

Chapter 4 Processing technology of vegetable oil

第四章 植物油脂的加工工艺



* Vegetable oils and fats

industrial
applications

the major components of food

- fat-soluble vitamins
 - vitamin A
 - vitamin E

feed

medicine



an important
source of energy

- essential fatty acids
 - linoleic acid
 - linolenic acid
 - arachidonic acid





1. Varieties and Compositions of Vegetable oilseeds

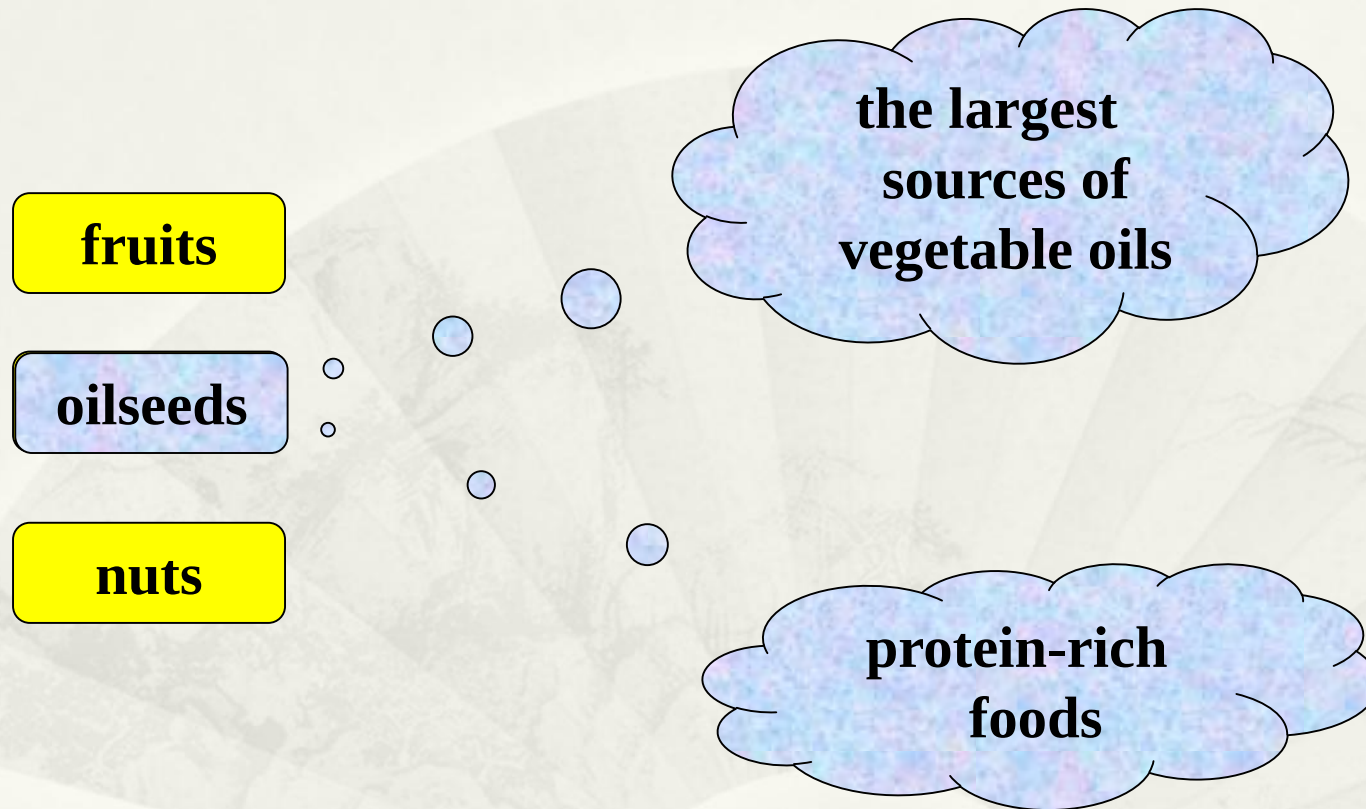
植物油料种子的种类和组成



1.1 Varieties of vegetable oilseeds

植物油料种子的种类

* Vegetable oils and fats are extracted



* Classification of oilseeds

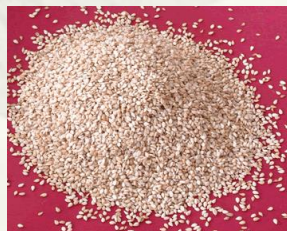
the plant seeds and fruit pulp
with **oil content** above 10%

