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# AMARANTH

***Abstract***

*The materials of the article provide a historical reference to the emergence and agronomic characteristics of amaranth. Today, more than 100 species of amaranth are known in the world. In Ukraine, amaranth began to be grown in 1989-1992. The yield of amaranth green mass can be more than 100 t/ha. Amaranth grain yield in Ukraine ranges from 25 to 40 centners per hectare. The chemical composition of amaranth grain and its processing products: amaranth oil, flour, grits was analyzed. The issues of using amaranth grain and its processing products in the bakery, meat, animal feed and pharmaceutical industry are considered. The main value of amaranth flour is the presence of protein and essential amino acids. Amaranth flour contains: 3.8 times more proteins than wheat flour, 9.4 times more lipids, 17 times more fiber, 8.8 times more ash; mineral substances: sodium 24 times, potassium 4.2 times, calcium 19 times, magnesium 6 times, phosphorus 5 times, iron 36 times; vitamins: thiamine 33 times, riboflavin 74 times, niacin 1.2 times. The oil contains up to 8% squalene, which provides healing and anti-inflammatory properties. The characteristics of the content of squalene in amaranth oil in comparison with olive oil are given. The agronomic issues of cultivation and features of post-harvest processing of amaranth are considered. The general view and layout of the seed plant using Fadeev's gentle fractional technology for the production of strong seeds are given. Methods of cleaning amaranth are analyzed and a technological scheme using pneumatic vibrating tables and a photoseparator is proposed. During cleaning, Fadeev sieves were used to remove mineral impurities, soot, and scum. A photo of various fractions obtained during amaranth cleaning is given. It has been established that the repeated separation of amaranth seeds, which have come off from the middle of the pneumovibrating table, can improve the quality of cleaning from the shrike. The photoseparator, when individually removing weeds, which are different in color from the color of pure seeds, cannot help but remove 4-5 pieces of pure seeds from the flow "for the company". It is this mixture of amaranth seeds and cornflower, which is dumped as waste after the photoseparator, is also "ennobled" during separation on a pneumatic shaker table, which in general makes it possible to minimize the share of waste when cleaning amaranth, and to bring the quality of cleaning to an absolute level.*

**Key words: amaranth, cleaning, Fedeeva sieve, fraction, technology.**

## Introduction

Her Majesty Nature is the supreme power that predetermines life on our Earth. Nature seemed to anticipate the spread of man on a new continent for his life - America. Yes, corn, beans, potatoes grew wild in America, but there was no wheat, rye, barley, oats, or rice. But there was amaranth. It was this that became the basis for flour, cereals, and bread for the natives of America after its domestication [1].

Amaranth occupies an exceptional place in the history of agribusiness among all the crops known on earth; it was amaranth that became a "participant" in the religious war between the pagans - American Indians and Christians - the "discoverers" of America. The fact is that amaranth was the main grain crop of South America and Mexico for 8 thousand years ("Aztec wheat", "Inca bread"), it played such a role in the lives of the Indians that they elevated it to a cult and called it "the grain of God".

One can only imagine with what mercilessness the Spanish conquerors destroyed amaranth, as a cult of worship of the pre-Christian Incas, if we take into account the bestial cruelty with which the colonization of Indian lands took place. Here is a small fragment from the history of the conquest of America.

November 16, 1532. Francisco Pizarro, a subject of the Spanish King Charles I, landed on the shore of South America in the area of the present-day state of Peru. 168 soldiers came ashore, including 62 horsemen and 106 infantrymen. In one day and part of the night they killed no less than 7,000 Indians from the 40,000 troops opposing them, led by the Inca Emperor Atahualpa.

This is how Pizarro lured the Inca Emperor, inviting him to a meeting. His parting words to the Indian envoy were as follows:

"Tell your master to come whenever and however he wishes, and also tell him that whenever and however he comes, I will receive him as a friend and brother. I ask him to come quickly, because I want to see him, and I will not harm or insult him."

