Physico-chemical and physical-mechanical exposure of cotton seeds

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Abstract. This study provides information on the physicochemical and physical-mechanical properties of cotton plant seeds. The physical and mechanical characteristics of cotton seeds are crucial for the design and operation of storage facilities, bunkers, transport devices, and machinery in preparatory workshops. Proper ventilation is essential when storing, transporting, and handling oilseeds, as the presence of carbon dioxide can pose safety risks. The study highlights the importance of monitoring carbon dioxide levels in oil warehouses, galleries, tunnels, and pits associated with oilseed transportation, with a maximum allowable concentration of 0.5% by volume. Stationary or mobile devices should be used to monitor carbon dioxide levels according to a schedule approved by the chief engineer of the enterprise. This information is crucial for ensuring the safe and efficient handling of cotton seeds and other oilseeds.

1 Introduction

Cottonseed differs from other oilseeds in that it contains gossypol, a substance with toxic properties. As a result, processing of cotton seeds requires special technological regimes. Cotton seeds are hydrated before processing because the seeds are transported to the mill from gin and the moisture content of the seeds is below a critical level. The moisture content of stored seeds is 6-8%. After cleaning the seed, its moisture content is brought to a state suitable for technological processes. The moisture content of soaked seeds is determined by the moisture content of their core. This moisture content is as follows: 8.5-9.5% for varieties 1-3, 9.5-10.5% for varieties 4 [1,2].

Moistened seed in this condition is considered the optimum moisture content for crushing, peeling and peeling. To moisten the seeds, special moistening chambers of the VNIIZH or, more recently, moistening chambers are used. To moisten the seeds, use a mixture of pure water and process steam; moistening is carried out for 50-60 minutes using a humidifier VNIIZH, moistened and heated with a large amount of steam [1,2].

From a technological point of view, oil seeds consist of two parts: the kernel and the shell. Some oilseeds like cotton seeds, hemp seeds, sesame seeds, etc. have only a shell on top of the seed, while some oilseeds like pistachios, peanuts, soybeans, etc. have a shell on top of the seed. have a thin seed coat over the kernel. shell over the seed. The outer husk of all oilseeds, regardless of the type of seed, is called husk, but only the husk of cotton seeds is

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called husk. The number of components in the shell and core is different. The seed coat consists primarily of fiber or cellulose, along with small amounts of higher molecular weight carbohydrates, waxy substances, and even smaller amounts of protein and water. In the brain, the main necessary substances are fats, proteins, phosphatides, vitamins and many other substances that come along with fats. The amount of oil in the peel is very small and this oiliness is called botanical oiliness. For example, the vegetable oil content in cotton seed husks is 0.5-0.6%, and the vegetable oil content in pistachio seeds is about 2-3%. However, the oil content of the grains of the above seeds is 34-38% for cotton grains and 60-65% for pistachio seeds. From these figures it is clear that the oil of any oil-bearing plant is found mainly in the kernel and very little in the shell. If oilseeds are processed without removing the shell, the resulting vegetable oil contains higher molecular weight carbohydrates and waxes in the shell [3,4].

2 Materials and methods

If the oil seed pods are processed without separation, this situation leads to a deterioration in the quality of the resulting vegetable oil and an increase in the amount of acids, an increase in the color and rancidity of the oil. In addition, if the seeds are processed without separating the shell, part of the productivity of the machines used in the process is spent on crushing, pressing, extraction and other processes of the shell, which contains very little oil. In general, the productivity of the entire workshop decreases. Taking into account the points stated above, it is worth noting that the shell should be separated from the core as much as possible.

Cotton seed products should not contain more than 30% whole grains after the first hull and no more than 0.8% after the second hull.

It is known that the dried product contains few whole seeds, large and small husks or whole and soft husk kernels, as well as finely ground grain-oily dust.

