinegar, etc., rice bran is widely used.



4.2.2米糠的利用途径及现状

Utilization and current status of rice bran

③生物质能源：米糠中的纤维素和其他有机物可以被利用为生物质能源。通过厌氧发酵或热解等处理，米糠可以转化为生物气体、生物柴油和生物炭等。

Biomass energy: cellulose and other organic matter in rice bran can be utilized as biomass energy. Through treatments such as anaerobic fermentation or pyrolysis, rice bran can be converted into biogas, biodiesel, and biochar, among others.

④农业土壤改良剂：经过适当处理后，米糠可以用作有机肥料或土壤改良剂。在农业生产中，将米糠还田可以提供有机质，改善土壤结构和保持水分。

Agricultural soil amendment: After proper treatment, rice bran can be used as organic fertilizer or soil amendment. In agricultural production, returning rice bran to the field can provide organic matter, improve soil structure and retain water.

4.2.3 米糠稳定化技术 Rice bran stabilization technology

米糠稳定化技术是指对米糠进行处理，以**延长其保存期限和提高其质量稳定性**的一系列技术方法。以下是一些常见的米糠稳定化技术：

Rice sugar stabilization technology refers to a series of technical methods for processing rice sugar to extend its shelf life and improve its quality stability. Here are some common rice sugar stabilization techniques:



4.2.3米糠稳定化技术

Rice bran stabilization technology

真空包装：将米糠放入真空包装袋中，抽取空气并密封包装，以减少氧气和湿气的接触。真空包装可以**延长米糠的保鲜期**，并**防止氧化和湿气引起变质**。

Vacuum packaging: The rice sugar is placed in a vacuum bag, the air is extracted and the package is sealed to reduce the contact of oxygen and moisture. Vacuum packaging can extend the shelf life of rice sugar and prevent deterioration caused by oxidation and moisture.



4.2.3米糠稳定化技术

Rice bran stabilization technology

酸度调节：通过调整米糠的酸度，**可以改变其pH值**，从而**抑制微生物的生长和繁殖**。酸度调节可以采用添加食醋、柠檬酸或苹果酸等酸性物质的方法。

Acidity adjustment: By adjusting the acidity of rice sugar, its pH value can be changed, thereby inhibiting the growth and reproduction of microorganisms. Acidity can be adjusted by adding acids such as vinegar, citric acid or malic acid.

脱水处理：通过脱水处理，降低米糖中的水分含量，**减少微生物的生存环境**，并提高米糖的稳定性。常见的脱水处理方法包括烘干、热风脱水、冷冻干燥等。

Dehydration treatment: Through dehydration treatment, the water content in rice sugar is reduced, the living environment of microorganisms is reduced, and the stability of rice sugar is improved. Common dehydration treatment methods include drying, hot air dehydration, freeze drying, etc.

4.2.3米糠稳定化技术

Rice bran stabilization technology

抗氧化剂添加：米糠中的**抗氧化剂可以防止氧化反应的发生**，延缓米糠的氧化变质。常用的抗氧化剂有**维生素C、维生素E、谷胱甘肽**等，可以通过添加这些物质来提高米糠的稳定性。

Antioxidants added: The antioxidants in rice sugar can prevent the occurrence of oxidation reactions and delay the oxidative deterioration of rice sugar. Commonly used antioxidants are vitamin C, vitamin E, glutathione, etc., which can be added to improve the stability of rice sugar.

包装材料选择：选择适合的包装材料也是稳定化技术中的重要环节。耐氧性好、湿敏性低的包装材料可以有效地隔离外界氧气和湿气，减少对米糠的影响。

Selection of packaging materials: Choosing suitable packaging materials is also an important part of stabilization technology. Packaging materials with good oxygen resistance and low moisture sensitivity can effectively isolate external oxygen and moisture and reduce the impact on rice sugar.