When, confident of his safety, accompanied by 40,000 troops, Atahualpa arrived at the place designated for the meeting (the city of Cajamarca), the Spaniards ambushed the Indians.

Eighty men carrying the stretcher with the emperor were killed, and the Indians who took their place and defended their emperor also fell under the fire of the Spaniards. The cavalry completed the capture.

Here are fragments of the report to the Spanish king (Charles I) about these events.

"... at the command of the governor (Pizarro), the Spanish warriors in armor, horsemen and infantrymen, rushed from their shelters straight into the thick of the unarmed Indians... and began to cut them to pieces... Since the Indians had no weapons, the Christians attacked them without any danger to themselves. The cavalry trampled them, killing and maiming, and pursued the survivors. The infantry moved against those who remained, and so successfully that after a short time most of them fell from the swords."

After the capture of Atahualpa: "The Indians, having knocked down part of the wall, rushed to flee to the plains. Our cavalry jumped over the broken wall and rushed towards them. Night was already falling, and our cavalry continued to stab the Indians in the field...

If night had not fallen, few of the Indian army, which numbered more than 40,000, would have survived. Six or seven thousand Indians lay dead and many more had their hands cut off or other wounds." This is how Pizarro explained the motive for the massacre carried out by the Spaniards to the captured Emperor Atahualpa:

"We have come to conquer this land by his command (King Charles I of Spain), so that everyone may have knowledge of God and His sacred Catholic faith; and because our goal is good, God, the creator of heaven and earth and everything in heaven and earth, has allowed this so that you may know Him and abandon the bestial and devilish life that you lead." So, against this background of the struggle for the true faith, uprooting the amaranth as a symbol of pagan worship was not difficult. This "devil's flower" was destroyed everywhere, the volume of its cultivation was significantly reduced. Crops of this crop survived only in the mountain valleys of Latin America.

**Review of literature**

So, amaranth. More than 100 species of amaranth are known. Amaranth also exists as a weed, often called amaranth. At the same time, amaranth is the oldest grain crop and is grown as such in many countries.

Translated from Greek, amaranth means "unfading flower", dried amaranth is preserved all winter. An interesting interpretation of this name in Russian is "A + MARAant", "A" is a particle of negation, "Mara" is the Slavic goddess of death. It turns out that such a phrase "amaranth" is denying death [2].

Since 1970, amaranth has gradually been revived as a cultivated plant. After four hundred years of oblivion, humanity remembered this crop of universal use with a unique chemical composition.

Today, amaranth is grown in almost all US states. The American Amaranth Institute and 23 research institutes in the US and Canada study this crop and support it in the food industry. The US government finances special amaranth programs. Since the early nineties of the last century, the industrial production of amaranth products has begun in the US. Today, on the shelves of US diet stores, you can see up to 30 types of amaranth products, from bread and candy to meat grown on amaranth feed. Such meat costs 25% more than usual.

The Spaniards brought amaranth seeds to Europe, where it was initially grown as an ornamental plant and only since the 18th century as a cereal and fodder crop. Before Peter the Great, bread was made from amaranth in Russia, but Peter's reforms prohibited the use of amaranth as food. Work with amaranth is also carried out in other countries, such as China, India, Australia, Russia. Researchers from many countries have come to the conclusion that amaranth should become an alternative crop to wheat, barley, and corn in areas with moisture deficit.

In Ukraine, amaranth was first grown in 1989-1992. In the Kyiv region, the yield of green mass reaches more than 100 t/ha. The yield of amaranth grain in Ukraine, depending on the region of cultivation, fluctuates in the range of 25-40 c/ha [3]. Amaranth grain contains 7-8% oil, which contains more than 70% mono- and polyunsaturated fatty acids and more than 9% phospholipids. In terms of fatty acid composition, amaranth oil is close to corn oil, but has a number of significant advantages. Vitamin E in amaranth oil is in an active form and, more importantly, it contains up to 10% squalene, which until recently was obtained only from the liver of a deep-sea shark. The quality of amaranth protein is considered to be very high due to the significant content of essential amino acids, in particular, the valuable amino acid lysine (4.3-5.7% of the total protein of the seeds), which is twice as much as that of wheat, and 3 times more than that of corn and sorghum, and even comparable to soy and cow's milk.