Conventionally, oil dust refers to the fine fraction of grains that has passed through a 1 mm sieve. So, since the ground product consists of several types of components, the main goal now is to completely extract the core from the product. The following principles are used for this purpose; 1) a method of dispersing product components on sieves of different sizes due to the fact that they have different proportions 2) a method of separating them in air separators, based on the aerodynamic characteristics of the product components. For almost all oilseed crops, except cotton, these two principles are used in combination, and the name of the machine used is designated as aspiration winch (a machine that works by blowing air) M1S-50, M2S-50, P1. -MST [5,6].

It was found that there are a large number of cracks around the spherosome and globules. It is believed that these cracks were caused by the release of water vapor due to changes in moisture content during the maturation, collection or storage of petroleum products. Therefore, the purpose of grinding major oilseeds and their kernels is to disrupt the internal structure of the product by removing the husks containing the oil. Only in this case can you squeeze out or extract a full and large amount of oil from the product. The shell of oilseeds can be separated. If the shell of an oilseed can be separated, its kernel is ground, otherwise seeds whose shell cannot be separated are ground directly.

3 Results and discussion

For crushing, industry mainly uses crushing and cutting methods. These methods are widely used in five-roller threshing machines, and more recently the SKET FB-600 threshing machine has been used. If the rotation speed of the crushing machine rolls is the same, then only crushing forces act on the product. If the speed is the same, and there are thin grooves

on the surfaces of the rollers, then the crushing and cutting forces act on the product simultaneously. If the speed of rotation of the rolls under these conditions is different, then the forces of crushing, cutting and friction simultaneously act on the product.

For most oilseeds, the screened fraction should not be less than 60%. If a sheet-like product is obtained after crushing machines, then the degree of damage to the internal structure is determined by the thickness of the sheet; its thickness should be about 0.3-0.6 mm. As for cotton products, the husk content in the pulp of the seed kernel before grinding should not exceed 10% for grades 1-3 and 15% for grade 4, since the more husk in the kernel, the less crushing effect, but after grinding before cooking the product a small amount of husk is added to it and its amount is increased to 15% for the 1st-3rd varieties, 17-18% for the 4th varieties The presence of such an amount of husk in the crushed kernel gives the product porosity, helps the cooking product to distribute water and steam evenly, and contributes to its normal cooking [3,4].

When oil is moistened and cooked, the physical and chemical properties of the oil and fatty substances in it change, resulting in the maximum amount of oil being obtained.

Table 1. The processing is separated from the fiber, technical seeds with the following indicators are accepted, which comply with the requirements of O'zDSt 596:2009.

Seed variety	Damaged seeds, not more than %	seed class	Mass fraction of moisture, not more than %	Hairy, % (basis)
Varieties of medium-fiber seeds				
I	1.5	1	8.0	Not more than 8.0
		2	10.0	No more than 9.0
		3	10.0	No more than 10.5
II	3.0	1	9.0	Not more than 8.0
		2	11.0	No more than 9.0
		3	11.0	No more than 10.5
III	11.0	-	12.0	7.0 – 11.0
IV	33.0	-	13.0	8.0 – 13.0
For varieties with thin fibers				
I	1.5	1	8.0	No more than 5.5
II	3.0	1	9.0	Not more than 7.0
III	11.0	-	12.0	7.0 – 10.0

Fiber seeds consist of a seed shell (husk) and a kernel separated from the shell by a layer of water. And the composition of the husk mainly includes fiber. The essence and main step are the same as the problem of protein substances. There are two types of cotton - medium-staple and fine-staple.

The seeds of fine-fiber cotton differ from the seeds of medium-fiber cotton by having low pubescence and slightly increased amounts of oil and gossypol [5].

A characteristic feature of cotton seeds is the presence of a yellow pigment in the core tissue - gossypol, the content of which in seeds varies widely and depends on many factors: seed growth conditions, maturity, varietal characteristics, etc. The walls of the core glands, in which gossypol and its derivatives are localized, consist of cellulose impregnated with pectin, hemicellulose and not identified substances. Gossypol is poisonous and is a cellular vascular and nerve poison. The coloration and toxicity of gossypol determine the color, nutritional or feed value of processed products (oil, cake, meal). Both of these factors change completely during the seed processing process. In addition to gossypol, cotton seeds contain proteins, phosphatides, nitrogen-free extractives, carbohydrates, etc. [6,7].

