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Analysis of different apricot varieties grown in Uzbekistan to improve the production of salted kernels

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Анализ различных сортов абрикоса, выращиваемых в Узбекистане, для совершенствования производства соленых косточек

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Abstract

The objective of this study was to evaluate the physical, structural, and hydration properties of nine apricot varieties grown in the Bukhara region of Uzbekistan — “Sinchalak”, “Kandak”, “Ak Navat”, “Shirin Djaupazak”, “Childona”, “Bodomcha”, “Kandak Krasny”, “Maisky”, and “Javzak” — and to develop, on this basis, an energy-efficient mechanized method for producing salted kernels (shurdanak) from apricot processing waste. For each variety, 100 pits were measured for length, width, shell thickness, joint width and mass using a digital caliper (±0.01 mm) and an analytical balance (±0.001 g); water-absorption kinetics were determined gravimetrically at 55±1°C in a 25–30 % saline solution over 0.5–4.0 minutes for intact and pre-cracked pits, and mechanical fracture resistance was measured with a digital force gauge; each experiment was replicated three times and evaluated by one-way ANOVA with Tukey’s post-hoc test ($p<0.05$). Shell thickness ranged from 0.72±0.04 mm (‘Childona’) to 1.24±0.08 mm (‘Ak Navat’), with corresponding minimum fracture forces of 145±12 N and 385±22 N. Pre-cracking increased the brine-absorption rate up to 2.8-fold relative to intact pits: ‘Childona’ reached 34.8±2.2 % moisture uptake within 2.0 minutes of soaking. The proposed continuous sequence — calibration, mechanical pre-cracking,

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controlled saline soaking, thermal stabilization, and roasting — raised throughput from 7.5±2.5 to 75.0±5.0 kg/h, reduced specific electrical energy consumption by 32.5 % (12.0 to 8.1 kWh/t) and thermal energy consumption by 28.0 % (4.82 to 3.47 MJ/kg), while lowering the kernel defect rate from 14.5±1.8 % to 2.1±0.3 % and improving salinity uniformity (RSD from 24.1 % to 3.8 %).

Аннотация

Целью настоящего исследования являлась оценка физических, структурных и гидратационных свойств девяти сортов абрикоса, выращиваемых в Бухарской области Узбекистана — «Синчалак», «Кандак», «Ак Нават», «Ширин Джаупазак», «Чилдона», «Бодомча», «Кандак Красный», «Майский» и «Жавзак», — а также разработка на этой основе энергоэффективного механизированного метода производства соленых косточек (шурданак) из отходов переработки абрикосов. Для каждого сорта у 100 косточек с помощью цифрового штангенциркуля (±0,01 мм) и аналитических весов (±0,001 г) измеряли длину, ширину, толщину скорлупы, ширину стыка и массу; кинетику влагопоглощения определяли гравиметрически при 55±1°C в 25–30 % солевом растворе в течение 0,5–4,0 минут для целых и предварительно надколотых косточек, механическую прочность на разрушение измеряли цифровым динамометром; каждый опыт повторяли трижды с последующей обработкой методом однофакторного дисперсионного анализа с post-hoc тестом Тьюки ($p<0,05$). Толщина скорлупы варьировала от 0,72±0,04 мм («Чилдона») до 1,24±0,08 мм («Ак Нават»), при соответствующих минимальных усилиях разрушения 145±12 Н и 385±22 Н. Предварительное раскалывание повышало скорость влагопоглощения до 2,8 раза по сравнению с целыми косточками: сорт «Чилдона» достигал влагопоглощения 34,8±2,2 % за 2,0 минуты замачивания. Предложенная непрерывная последовательность — калибровка, механическое предварительное раскалывание, контролируемое засаливание, термическая стабилизация и обжаривание — повысила производительность с 7,5±2,5 до 75,0±5,0 кг/ч, снизила удельное потребление электроэнергии на 32,5 % (с 12,0 до 8,1 кВт·ч/т) и удельное потребление тепловой энергии на 28,0 % (с 4,82 до 3,47 МДж/кг), при этом доля дефектных ядер снизилась с 14,5±1,8 % до 2,1±0,3 %, а равномерность засолки (коэффициент вариации) улучшилась с 24,1 % до 3,8 %.

Keywords: processing, pit of apricot, salted kernels, the mechanization process, the formation of cracks, shells, bone, research, waste, water absorption, grade.

Ключевые слова: переработка, косточка абрикоса, соленые косточки, механизация процесса, образование трещины, скорлупа косточки, исследования, отходы, влагопоглощение, сорт.

Introduction

In the East, where the apricot has long been known for its healing properties, apricot kernels were harvested in large quantities, dried and prepared similarly to other nuts (almonds, walnuts, etc.). An apricot kernel is a woody, shell-covered core found within the pulp of the apricot. Kernels are primarily used as seeds for plant propagation.

Apricot kernels contain a large amount of fatty acids, several mineral compounds, organic acids, and a number of both essential and replaceable amino acids [5, p. 366]. The presence of various fatty acids determines the energy value of the product. Organic acids and minerals have a positive effect on the functioning of internal organs and metabolism.

In Central Asia, more specifically in the ancient city of Bukhara, known as the «Pearl of the East,» an ancient recipe for making traditional salted pits – shurdanak - has been preserved since ancient times. The traditional preparation method involves mechanically cracking the shells (by striking each pit with a hammer) to create cracks, soaking them in a brine solution for 1 to 4 minutes at a temperature of 50 to 60°C, and then roasting them in a cauldron. However, this artisanal method is labor-intensive, has low productivity, and lacks quality control [10].