Starch, which makes up to 70% of the mass of amaranth seeds, has unique properties. The size of amaranth starch granules is several times smaller than that of rice or corn. Due to this, amaranth starch is more preferable as a filler in the manufacture of sausages that are frozen and then defrosted [4].

Caloric content 371 kcal per 100 grams. 100 grams contain: proteins (13.6 g), fats (7.1 g), carbohydrates (58.6 g), ash (2.9 g), water (11.3 g). Soyustov: vitamins A, B1, B2, B4, B5, B6, B9, PP, C, E. Macronutrients: potassium, calcium, magnesium, sodium, phosphorus. Micronutrients: iron, manganese, copper, selenium, zinc. The special value of amaranth grains is that its protein (20-23%) has an increased ratio of lysine and, in addition, the fat has an increased content of fatty acids. But the uniqueness of amaranth is that it contains squalene. Its ability to "capture" oxygen and diffuse it into any tissue, including the skin, provides immune stimulation and, thus, affects the entire body [2]. Experts say that more than half of the children born today will live to 100 years. The basis of this statement is probably based on three perspectives: improvement of living conditions due to more efficient work and a greater share of time that can be allocated to personal life, systemic prevention that prevents disruption of the normal functioning of life-determining systems, and, finally, high technologies for the production of food products that provide a balanced composition. This third condition is designated quite specifically today.

An important place in this direction is given to the use of not only traditional agricultural crops in the raw material base, but also relatively new ones, such as amaranth [4].

Modern technologies for separating amaranth grain into different anatomical components create the prerequisites for their use to improve the consumer properties and nutritional value of bakery, flour confectionery, meat and other products. This creates conditions for expanding and improving the range of various general and special purpose food products.

The anatomical structure of the amaranth grain is unique - the embryo encircles the endosperm in a ring-shaped manner. Oil is extracted from the germ grain using CO2 extraction. After extraction, the germ grain meal is ground using traditional equipment to produce semi-defatted protein amaranth flour (AM) [4].

Amaranth flour contains: 3.8 times more proteins than wheat flour, 9.4 times more lipids, 17 times more fiber, 8.8 times more ash; minerals: 24 times more sodium, 4.2 times more potassium, 19 times more calcium, 6 times more magnesium, 5 times more phosphorus, 36 times more iron; vitamins: 33 times more thiamine, 74 times more riboflavin, 1.2 times more niacin. In addition, amaranth flour proteins have high biological value. The amount of essential amino acids in amaranth flour protein is 17.6 g/100 g protein, the total amount of amino acids is 37.7 g/100 g protein. While in wheat flour the total amount of amino acids is 10.4 g/100 g protein. Thus, amaranth flour has a more balanced amino acid composition compared to wheat flour, so it is advisable to use it in bread baking instead of wheat flour to improve the balance of limiting amino acids. The introduction of amaranth flour helps to increase the biological value of bread by improving the amino acid composition and noticeably eliminating the deficiency of essential amino acids in protein in bread. At the same time, the degree of satisfaction of the daily human requirement for essential amino acids increases by 1.5-2 times [5]. The introduction of amaranth flour into wheat flour led to a significant improvement in the quality of the bread. It was even visually clear that this was a "different" bread (Fig. 1). An important indicator of the functional composition of amaranth proteins is the absence of an alcohol-soluble fraction (prolamins), which forms gluten during dough kneading.

**Fig. 1. Bread with the addition of amaranth flour**

The analysis of the obtained data, as well as the cost price, allow us to conclude that semi-skimmed protein amaranth flour is suitable for the production of meat products both in terms of its functional and technological properties and in terms of cost price [4].

Promising is the processing of amaranth grain not only as an additive to traditional types of food products, but also for its use in therapeutic and prophylactic purposes [4].