Table 2. Chemical composition of Cotton Seeds.

No.	The name of indicators	Unit	Limit values
1	**2**	**3**	**4**
1	Contents in seed		
	Cores	%	35-71
	Shells	%	29-65
2	Fatty oil content		
	Seeds	%	15.9-28.6
	Core	%	34.1-46.8
	in a shell	%	0.32-1.24
3	Crude Protein Content	%	16.8-29.4
4	General P_2O_5 content	%	0.76-1.77
5	Content of P_2O_5 phosphatides	%	0.11-0.15
6	Fiber content	%	12.4-18.7
7	Content of mineral elements (ash content)	%	2.3-4.7
8	Content of nitrogen-free extractives	%	26.3-29.0
9	Gossypol to dry weight		
	Cores	%	0.002-1.710
	Free	%	0.002-1.64
	Related	%	0.08-0.7
10	Tannins	%	8.5-9.5
11	Carbohydrate content	%	24.0-31.0
12	B_2 (riboflavin)	%	0.23
13	B_5 (pantothenic acid)	%	1.1
14	PP-B_5 (nicotine acid)	%	1.6

The physical and mechanical properties of cotton seeds are necessary for calculating storage facilities, bunkers, transport devices, machines in preparatory workshops and, in some cases, for establishing operating modes of equipment.

Table 3. Physical and mechanical indicators for the most common Cotton Seed Varieties.

No.	The name of indicators	Unit	Limit values
1	2	3	4
1	Linear dimensions		
	Length	Mm	9.0
	Width	Mm	5.0
	Thickness	Mm	4.2
2	Seed density, kg/m^3		
	Apparent	kg/m^3	1.05-1.06
	True	kg/m^3	1.11-1.6
3	Core density, true	kg/m^3	1.04-1.05
4	Husk density, true	kg/m^3	1.34-1.36
5	Volumetric weight of seeds with pubescence 7.7%		
	Minimum	kg/m^3	350.0
	Maximum	kg/m^3	363.0
	Average	kg/m^3	356.5
	Angle of repose with pubescence 7.7%	deg.	51-52
	Internal friction coefficient	Ct	0.81
	Grip strength	kg/cm^2	0.125

Cotton seeds are stored in bulk in warehouses, under a canopy or in open specialized areas equipped with active ventilation means, in accordance with sanitary rules and storage conditions approved in the prescribed manner.

Short-term storage of seeds, up to 5-10 days, in open areas not equipped with means of active ventilation is allowed.During storage and transportation, mixing seeds of medium-fiber and fine-fiber selected varieties, as well as industrial varieties, is not allowed. Processing of industrial varieties of cotton seeds is carried out in a mixture [7,8].

Before the arrival of seeds of a new crop at an oil and fat enterprise, workers in the raw department and laboratory should develop a plan for the reception and placement of seeds, which should take into account the need to reduce unnecessary transfers of seeds during processing and feeding into production.

The plan for receiving and placing seeds must be drawn up taking into account the measures that will be used to preserve the seeds. The plan must be approved by the plant management.

Before sending seeds for storage, the condition of the seeds in appearance is taken into account. Seeds that are spoiled by spontaneous combustion, immature, moldy, sprouted, musty, moldy or otherwise, or have a seal characteristic of seeds, are stored without mixing such seeds with normal seeds.

When accepting and placing seeds, it should be taken into account that seeds that have previously been treated cannot be stored for a long time and must be processed first.

In factory conditions, seeds should be stored separately depending on the variety. Seeds are stored separately in three groups of industrial varieties: 1st year and 2nd month, 3rd year, 4th year.

All storage equipment must be in good working order and located in specially designated areas.

To maintain cleanliness in storage facilities and prevent the introduction of dirt and barn pests into them, at the entrance to each storage facility, it is necessary to have shoe cleaning equipment.