oilseeds

oilseeds with high
oil content

oilseeds with low
oil content

- oil content > 30%
- peanut
- colza
- cottonseed
- sesame



* Classification of oilseeds

the plant seeds and fruit pulp
with **oil content** above 10%

oilseeds

oilseeds with high.
oil content

• oil content > 30%

oilseeds with low
oil content

• oil content < 20%

• Soybean

• rice bran

• corn embryo



testa

- **Protect:**
 - **embryo**
 - **endosperm**

outside of seed

1.2 Structure of vegetable oilseeds

植物油料种子的结构

husk

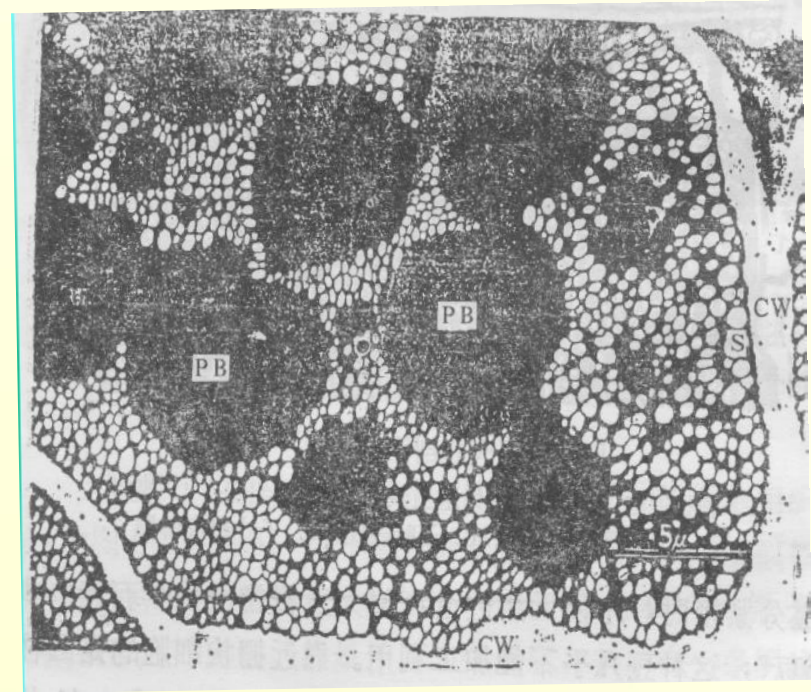
**endosperm
or
cotyledon**

embryo

protoplasm
原生质体
or
spherosome

protein bodies

oils



**storage
protein**

triglycerides

phospholipids

proteins

sterols

1.3 Main components of oilseeds

油料种子的主要化学成分

tocopherols

carbohydrates

- **pigments**
 - **gossypol**
 - **carotene**
 - **chlorophyll**

1.3.1 Oil（油脂）

(1) Definition of Lipids（脂质的定义）

- * Lipids are defined as “a wide variety of natural products including **fatty acids** and **their derivatives** (steroids, terpenes, carotenoids, and bile acids), which is soluble in organic solvents such as diethyl ether, hexane, benzene, chloroform, or methanol.”
- * 脂质是天然食品中的一大类成分，包括脂肪酸及其衍生物（如类固醇、萜烯类、类胡萝卜素、胆汁酸类），它们易溶于有机溶剂如乙醚、己烷、苯、氯仿、甲醇等。

1 of glycerol

oil

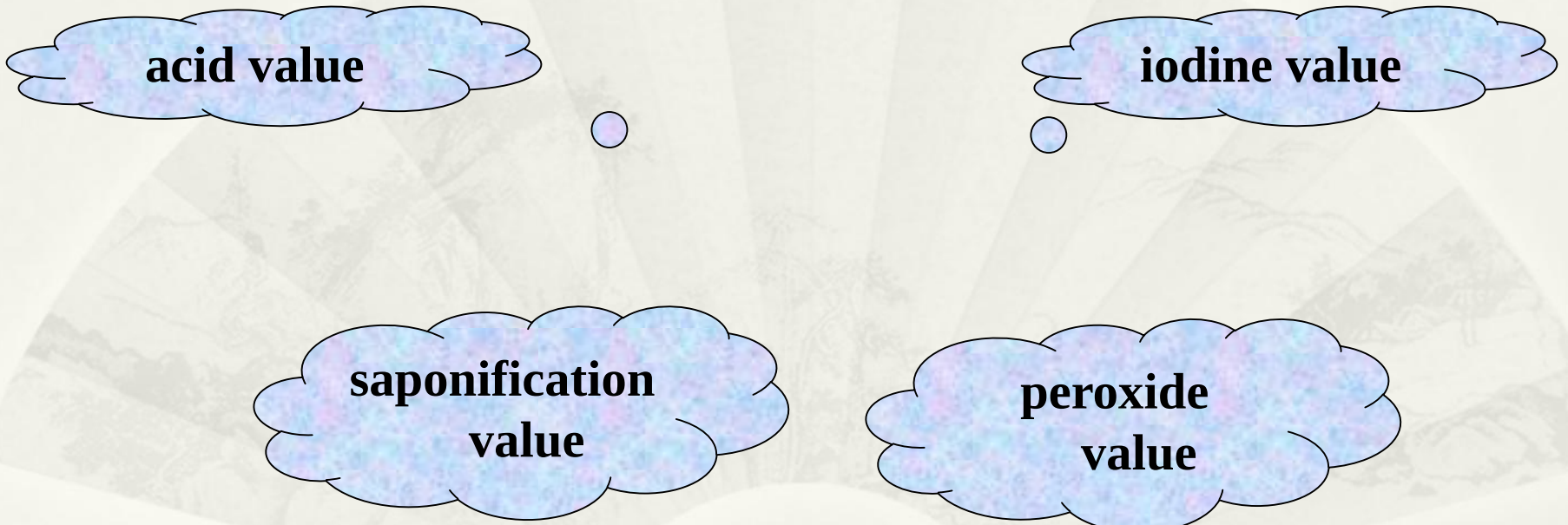


triglyceride

3 of fatty acids



(2) Physical characteristics of oil



acid value

The diagram features four blue, cloud-like shapes arranged in a square pattern. Each cloud contains a text label. The top-left cloud is labeled 'acid value', the top-right 'iodine value', the bottom-left 'saponification value', and the bottom-right 'peroxide value'. The background is a light beige color with a faint, circular, fan-like pattern. There are several small blue circles scattered around the clouds, some above and some below them.