Modern science has thoroughly studied the medicinal properties of amaranth – today expensive but effective medicines are made from it. In Ukraine, zoned medicinal varieties of amaranth have been developed: "Kharkiv-1 medicinal", "Lera", etc. Due to its high medicinal and nutritional value, the UN Food Commission declared amaranth a crop of the 21st century [6].

Food products made from amaranth grain prevent many diseases. Amaranth oil is a source of squalene. Squalene prevents many diseases by strengthening the immune system. Squalene is known as an anti-inflammatory agent. Squalene is converted into vitamin D and thus protects the body from radiation damage. Squalene was first discovered in the liver of a rare deep-sea shark. Shark liver extract is a very expensive oil today. This is despite the fact that it contains only 1-1.5% squalene. Amaranth oil is close in composition to sea buckthorn oil. Amaranth oil contains 8% squalene. Of the oils known on the market, olive oil can be compared with amaranth oil in terms of the proportion of squalene, and olive oil is thirty times inferior to amaranth in this comparison (Fig. 2). Other oils are hundreds of times inferior to amaranth oil in terms of squalene content [3].

Squalene is one of the most important biologically active compounds and acts as a regulator of lipid and steroid metabolism in the body, being a precursor to a number of steroid hormones, cholesterol and vitamin D [4].

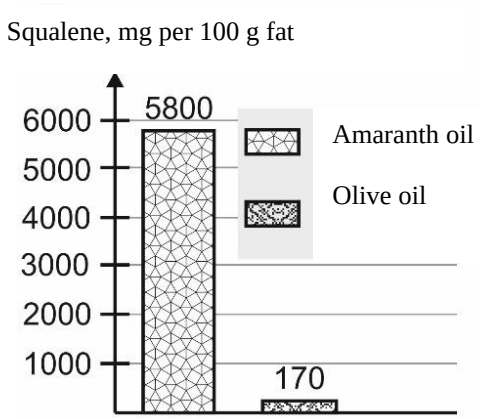



**Fig. 2. The proportion of squalene in amaranth oil and olive oil [3].**

Squalene interacts with water in the body, releasing oxygen, which cleanses blood vessels, capillaries and triggers the mechanism of tissue regeneration in internal organs and skin. It effectively protects the body's cells and, above all, the liver from the harmful effects of toxins. Squalene is a powerful antioxidant and has a radioprotective effect. Squalene promotes rapid healing and renewal of both superficial tissues and damaged internal organs. Squalene neutralizes free radicals, carcinogens and other toxic substances that are the primary causes of cancer [6].

Amaranth oil is also widely used in cosmetology, as squalene is a unique means for restoring the skin. Squalene is one of the main components of human skin. Squalene provides skin protection and hydration, "fills" cells with oxygen, and slows down the aging process [2]. In addition to squalene, amaranth oil contains the most active form of vitamin E, which helps prevent premature skin aging. Creams, masks, and other cosmetic products based on amaranth oil help restore and rejuvenate the skin, improve its tone, nourish and soften rough skin. They also provide antibacterial protection and improve the quality of treatment for psoriasis, eczema, neurodermatitis, dermatitis, allergic dermatoses, trophic ulcers, and the herpes virus [2].

In Chinese medicine, amaranth seed oil is a proven anti-aging remedy, for healing wounds and restoring tissue from damaged internal organs and skin.

In modern medicine, it is also used to treat hemorrhoids, inflammation of the genitourinary system, vitamin deficiency, anemia, diabetes, fatigue, neuroses, obesity, burns, periodontitis, stomatitis, duodenal and gastric ulcers, and atherosclerosis [2].

Amaranth is a dietary product because it does not contain sugar. Amaranth differs from other cereals in that it does not contain gluten, which makes amaranth the basis for food products for patients with celiac disease [6].