4.2.4米糠油的生产

Production of rice bran oil

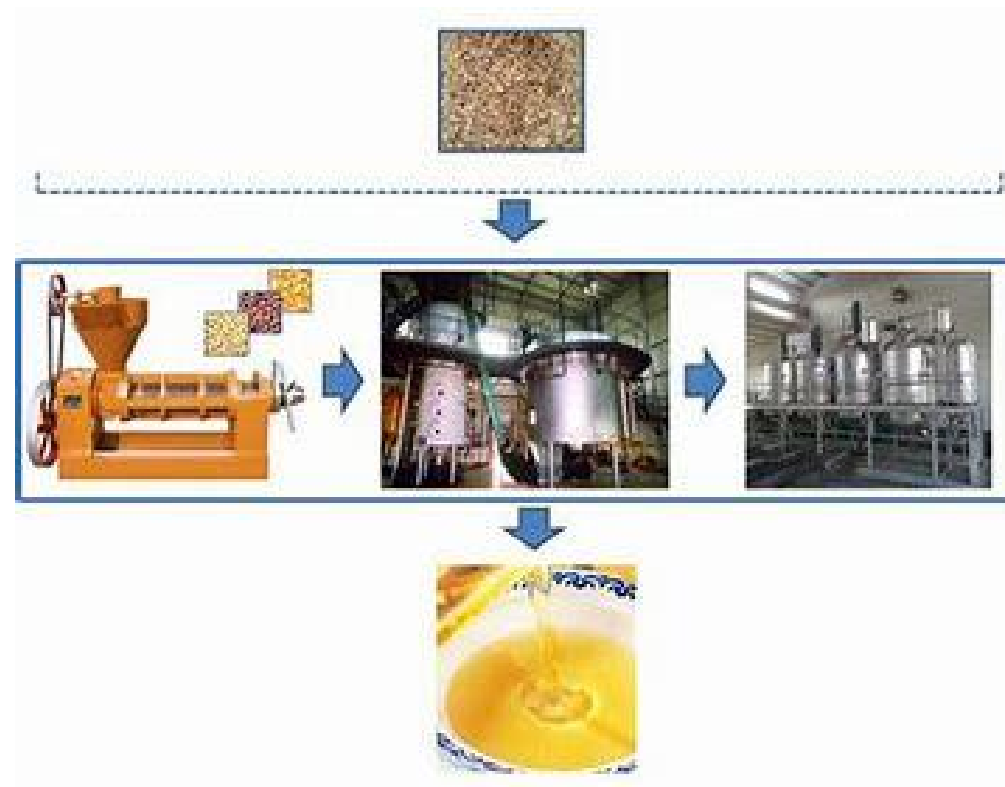
米糠油是指通过加工米糠（稻谷外层的外壳）提取而得的食用油。下面是米糠油的一般生产过程：

Rice bran oil refers to the edible oil extracted by processing rice bran (the outer shell of rice). Here is the general production process of rice bran oil:

清洁和预处理：首先，将收集到的米糠进行清洁去杂，去除其中的杂质和不良颗粒。然后，对米糠进行预处理，如脱水、烘干等，以**降低其水分含量并改善后续加工过程。**

Cleaning and pretreatment: First, the collected rice bran is cleaned and impurities removed to remove impurities and bad particles.

Then, the rice bran is pretreated, such as dehydration, drying, etc., to reduce its moisture content and improve subsequent processing.



4.2.4米糠油的生产 Production of rice bran oil

粉碎和破壳：将经预处理的米糠送入粉碎机或破壳机，对米糠进行碾碎和破壳，使得米糠外壳破裂，有利于后续的油脂提取。

Crushing and shell breaking: The pretreated rice bran is sent to the crusher or shell breaker to crush and break the shell of the rice bran, so that the rice bran shell is broken, which is conducive to subsequent oil extraction.



4.2.4米糠油的生产

Production of rice bran oil

溶剂提取：通过溶剂提取方法，将碾碎的米糠与食品级有机溶剂（如正己烷、乙醚等）进行接触，使米糠中的油脂溶解在溶剂中。该过程可以采用**离心浸提、浸渍法、循环浸泡**等方法进行。

Solvent extraction: Through the solvent extraction method, the crushed rice bran is in contact with food-grade organic solvents (such as n-hexane, ether, etc.) to dissolve the oil in the rice bran in the solvent. The process can be carried out by centrifugal extraction, impregnation method, cyclic immersion and other methods.

溶剂脱除和油脂精炼：将含有溶剂和油脂的混合液进行脱溶剂处理，一般采用蒸发和蒸馏的方法，将有机溶剂从溶剂油中分离出来。然后，通过**过滤、脱酸、脱色**等工艺步骤进行油脂的精炼和净化。

Solvent removal and oil refining: The mixture containing solvent and grease is desolvated, and the organic solvent is generally separated from the solvent oil by evaporation and distillation. Then, the oil is refined and purified through process steps such as filtration, deacidification and decolorization.