iodine value

saponification
value

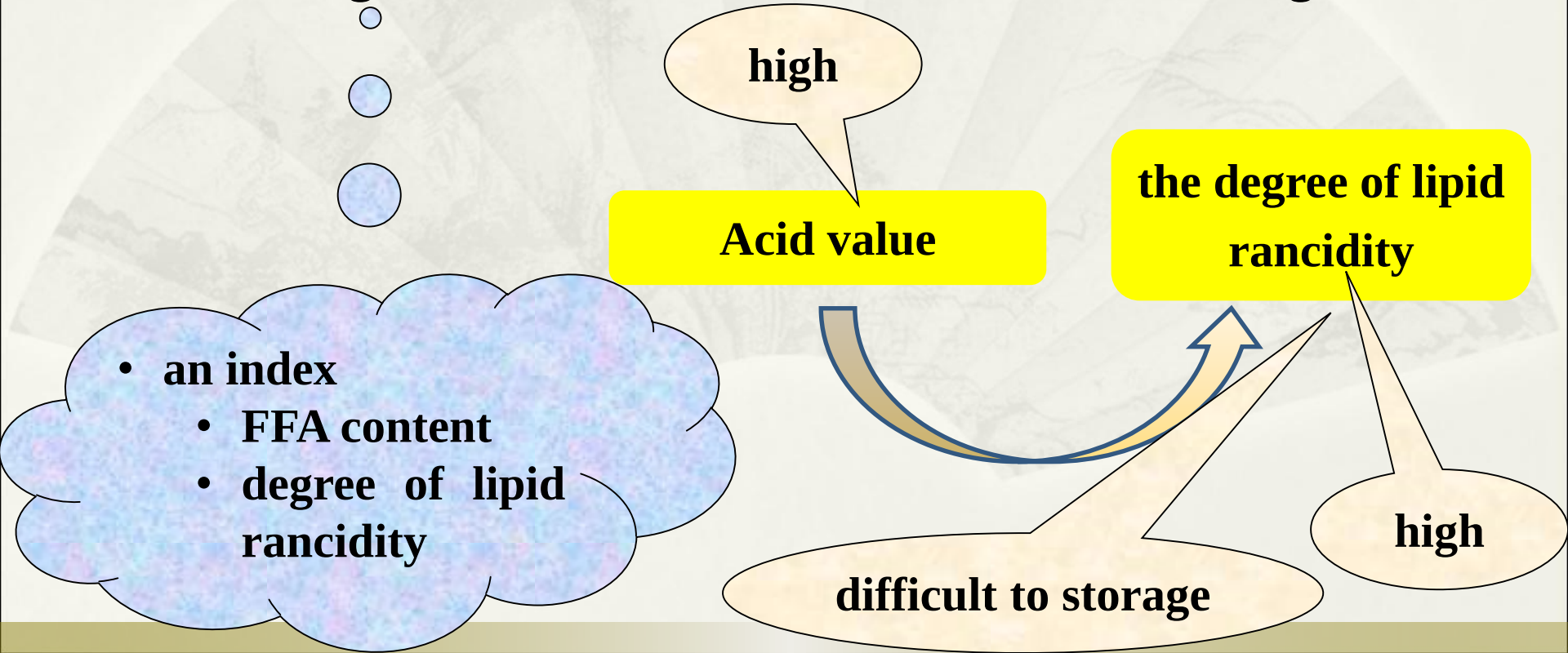
peroxide
value

① Acid value (酸价)

与油脂的酸解有关
，与不饱和度无关

* Acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free acids in 1g of sample.

* 中和1g油脂样品中的游离脂肪酸所需的KOH mg数。



**Not exist in
pure oil**

Free fatty acid

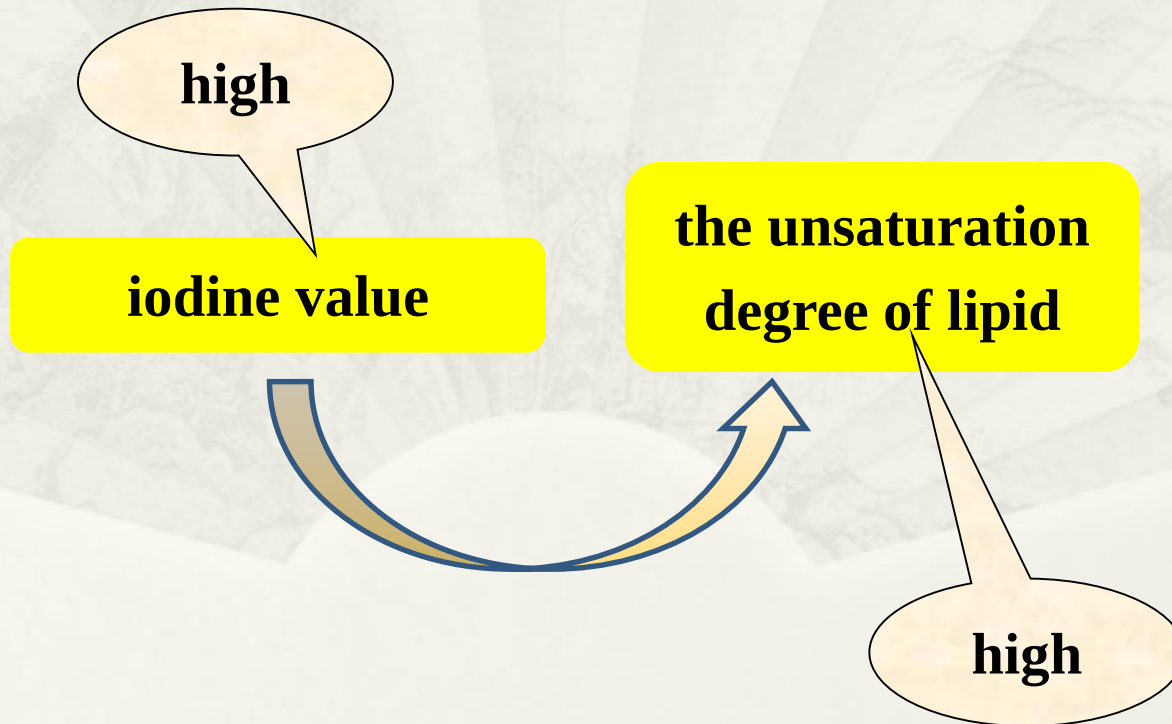
**immatured
oilseed**

**Hydrolysis
of oil**

**Abnormal storage
or processing**

② Iodine value (碘价)

- * Iodine value (IV) measures the unsaturation degree of lipid and is defined as the number of grams of iodine absorbed by 100g of lipid.
- * 100g脂类样品所能吸收的碘g数，表示油脂的不饱和程度。



iodine value

lipid

Non-drying oil

$IV < 80$

Semi-drying oil

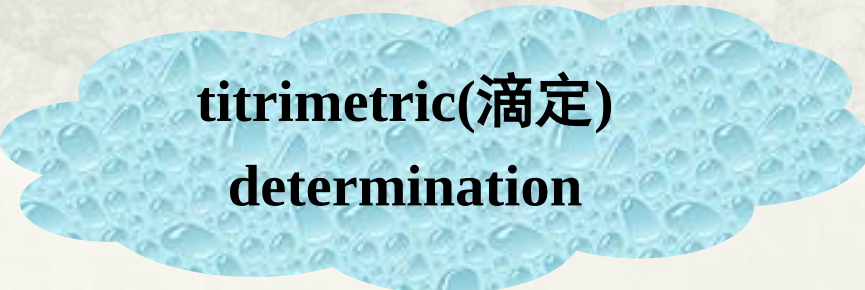
$80 < IV < 130$

Drying oil

$IV > 130$

③ Peroxide value (过氧化值)