Amaranth grains contain fatty acids, of which polyunsaturated fatty acids (PUFAs) are the most valuable, especially essential ones, i.e. not synthesized by the body, but supplied to it only with food. Amaranth flour (cereals) contains vitamin E, but its unique feature is that in amaranth this vitamin is 40-50 times more biologically active than known tocopherol forms. Vitamin E is necessary for a person for normal heart function, improved cholesterol balance. Vitamin E of amaranth reduces cholesterol levels in the blood, increases the elasticity of the vascular walls, and reduces the risk of thrombosis. Amaranth products are especially important for baby food. They are also recommended for people who have undergone injuries and operations for rapid wound healing and high-quality recovery. Due to active tissue regeneration, scars from scars gradually decrease. Amaranth is recommended for the treatment of cardiovascular diseases, atherosclerosis, angina, and high blood pressure diseases [6]. Whenever I touch upon issues of agricultural technology, I ask myself: "What new can you tell an agronomist if you yourself have not grown the crop you are writing about?" And I answer: "Nothing except general recommendations taken from specialized literature." In this regard, Ukraine is a unique country.

In a relatively short distance from an agricultural producer who has planned to produce a particular agricultural crop, you can easily find a breeding center for this crop and get the most in-depth advice on its cultivation. The same picture applies to amaranth. But I will give some basic points of agricultural technology for its cultivation.

Amaranth does not require special growing conditions and, nevertheless, gives a high level of yield.

Amaranth is grown as a forage, grain, vegetable, medicinal and ornamental crop. It is used in the confectionery, bakery, pharmaceutical, perfume industries, in baby food, and also in landscaping as a flower and ornamental crop. Its main value is the ability to generate high-quality protein in grain and leaves [3].

Amaranth has an exceptionally high forage value. The yield of green mass is 500-900 c/ha, and in some cases can reach 1000-1500 c/ha. Amaranth can produce two cuts. The chemical composition of amaranth silage is considered valuable due to the following composition: dry matter 23.6%, protein 3.5%, fat 0.9%, fiber 5.5%, ash 4.2% [3].

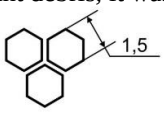
Amaranth is grown in fodder and grain crop rotations. It is undemanding to predecessors, which can be perennial and annual grasses, grain and leguminous crops, potatoes, beets and other row crops. Results and discussion

Since amaranth seeds are very small, seed germination occurs slowly, and weed control in this case comes to the fore. The field must be free of weeds. Amaranth is grown both in wide-row crops and in ordinary row crops. Amaranth seeds are sown to a depth of 2-2.5 cm. The seeding rate in row crops is 1.2-1.5 kg / ha, in wide-row crops 0.6-0.8 kg / ha. Sowing in the third ten-day period of April and in the first ten-day period of May. Post-harvest sowing can be carried out in late June - early July, but not later than July 20 [3].

For friendly germination of amaranth seeds, the soil should be warmed up to + 8-10 ° C. Amaranth is undemanding to moisture, drought-resistant. To generate 1 gram of dry matter, amaranth uses three times less water than legumes and half as much as cereals. The plant tolerates daily temperature fluctuations well [3]. The plant can reach a height of more than three meters, the number of leaves on the plant is more than two hundred [2]. The panicle in a mature state reaches a length of 30-50 cm, and the panicle diameter can reach 15-25 cm [4]. One plant produces up to half a million small grains. The weight of 1000 seeds is 0.4 g [1]. Harvesting is carried out by direct combining. After harvesting, it is necessary to clean. Amaranth, like any small-seeded crop, is difficult to ventilate during storage, which makes it prone to self-heating, especially if the humidity is above 12% and the cleaning of impurities is not performed [3]. When we received amaranth seeds for cleaning, calibration and preparation for sowing, we realized that we would cope with the task, since such a size and shape of seeds cannot cause difficulties during cleaning. The only thing that was alarming was the presence of wild amaranth seeds in the composition of amaranth seeds, exactly the same in shape and size - pigweed.