4.2.4米糠油的生产

Production of rice bran oil

植物油加工：经过精炼的米糠油可以进一步进行植物油的加工处理，如脱臭、去酸、脱色等，以提高其质量和纯度。

Vegetable oil processing: After refining rice bran oil, it can be further processed by vegetable oil, such as deodorization, acid removal, decolorization, etc., to improve its quality and purity.

检验和包装：对最终得到的米糠油进行质量检验，包括检测酸价、过氧化值、色泽等指标，确保符合食用油的标准要求。然后，将米糠油进行包装，储存和销售。

Inspection and packaging: quality inspection of the final rice bran oil, including detection of acid value, peroxide value, color and other indicators to ensure that it meets the standard requirements of edible oil. The rice bran oil is then packaged, stored and sold.



4.2.5 植酸钙的生产 Production of calcium phytate

植酸钙是一种常见的饲料添加剂，用于补充动物饲料中的钙和磷。下面是植酸钙的一般生产过程：

Calcium phytate is a common feed additive used to supplement calcium and phosphorus in animal feed. The following is the general production process of calcium phytate:



4.2.5 植酸钙的生产

Production of calcium phytate

①原料准备：植酸钙主要以稻壳或其他植物饼粉、谷物糠等为原料。首先需要对原料进行清洁和破碎处理，**确保原料的质量和适用性。**

Raw material preparation: calcium phytate is mainly made of rice husk or other plant cake powder, grain bran, etc. as raw materials. First of all, the raw materials need to be cleaned and crushed to ensure the quality and suitability of the raw materials.

②酸化处理：将原料加入反应釜中，并在适宜的温度和湿度条件下，加入酸性物质（如硫酸、盐酸等）进行酸化处理。酸能够使植物中的植酸酶失活，降低植酸的含量。

Acidification: the raw materials are added to the reactor, and under suitable temperature and humidity conditions, acidic substances (such as sulfuric acid, hydrochloric acid, etc.) are added for acidification. Acid can inactivate phytase in plants and reduce the content of phytic acid.

4.2.5 植酸钙的生产

Production of calcium phytate

③沉淀和分离：经过酸化处理后，植酸与钙结合形成溶解度较低的植酸钙沉淀。通过沉淀和分离工艺，将植酸钙与其他杂质分离出来。通常采用**离心分离或过滤**方法进行。

Precipitation and separation: After acidification treatment, phytic acid combines with calcium to form calcium phytate precipitation with low solubility. By precipitation and separation process, calcium phytate is separated from other impurities. This is usually done by centrifugal separation or filtration.

④湿法破碎：经过分离的植酸钙沉淀需要进行湿法破碎，使其达到细微的颗粒状态。湿法破碎可以采用磨机或球磨机等设备进行。

Wet crushing: The separated calcium phytate precipitation needs to be wet crushed to make it reach a fine particle state. Wet crushing can be carried out with equipment such as a mill or ball mill.

植酸钙的生产

Production of calcium phytate

⑤干燥和粉碎：将湿法破碎后的植酸钙颗粒进行干燥处理，去除水分。然后通过粉碎设备进行细碎，得到所需的**粒度和颗粒形态**。

Drying and crushing: the calcium phytate granules after wet crushing are dried to remove moisture. It is then finely crushed by the crushing equipment to obtain the desired particle size and particle morphology.

⑥检验和包装：对最终得到的植酸钙进行质量检验，包括检测钙含量、磷含量、重金属含量等指标，确保符合相关的标准要求。然后，将植酸钙进行包装，储存和销售。

Inspection and packaging: quality inspection of the final calcium phytate, including detection of calcium content, phosphorus content, heavy metal content and other indicators to ensure that it meets the relevant standard requirements. Then, calcium phytate is packaged, stored and sold.

4.3 稻壳的综合利用 Comprehensive utilization of rice husks

4.3.1 稻壳的理化特性 Physical and chemical properties of rice husks

稻壳是稻谷的外层保护壳，具有以下理化特性：

Rice husk is the outer protective case of rice, which has the following physical and chemical characteristics:

组成成分：稻壳主要由**纤维素、半纤维素和木质素**组成。其中，纤维素是主要的成分，占据了稻壳总质量的60%~70%。此外，稻壳中还含有一定量的蛋白质、脂肪、灰分等。

Composition: Rice husk is mainly composed of cellulose, hemicellulose and lignin. Among them, cellulose is the main ingredient, accounting for 60% to 70% of the total mass of rice husks. In addition, the rice husk also contains a certain amount of protein, fat, ash, etc.