- * Peroxide value is defined as the millimoles of peroxidises per kilogram of sample.
- * 过氧化值是指1kg油脂中过氧化物的毫摩尔数。

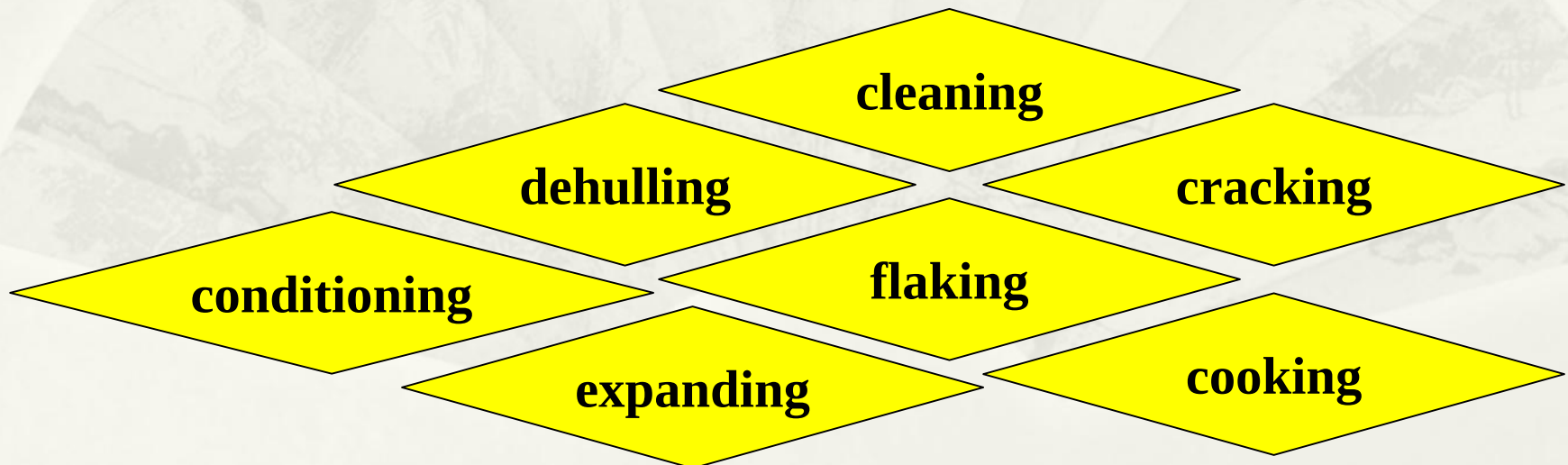


titrimetric(滴定)
determination

2 Pretreatments of vegetable oilseeds

植物油料的预处理

- * **Lipids in nature are associated with other molecules**
 - * **interaction between lipids and proteins**
 - * **covalent bonding among lipids, carbohydrates, and proteins.**
- * **Therefore, to obtain triglycerides with high yield and purity from a complex cellular matrix, different chemical and physical treatments must be administered.**



2.2 Dehulling of oilseeds

油料的剥壳

① Compared with meat, hulls always contain low oil content .

< 1%

**absorb oil
in the press cake**

**reduce the capacity
of equipment**

① Compared with meat, hulls always contain low oil content .

② Some oilseed hulls contain high-melting waxes, pigments, and gums.