## Results of investigation and discussion

The distinguishing feature is color, pigweed seeds are dark in color. It is clear that the photoseparator will separate dark seeds from the rest of the light seeds, but the very principle of the photoseparator, especially on small-seeded material, does not allow such a separation to be made strict enough, and when selecting one dark achene, 4-5 yellow, conditioned ones end up in the waste. Therefore, our task was to leave as few pigweed seeds as possible before the photoseparator. The hope was that between the wild form of seeds and the cultivated one there is a distinguishing feature - density, i.e. we assumed that amaranth seeds are, if not much, still denser than amaranth seeds. If so, then separation should occur on the pneumatic vibration table. And so it happened, but everything in order. Figure 3 shows the layout of the seed plant (Fadeev's gentle fractional technology for producing strong seeds).

The amaranth seeds were brought to us in post-harvest contamination (Fig. 4). Due to the large difference in the sizes of the seeds and plant debris, it was easy to separate it on the Fadeev sieves 

(Fig. 5, 6).

The selection of small plant and, to a greater extent, mineral debris was carried out on slotted sieves 

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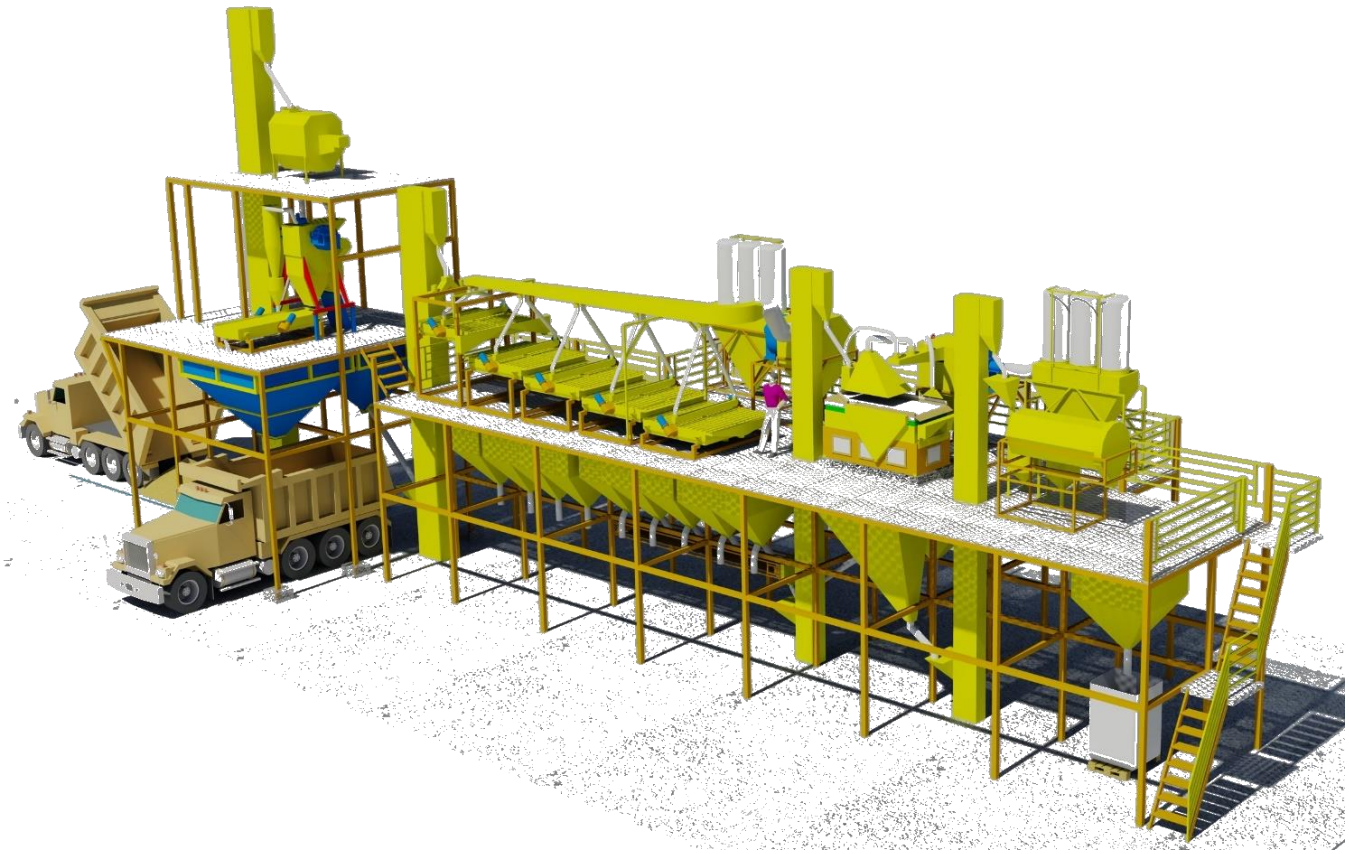