4.3.1 稻壳的理化特性 Physical and chemical properties of rice husks

密度：稻壳的密度较低，一般在 $0.25-0.55 \text{ g/cm}^3$ 之间，取决于稻谷品种和处理方式等因素。

Density: The density of rice husk is low, generally between 0.25 and 0.55 g/cm^3 , depending on factors such as rice varieties and treatment methods.

水分含量：稻壳的水分含量较高，一般在 $10\% \sim 20\%$ 之间，但会受到环境湿度和储存条件的影响而变化。

Moisture content: The moisture content of rice husk is relatively high, generally between 10% and 20% , but it will change due to the influence of environmental humidity and storage conditions.

燃烧特性：稻壳属于可燃物质，其燃烧时释放出热能。由于稻壳含有较多的纤维素和半纤维素，其燃烧速率快，容易发生明火，但燃烧后的灰渣残留量较少。

Combustion characteristics: rice husk belongs to combustible substances, and heat energy is released when burned. Since rice husk contains more cellulose and hemicellulose, its combustion rate is fast and open flame is prone to occur, but the amount of ash residue after combustion is less.



4.3.1 稻壳的理化特性 Physical and chemical properties of rice husks

粉尘含量: 稻壳加工过程中会产生大量的粉尘，其中含有微小颗粒和纤维物质。长期暴露在稻壳粉尘环境中可能对人体健康造成影响，需要采取相应的防护和控制措施。

Dust content: A large amount of dust will be produced during the processing of rice husk, which contains tiny particles and fibrous substances. Long-term exposure to rice husk dust may cause effects on human health, and corresponding protective and control measures need to be taken.

pH值: 稻壳的pH值一般较高，约在8-9之间，属于碱性。

pH value: The pH value of rice husk is generally high, between 8-9, which is alkaline.

孔隙结构: 稻壳具有丰富的孔隙结构，使其具有一定的吸水性和透气性。

Pore structure: rice husk has rich pore structure, making it have certain water absorption and air permeability.



4.3.2 稻壳的能源利用

Energy use of rice husks

稻壳是一种常见的农作物副产品，**具有丰富的能源潜力**。以下是几种常见的稻壳**能源利用方式**：

Rice husk is a common crop by-product with abundant energy potential. Here are a few common ways to use rice husk energy:

燃料利用：稻壳可以直接作为生物质燃料进行燃烧，用于发电、供热或烹饪等用途。稻壳燃烧时释放出的热能**可替代传统的化石燃料**，具有较低的碳排放和环境影响。

Fuel utilization: rice husks can be burned directly as biomass fuel for power generation, heating or cooking. The heat released when rice husks are burned can replace traditional fossil fuels, with lower carbon emissions and environmental impact.



4.3.2 稻壳的能源利用

Energy use of rice husks

生物质颗粒：将稻壳经过加工处理，制成高能效的生物质颗粒（如木屑颗粒），可用作固体生物燃料。生物质颗粒可广泛应用于工业锅炉、家庭取暖和炊具等领域。

Biomass pellets: Rice husks are processed to make energy-efficient biomass pellets (such as wood pellets), which can be used as solid biofuel. Biomass pellets can be widely used in industrial boilers, home heating and cookware.

生物质炭：通过稻壳的干燥、炭化和活化等过程，可以将其转化为生物质炭。生物质炭具有高热值、良好的燃烧性能和吸附能力，可用于烟囱净化、土壤改良、水处理等方面。

Biochar: Through the process of drying, carbonization and activation of rice husks, it can be converted into biochar. Biochar has high calorific value, good combustion performance and adsorption capacity, and can be used for chimney purification, soil improvement, water treatment and other aspects.

4.3.2 稻壳的能源利用

Energy use of rice husks

①**生物气化**：稻壳可以通过生物气化技术转化为生物质气体。生物质气体主要由一氧化碳、氢气和甲烷等组成，可用于**发电、供热以及工业燃料的生产**。

Gasification technology: Biomass gas is mainly composed of carbon monoxide, hydrogen and methane, and can be used for **power generation, heating and industrial fuel production**.

②**发酵床和有机肥料**：将稻壳用作发酵床的原料，与其他有机物一起堆肥，可以制成高品质的有机肥料。这种有机肥料富含养分，可用于**农田改良和植物栽培**。

Fermentation bed and organic fertilizer: Using rice husks as raw materials for fermentation beds and composting with other organic matter can make high-quality organic fertilizers. This organic fertilizer is rich in nutrients and can be used for **field improvement and plant cultivation**.