**extracted with
raw oil**

high level of wax

dark color

**difficult to refine
for crude oil**

appropriate dehulling

**oil cells
→ ruptured**

**kernel is easy to
separate from the hull**

free oil

oil yield ↗

before dehulling

dried

**some seeds
soybeans**

conditioned

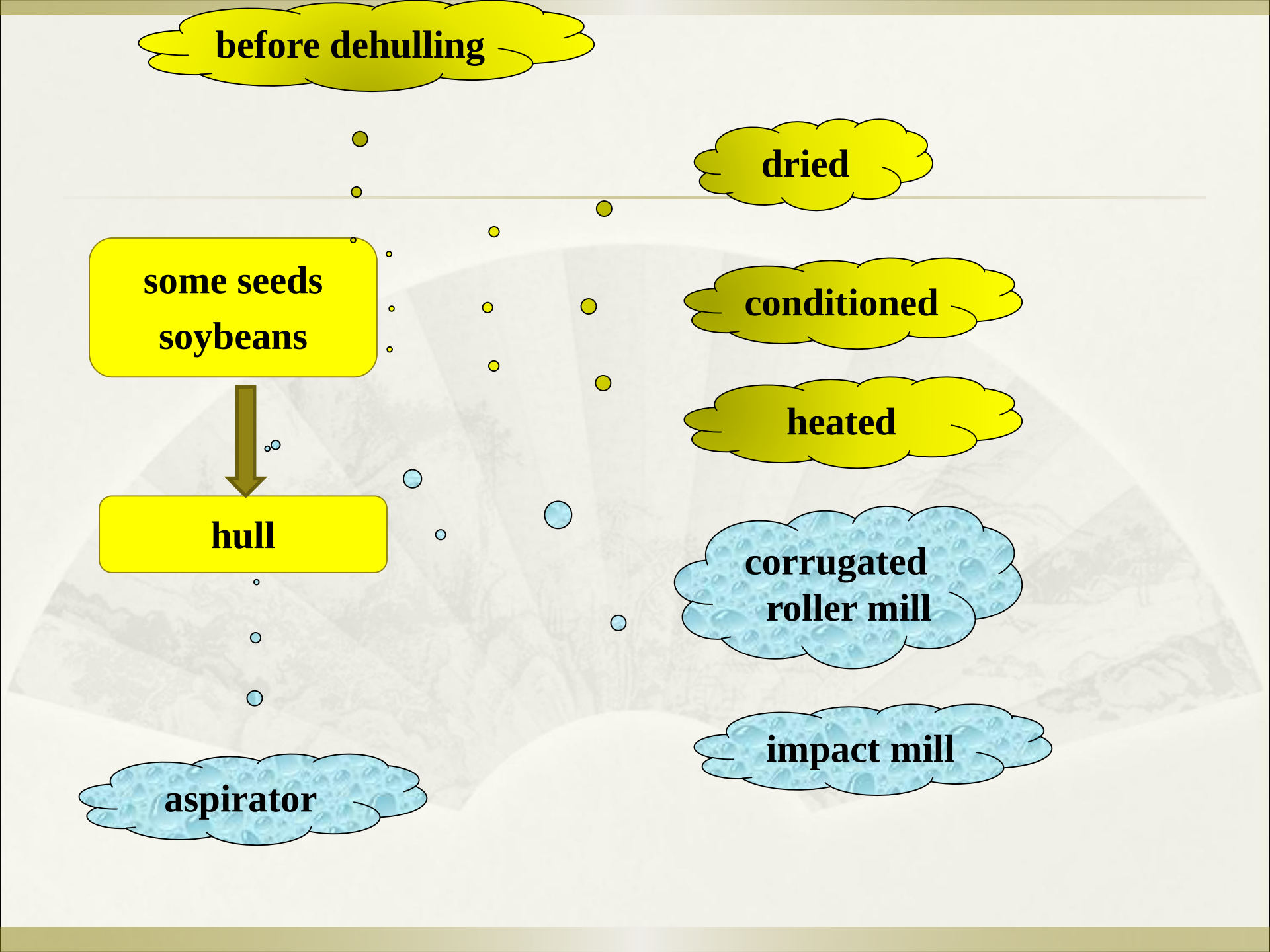
heated

hull

**corrugated
roller mill**

aspirator

impact mill

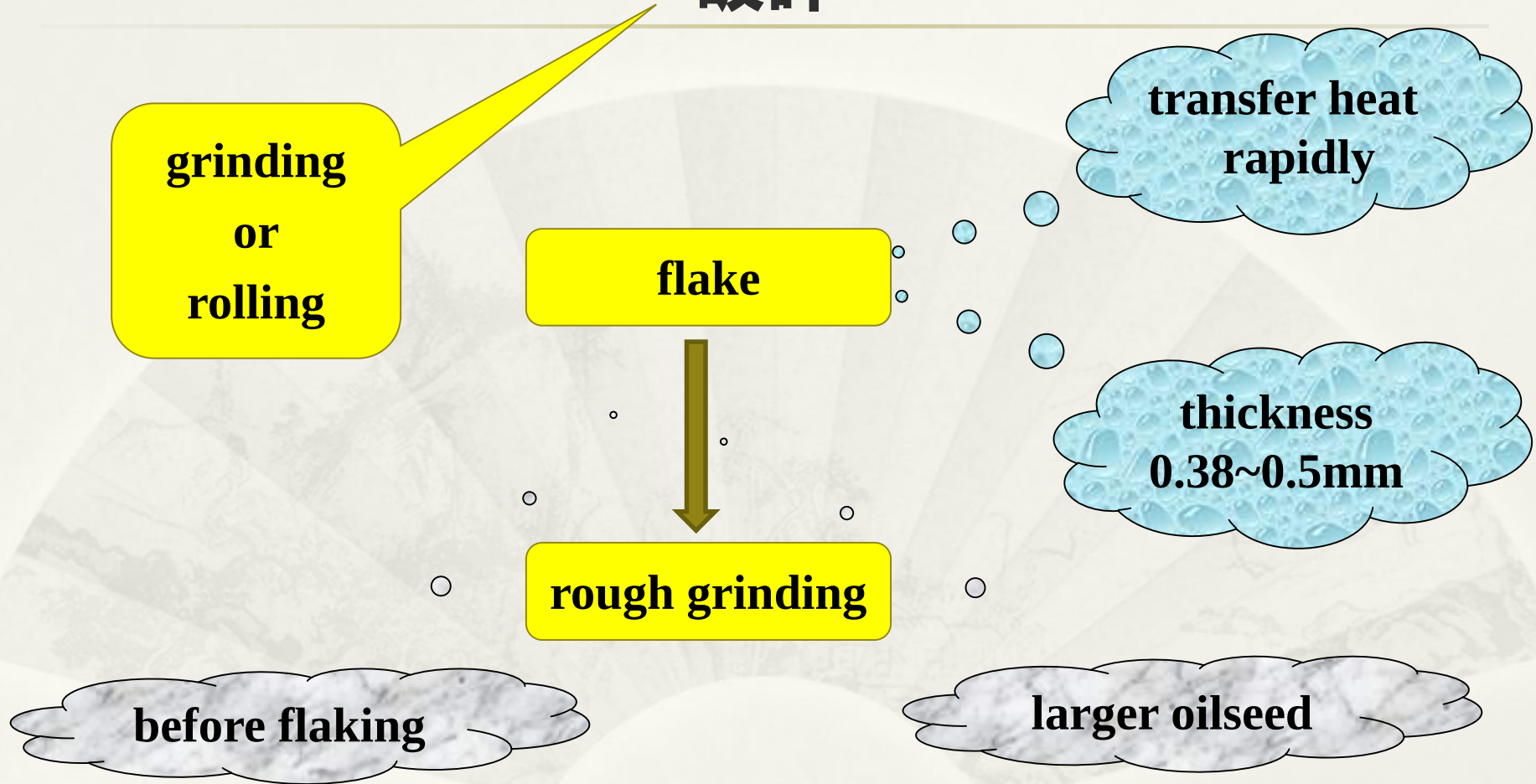


2.3 Cracking and conditioning of oilseeds

油料的破碎与软化

2.3.1 Cracking or Particle size reduction

破碎



2.3.2 Conditioning (软化)

- * The purpose of conditioning
 - * to adjust water content and temperature of oilseeds;
 - * to produce suitable plasticity for oilseed;
 - * to make the next procedure flaking easily.