**Fig. 3. General view of the seed plant for any agricultural crops.**

**Fig. 4. Source material.**

**Fig. 5. Escape from the Fadeev sieve 1.5.**

**Fig. 6. Passage through the Fadeev sieve 1.5.**

**Fig. 7. Passage through the slotted sieve 0.6.**

The passage in this case was dead waste (Fig. 7).

Thus, the amaranth, cleared of large plant and small plant and mineral debris, was sent for separation of seeds by density on the pneumatic vibration table PVSF. Since the pneumatic vibrating tables we produce have a unique operating mode setting due to the monotonically regulated fans of each one individually for the optimal formation of a fluidized bed on the deck, the separation of seeds by density occurs even in the case of a very small difference in this parameter in the composition of the mixture. The separation of amaranth and pigweed showed exactly this (Fig. 8, 9, 10).

Thus, the general scheme of amaranth cleaning before the photo separator looks like this (Fig. 11).

When re-separating amaranth seeds that have come down from the middle of the pneumatic vibration table deck, it is also possible to improve the quality of its cleaning from amaranth.

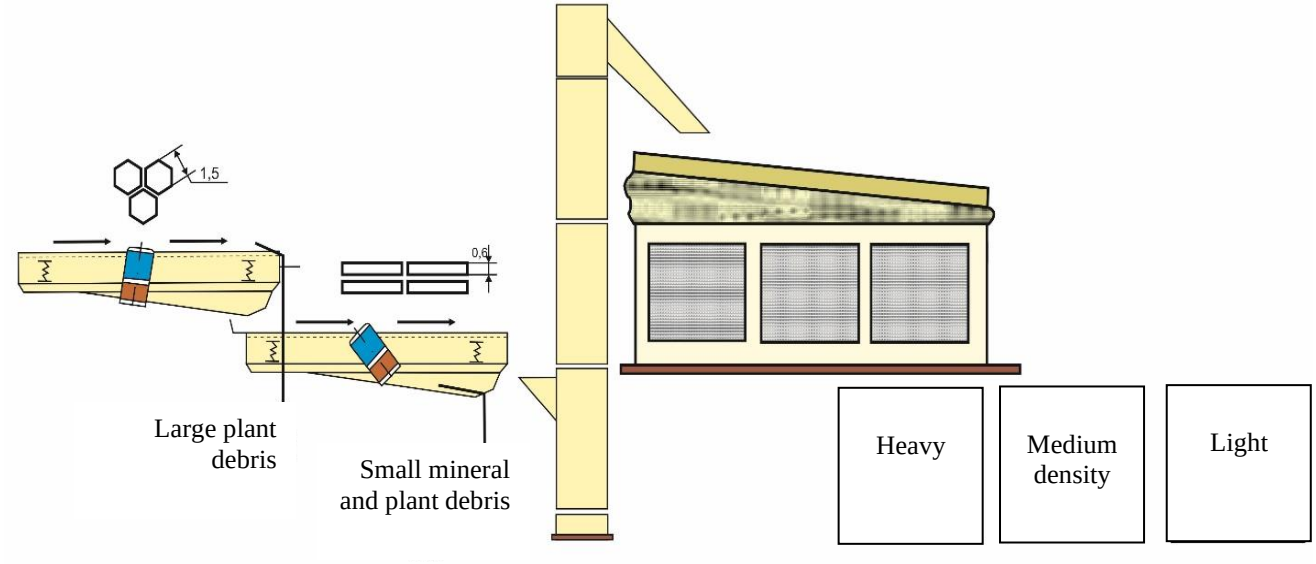


**Fig. 11. Scheme of amaranth cleaning.**

## Conclusion

As is known, when a photo separator individually removes a weed particle that is different in color from the color of clean seeds, it cannot help but remove 4-5 pieces of clean seeds from the flow "for the company". It is this mixture of amaranth and amaranth seeds that is poured as waste after the photo separator, which is also "refined" during separation on a pneumatic vibration table, which generally allows to minimize the proportion of waste during amaranth cleaning, and to bring the cleaning quality to absolute (Fig. 12). It is this quality of amaranth cleaning before its processing that is performed at the production facility headed by Alexander Duda, the president of amaranth and amaranth product manufacturers.

Amaranth deserves great attention, and even more so, the products of its processing.

**Fig. 8. Escape from the light edge of the PVSF deck.**

**Fig. 9. Escape from the middle of the PVSF deck.**

**Fig. 10. Escape from the "heavy" edge of the PVSF deck.**

**Fig. 12. Amaranth after cleaning on the photo separator.**

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# АМАРАНТ