4.3.2.1 稻壳制取化工原料

Rice husk to produce chemical raw materials

糖：稻壳中含有一定量的多糖，如半纤维素和葡聚糖等。这些糖类物质可以通过酶解和发酵等方法转化为各种糖类化工原料，包括生物燃料乙醇、生物聚合物等。

Sugar: Rice husk contains a certain amount of polysaccharides, such as hemicellulose and dextran. These carbohydrates can be converted into various carbohydrate chemical raw materials through enzymatic hydrolysis and fermentation, including biofuels, ethanol, biopolymers, etc.

酸类化学品：稻壳中的木质素和其他成分可通过热解或化学处理提取出来，用于制备酸类化学品。例如，通过催化剂作用，可以将稻壳中的木质素转化为苯酚、酚醛树脂等。

Acid chemicals: Lignin and other components in rice husks can be extracted by pyrolysis or chemical treatment for the preparation of acid chemicals. For example, by catalyst action, lignin in rice husk can be converted into phenol, phenolic resin, etc.

4.3.2.1 稻壳制取化工原料

Rice husk to produce chemical raw materials

活性炭：稻壳经过炭化和活化处理后，可以制成高品质的活性炭。活性炭具有较大的比表面积和吸附能力，广泛应用于净水、净化空气、废气处理等领域。

Activated carbon: After the rice husk is carbonized and activated, it can be made into high-quality activated carbon. Activated carbon has a large specific surface area and adsorption capacity, and is widely used in water purification, air purification, waste gas treatment and other fields.

有机肥料：稻壳经过堆肥和发酵等处理，可以制成优质的有机肥料。这种有机肥料中含有丰富的养分和有益微生物，可提高土壤肥力，促进农作物生长。

Organic fertilizer: After processing such as composting and fermentation, rice husks can be made into high-quality organic fertilizers. This organic fertilizer is rich in nutrients and beneficial microorganisms that improve soil fertility and promote crop growth.

4.3.2.2 稻壳饲料的制备

Preparation of rice husk feed

稻壳可以通过适当的加工和处理，制备成饲料用于动物的喂养。以下是一种常见的稻壳饲料的制备方法：

Rice husks can be prepared into feed for animal feeding through proper processing and handling. The following is a common preparation method for rice husk feed:

清洗：将稻壳进行清洗，去除杂质和不洁物，确保饲料的卫生和品质。

Cleaning: Wash the rice husk to remove impurities and unclean substances to ensure the hygiene and quality of the feed.

粉碎：使用颚式破碎机或其他合适的机械设备，将清洗后的稻壳进行粉碎，使其**颗粒大小适宜**，便于动物食用和消化。

Crushing: Use a jaw crusher or other suitable mechanical equipment to crush the cleaned rice husk to make its particle size suitable for animal consumption and digestion.



4.3.2.2 稻壳饲料的制备

Preparation of rice husk feed

发酵：将粉碎后的稻壳进行发酵处理。可以添加菌种或发酵剂，促进发酵过程。发酵可降低稻壳中的纤维素和抗营养物质含量，提高饲料的营养价值和口感。

Fermentation: The crushed rice husk is fermented. Cultures or starter cultures can be added to facilitate the fermentation process. Fermentation can reduce the content of cellulose and antinutrients in rice husks, and improve the nutritional value and taste of feed.

混合：将发酵后的稻壳与其他饲料原料（如谷物、豆粕等）按一定比例混合，使饲料的营养成分均衡，并增加其可口性。

Mixing: The fermented rice husk is mixed with other feed raw materials (such as grain, soybean meal, etc.) in a certain proportion to make the nutritional composition of the feed balanced and increase its palatability.



4.3.2.2 稻壳饲料的制备

Preparation of rice husk feed

干燥：将混合好的饲料进行干燥处理，以降低水分含量，**延长保存期限。**

Drying: The mixed feed is dried to reduce the moisture content and extend the shelf life.

包装和存储：将制备好的稻壳饲料进行包装，存放在干燥、通风、防潮的环境中，**以确保其质量和安全。**

Packaging and storage: The prepared rice husk feed is packaged and stored in a dry, ventilated and moisture-proof environment to ensure its quality and safety.





Thank You

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