heating the seed

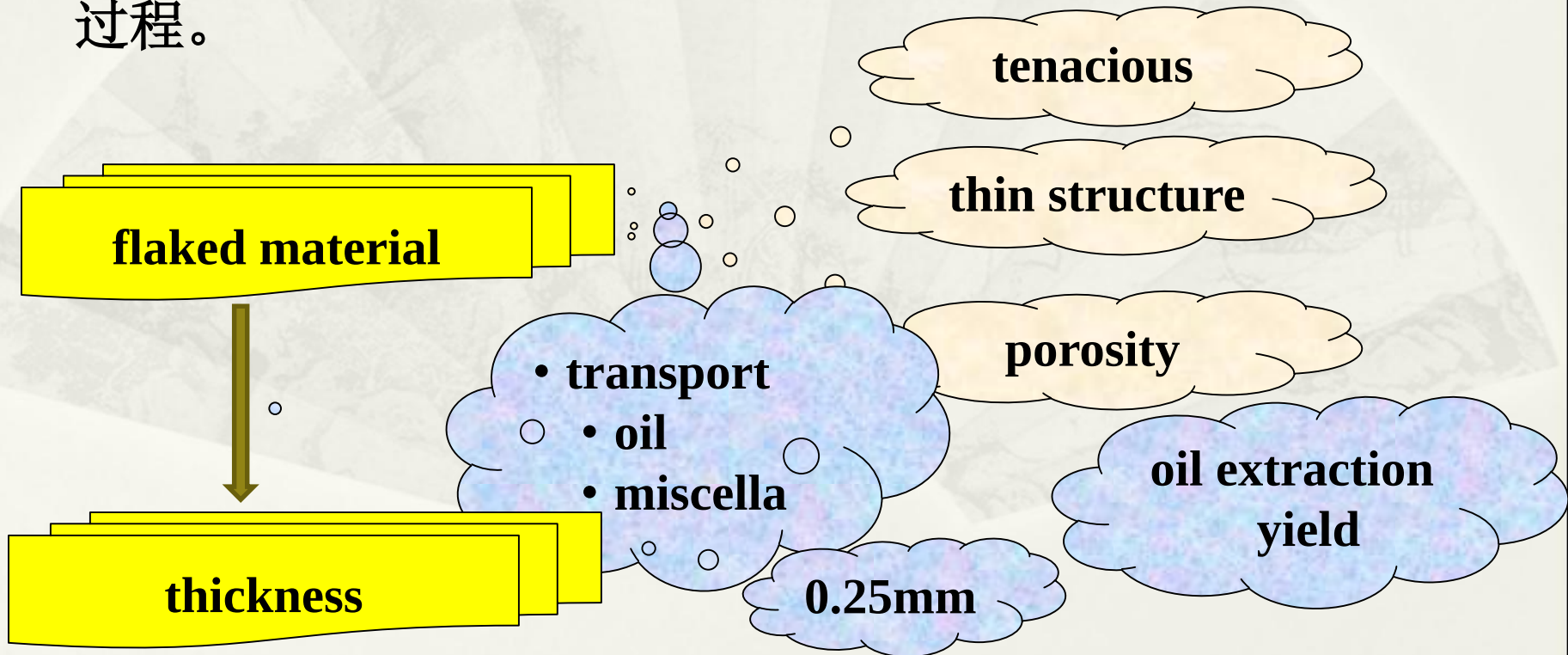
at 70~80°C

20~30min

**10.5~11.5%
of moisture**

2.4 Flaking of oilseed (油料的轧坯)

- * Flaking of oilseed is the procedure to change the shape from particles to flakes by mechanical force.
- * 轧粒是利用机械的挤压力，将颗粒状油料轧成片状料坯的过程。



2.5 Extrusion puffing of flaked cake

油料生坯的挤压膨化

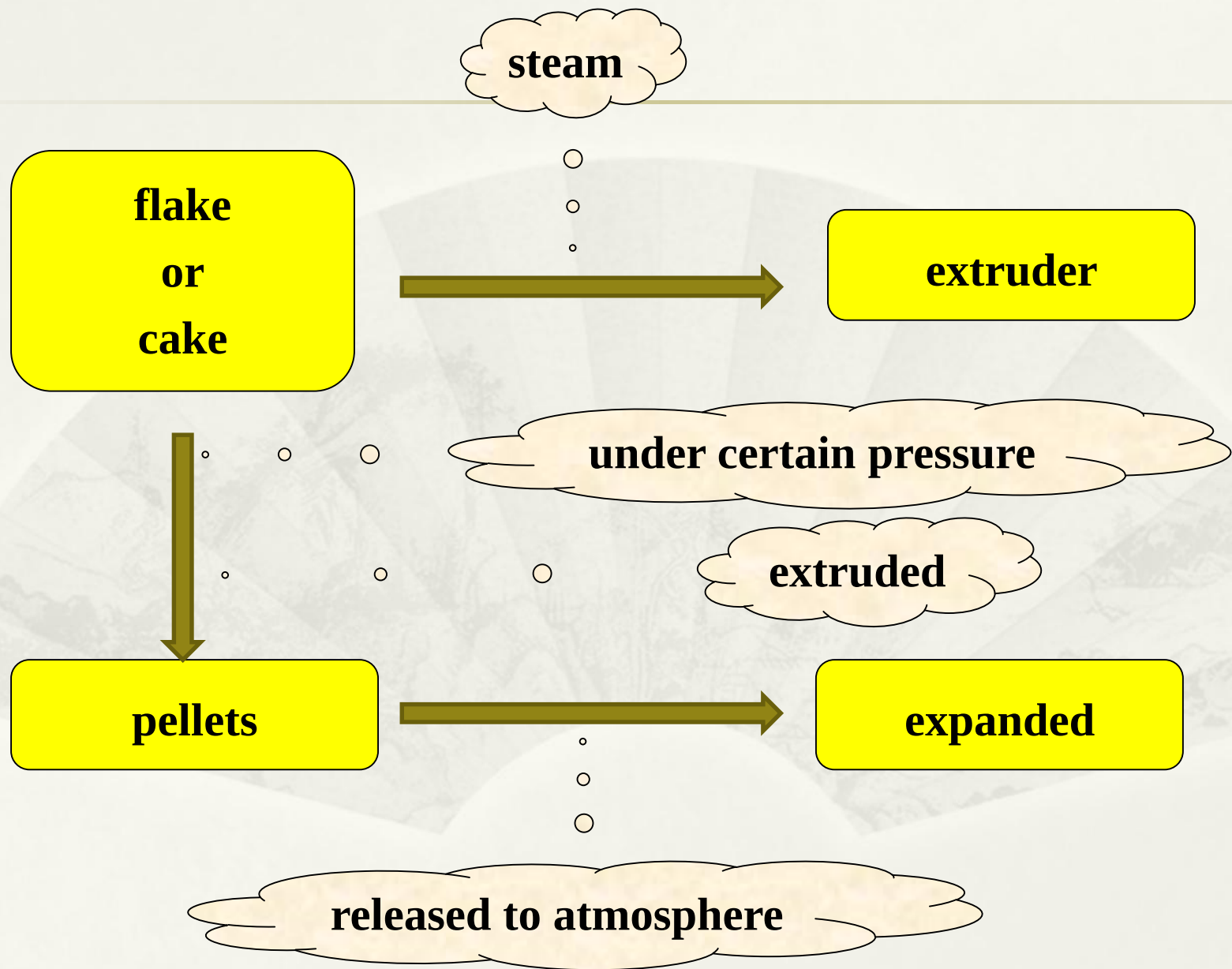
- * **Extrusion puffing of flaked cake is a procedure that makes the cake into porous pellets with a high bulk density by heating, homogenizing, and shaping with a extruder.**
- * **油料料坯的挤压膨化是利用挤压机通过加热、混合、成型等工序将生坯制成具有较高容重的多孔颗粒物料的过程。**