All storage facilities must be equipped with installations for remote control of seed temperature. In their absence, seed temperature control is carried out using portable thermal rods.

Basement and semi-basement premises of oil seed warehouses, galleries and tunnels intended for transporting oil seeds, as well as pits more than 1 meter deep, in which equipment for transporting seeds is located, must be equipped with supply and exhaust mechanical ventilation.

If there is a malfunction in the ventilation of basement and semi-basement premises of oil seed warehouses, galleries, tunnels intended for transporting oil seeds, as well as pits in which equipment for transporting seeds is located, entry into them is permitted only after checking their air environment for the presence of carbon dioxide, the content of which should not exceed 0.5% by volume. The presence of carbon dioxide in basements and semi-basements of oil seed warehouses, galleries, tunnels and pits associated with the transportation of oil seeds must be monitored by stationary or portable devices according to a schedule approved by the chief engineer of the enterprise.

Places where carbon dioxide may appear must be marked with warning signs and provided with hose gas masks PSh-1, PSh-2.

Cotton seeds must be stored in covered warehouses with a flat bottom, under a canopy, and in the absence or insufficient capacity of warehouses - in tightly compacted pyramids (bundles) in open areas.

Open areas for storing cotton seeds should be located with a gap of at least:

a) from the axis of the railway by 4 m;
b) from buildings of I and II flammability degrees at 8 m;

c) from buildings of III degree of fire hazard at 10 m;
d) from buildings of flammability degree 4-5 at 12 m.

Fire breaks between cotton seed riots (between the longitudinal and end sides of the riots) at the creamery must be agreed upon with local (republican) fire authorities. Fire gaps between groups of riots should be 25 m.

Low-hairy seeds (with a hairiness of 2% and below) are stored in mechanized warehouses with a conical bottom or closed warehouses with a flat bottom. The sites are constructed on an elevated site with a low groundwater table. The foundations of the site must have a slope on both sides at an angle of about 5°C and a coating of a waterproofing layer that prevents the penetration of groundwater. Ditches are installed along the perimeter of the site to drain rainwater outside the site. When compacted well, the pubescent cotton seeds in the upper layers of the riot form a crust, which prevents moisture from penetrating into the interior of the riot.

Drainage channels installed around warehouses must be kept in good condition.

Tunnels, warehouse reception pits, etc. must be dry, well ventilated and accessible for inspection.

With regard to mechanized warehouses and elevators, in addition to the listed requirements, the following are also imposed:

a) transport belts, heads and shoes of elevators, buckets, seed cleaning machines and other equipment of mechanized warehouses are kept in full working order and systematically cleaned of dust and spilled seeds;
b) special attention is paid to the thorough systematic cleaning of galleries and pits throughout the warehouse.

The area in which the storage facilities are located and the surrounding area are kept clean. After emptying the seeds, the storage facility or its individual cells are cleaned and disinfected. Storage equipment and inventory are kept clean and, if necessary, disinfected.

4 Conclusion

Part of the complex for rational seed storage is active ventilation, which allows reducing the temperature and humidity of seeds by aerating them with dry air, ensures renewal of the air composition in the inter-seed spaces without moving the seed mass, and creates conditions for post-harvest ripening of seeds. To carry out active ventilation of seeds, it is advisable to build stationary blowing platforms measuring 25x10 under the seeds or in warehouses. The blowing unit consists of fans, air ducts with outlets, concrete ducts, grilles and dampers. The channels are covered with a metal mesh up to 5 mm thick with holes measuring 4 x 50 mm. The cross section of the working part is 400x400 mm. The effective height of a seed embankment with active ventilation is a height of no more than 10 m. Stationary blowing sites can be built anywhere. It is advisable to carry out blowing during the cold season, since this significantly reduces the temperature of the seed mass and prevents self-heating. The specific air consumption per 1 ton of seeds is 35 m^3/t.h. All air ducts must be grounded to protect against static electricity.

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