***Анотація***

*В матеріалах статті наведено історичну довідку виникнення та агрономічну характеристику амаранта. Сьогодні у світі відомо понад 100 видів амаранта. В Україні амарант почали вирощувати у 1989-1992 рр. Врожайність зеленої маси амаранту може складати понад 100 т/га. Врожайність зерна амаранту в Україні коливається в діапазоні 25-40 ц/га. Проаналізовано хімічний склад зерна амаранту та продуктів його переробки: амарантової олії, муки, крупки. Розглянуті питання використання зерна амаранту та продуктів його переробки у хлібопекарській, м'ясній, комбікормовій та фармацевтичній промисловості. Основна цінність амарантової муки - наявність білка та незамінних амінокислот. В амарантовому борошні міститься: білків в 3,8 раз більше, ніж в пшеничному борошні, ліпідів в 9,4 рази, клітковини в 17 раз, золи в 8,8 рази; мінеральних речовин: натрію в 24 рази, калію в 4,2 рази, кальцію в 19 разів, магнію в 6 разів, фосфору в 5 разів, заліза в 36 раз; вітамінів: тіаміну в 33 рази, рибофлавіну в 74 разів, ніацину в 1,2 рази. В олії міститься до 8% сквалена, який надає лікувальних та протизапальних властивостей. Наведена характеристика вмісту сквалена в амарантовій олії у порівнянні з оливковою. Розглянуті агрономічні питання вирощування та особливості післязбиральної обробки амаранту. Приведені загальний вид та компоновка насіннєвого заводу з використанням щадної пофракційної технології Фадєєва з виробництва сильного насіння. Проаналізовані способи очистки амаранту та запропонована технологічна схема з використанням пневмовібростолів та фотосепаратора. Під час очистки застосовували сита Фадєєва для вилучення мінеральних домішок, сору, щириці. Наведено фото різних фракцій, отриманих під час очищення амаранту. Встановлено, що при повторній сепарації насіння амаранту, яке зійшло з середини деки пневмовібростолу, вдається підвищити якість очищення від щириці. Фотосепаратор при поштучному видаленні бур'янів, відмінної за кольором від кольору чистого насіння, не може попутно не винести з потоку «за компанію» 4-5 штук чистого насіння. Саме така суміш насіння амаранту і щириці, що в якості відходу зсипається після фотосепаратора, також «вшляхетнюється» при сепарації на пневмовібростолі, що в цілому дозволяє звести до мінімуму частку відходу при очищенні амаранту, і довести якість очищення до абсолютного.*

**Ключові слова: амарант, очищення, сито Федєєва, фракція, технологія.**

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