The diagram illustrates a process flow. On the left, there are three overlapping yellow rectangular boxes, each containing the text 'flake after extrusion'. A line of three small circles connects these boxes to a large, light-yellow cloud shape on the right. Inside the cloud, the text 'used for solvent extraction directly' is written.

flake after extrusion

**used for
solvent extraction
directly**



*** The purpose of extrusion puffing（挤压膨化的目的）：**

(1) Increasing bulk density and porosity, completely damaging cell structures, and inactivating enzyme.

容重增大，多孔性增加，油料细胞组织被彻底破坏，酶类被钝化。

*** The purpose of extrusion puffing（挤压膨化的目的）：**

- (1) Increasing bulk density and porosity, completely damaging cell structures, and inactivating enzyme.**
- (2) Reducing ratio of solvent to meal, and increasing extraction rate.**

浸出溶剂比减小，浸出速率提高；

*** The purpose of extrusion puffing（挤压膨化的目的）：**

- (1) Increasing bulk density and porosity, completely damaging cell structures, and inactivating enzyme.**
- (2) Reducing ratio of solvent to meal, and increasing extraction rate.**
- (3) Increasing concentration of miscella, and reducing solvent level in wet meal.**

混合油浓度增大，湿粕含溶降低；

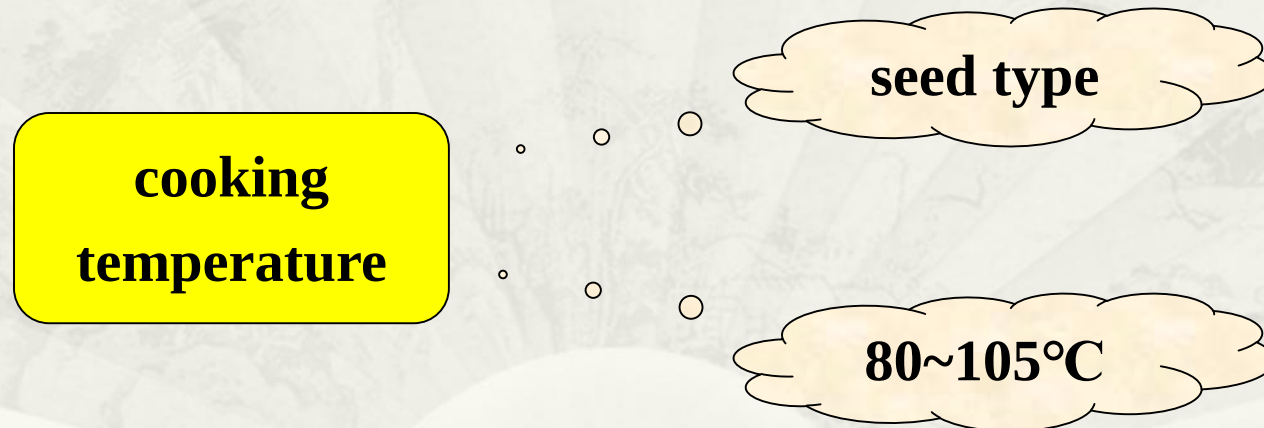
*** The purpose of extrusion puffing（挤压膨化的目的）：**

- (1) Increasing bulk density and porosity, completely damaging cell structures, and inactivating enzyme.
- (2) Reducing ratio of solvent to meal, and increasing extraction rate.
- (3) Increasing concentration of miscella, and reducing solvent level in wet meal.
- (4) Improving crude oil quality.**

浸出毛油的品质提高。

2.6 Heating and cooking of oilseeds

油料的加热或蒸炒



*** The purpose of proper heating or cooking:**

(1) completely breakdown of the oil cells;

充分破坏油料细胞;



*** The purpose of proper heating or cooking:**

(1) completely breakdown of the oil cells;

(2) coagulation of the proteins to facilitate the oil and meal separation;

使蛋白凝固变性，便于油与饼粕的分离；

*** The purpose of proper heating or cooking:**

- (1) completely breakdown of the oil cells;
- (2) coagulation of the proteins to facilitate the oil and meal separation;
- (3) insolubilization of the phospholipids;
降低磷脂的溶解性;

*** The purpose of proper heating or cooking:**

- (1) completely breakdown of the oil cells;
- (2) coagulation of the proteins to facilitate the oil and meal separation;
- (3) insolubilization of the phospholipids;
- (4) **destruction of molds and bacteria, inactivation of enzymes;**

破坏霉菌和细菌等微生物，钝化酶活；

lipase

lipoxygenase

myrosinase

phospholipase

*** The purpose of proper heating or cooking:**

- (1) completely breakdown of the oil cells;
- (2) coagulation of the proteins to facilitate the oil and meal separation;
- (3) insolubilization of the phospholipids;
- (4) destruction of molds and bacteria, inactivation of enzymes;
- (5) **drying to a suitable moisture content;**
可以调节料坯水分;

*** The purpose of proper heating or cooking:**

- (1) completely breakdown of the oil cells;
- (2) coagulation of the proteins to facilitate the oil and meal separation;
- (3) insolubilization of the phospholipids;
- (4) destruction of molds and bacteria, inactivation of enzymes;
- (5) drying to a suitable moisture content;
- (6) destroying or deactivating gossypol.**

破坏或抑制棉酚的活性。

3 Extraction method for oil

油脂提取的方法

quality of oil

aroma

**appearance
of oil**

- * Oil extraction mainly involves pressing the oil-bearing material to separate crude oil from the solids rich in protein, washing flaked or modestly pressed material with solvent (almost always hexane).
- * 油脂的提取主要是从富含蛋白的油料饼粕中将油脂压榨出来，或利用溶剂（多为正己烷）从轧坯或预榨饼中浸提。
- * The defatted solids after pressing are known as **cake** and after solvent extraction as **meal**.
- * 经压榨后的脱脂物称为油饼，经溶剂浸提后的称为油粕。

*** All oil recovery processes are designed:**

① to obtain triglycerides as free as possible from undesirable impurities;

尽可能将油脂与其它非油杂质分离；

② to obtain a yield as high as possible, consistent with economics of the process;

尽可能高的出油率，获得最大的经济效益；

③ to produce cake, meal, or flour (finely ground meal), usually high in protein content, of maximum value.

得到富含蛋白、附加值高的油料饼粕。

oil content

**residual oil
content**

**denaturation
degree of protein**

oil extraction method

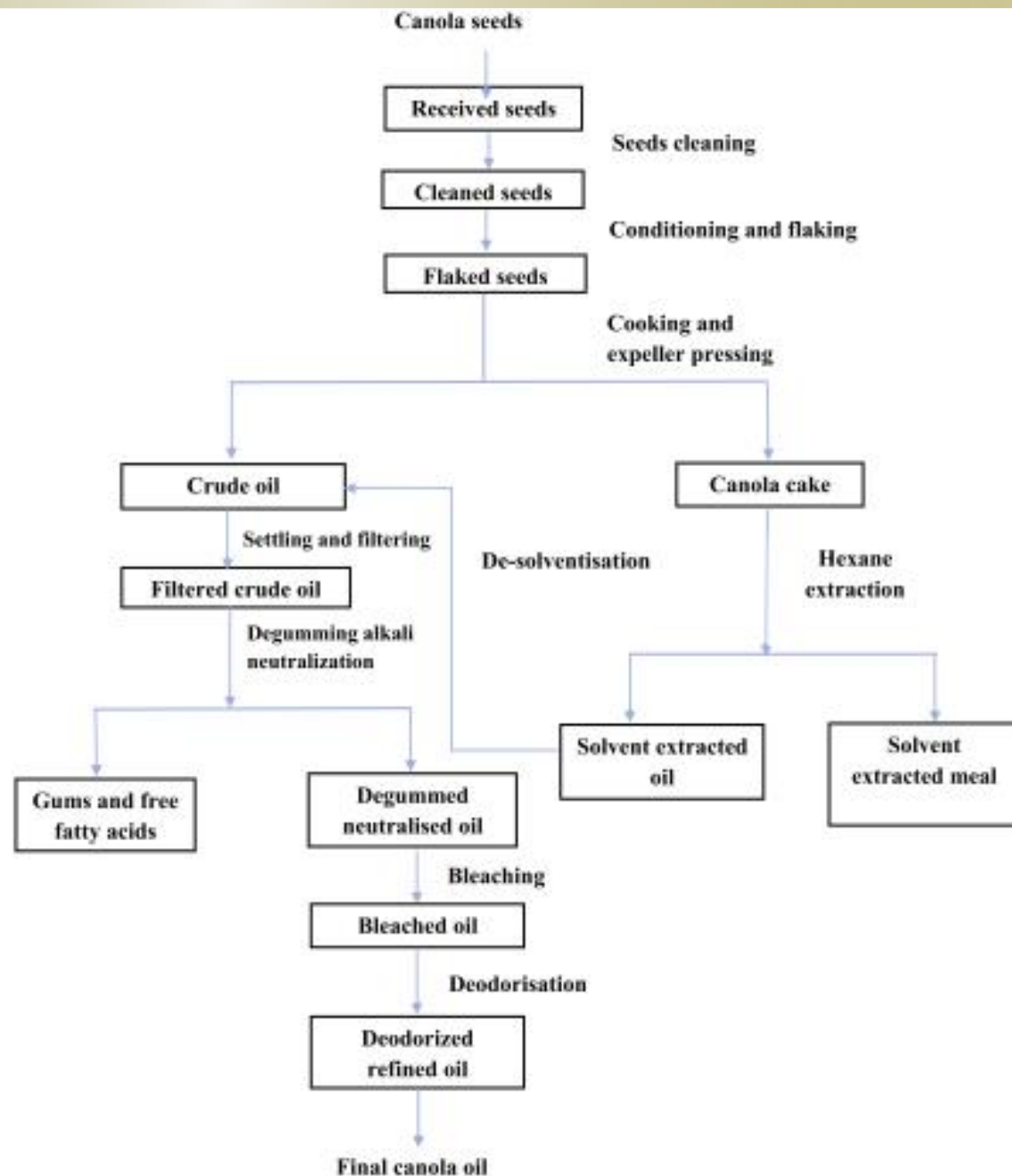
**hard
pressing**

**solvent
extraction**

**aqueous
extraction**

**supercritical
fluid
extraction**

Fig. 1 Conventional canola oil extraction process: pressing, solvent extraction, and oil refining steps



3.1 Hard pressing（机械压榨法制油）

- * **Hard pressing, or mechanical pressing, or hard screw pressing is the oldest oil recovery method.**
- * **压榨法制油是最古老的一种制油方法。**
- * **The oilseed, usually by various pretreatments to enhance oil recovery, is pressed to squeeze the oil from the solids known as cake.**
- * **借助机械外力把油脂从经过适当预处理的料坯中挤压出来的过程。**

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