The relevance of this study is determined by the need to process apricot fruit waste (pits) and to mechanize the artisanal production of the national product «salted kernels.» The aim of this study is to establish, through comparative analysis of the physical, structural and hydration properties of nine apricot varieties, an optimal, energy-efficient method for preparing salted pits by mechanizing the shell-cracking process and intensifying the subsequent heat- and mass-exchange stages of soaking, thermal treatment and frying [1, p. 174-175]. To achieve this aim, the following tasks were set: (1) to measure and compare the geometric, mass and mechanical fracture characteristics of pits from nine varieties; (2) to determine the water-absorption kinetics of intact and pre-cracked pits under controlled saline-soaking conditions; and (3) to develop, on this basis, a mechanized processing sequence and to quantify its productivity, defect-rate and energy benefits relative to the traditional artisanal method.

Unlike existing artisanal methods, our proposed method combines calibrated cracking, controlled saline soaking, and thermal treatment in a single integrated sequence, allowing for process intensification and reduced energy consumption.

Research Methods and Methodologies

Sampling and Varietal Classification: We examined nine different apricot varieties and their kernels, grown in the Bukhara region of Uzbekistan: “Sinchalak”, “Kandak”, “Ak Navat”, “Shirin Djaupazak”, “Maisky”, “Childona”, “Kandak Krasny” and “Bodomcha”. All samples were harvested at commercial maturity (June–July 2025).

Geometric and Mass Parameters Measurement: For each variety, 100 randomly selected pits were measured using a digital caliper (Absolute Digimatic model, precision ±0.01 mm) and weighed on an electronic analytical balance (OHAUS Pioneer model, precision ±0.001 g). The following parameters were recorded: maximum pit length (mm), maximum pit width (mm), shell wall thickness (mm) — measured at three points per pit, shell joint width (mm), and the weight of individual pit (g). All measurements were taken by the same operator to minimize inter-observer variability.

Hydration Kinetics Determination: Water absorption by apricot kernels was studied at 55±1°C in a 25–30 % saline solution. A thermostatically controlled water bath (model TW-2, precision ±0.1°C) was used to maintain the solution temperature. Samples were first dried to a constant initial moisture content (6.5±0.2 %), then both intact and mechanically pre-cracked pits were immersed in

the saline solution for periods of 0.5 to 4.0 minutes; after extraction, surface moisture was removed by vacuum filtration blotting and samples were re-weighed. Water absorption (W, %) was calculated as:

$$W = \frac{m_w - m_d}{m_d} \times 100\%$$

where m_w = mass after soaking, m_d = dry mass. Each experiment was replicated three times.

Mechanical Cracking and Thermal Processing Line: Mechanical fracture resistance was measured using a laboratory compression tester fitted with a digital force gauge (up to 1 kN, precision ±1 N). The pre-cracking step was performed using a dual-roller mechanical cracker with adjustable clearance, applying a controlled, reproducible force along the suture line of each pit. Energy consumption during thermal treatment and roasting was recorded with calibrated multi-function energy meters connected to the experimental processing line. The integrated sequence consists of:

1. Calibrating pits according to maximum and minimum sizes;
2. Pre-cracking the shell using a mechanical cracker (controlled force application);
3. Moistening in 25–30 % saline solution at 50–60°C for 1.5–2 minutes;
4. Thermal stabilization at 105–110°C for 1.5–2 minutes to expand internal vapor pockets and lock the structural cracks;
5. Continuous roasting at 140–150°C for 2–3 minutes.

Statistical Analysis: Data are presented as mean ± standard deviation. Comparisons between varieties were made using one-way ANOVA with Tukey's post-hoc test ($p < 0.05$) in SPSS software to determine statistically significant differences.

Results and Discussion

Table 1. Summarizes the dimensional and mass parameters of the nine studied varieties (mean ± SD, n = 100 pits per variety)

Variety	Length (mm)	Width (mm)	Shell thickness (mm)	Joint width (mm)	Weight (g)
Sinchalak	19.1 ± 0.5	18.0 ± 0.4	0.81 ± 0.05	4.0 ± 0.3	1.2–1.7
Kandak	20.2 ± 0.6	14.1 ± 0.5	1.02 ± 0.07	3.0 ± 0.2	1.0–1.2
Ak Navat	19.4 ± 0.4	15.2 ± 0.4	1.24 ± 0.08	5.0 ± 0.4	0.9–1.2
Shirin Djaupazak	21.0 ± 0.7	14.3 ± 0.5	1.05 ± 0.06	4.0 ± 0.3	1.0–1.3
Childona	15.3 ± 0.4	13.2 ± 0.4	0.72 ± 0.04	3.0 ± 0.2	0.7–0.9
Bodomcha	20.1 ± 0.5	28.2 ± 0.6	0.84 ± 0.05	5.0 ± 0.4	1.1–1.5
Kandak Krasny	20.3 ± 0.6	17.1 ± 0.5	1.01 ± 0.06	4.0 ± 0.3	1.0–1.2
Maisky	20.2 ± 0.5	18.1 ± 0.4	0.98 ± 0.05	4.0 ± 0.3	0.4–0.8
Javzak	20.4 ± 0.6	15.3 ± 0.5	1.03 ± 0.07	4.0 ± 0.3	0.9–1.4

As shown in Table 1, the nine varieties differ markedly in both size and shell structure ($p < 0.05$). The "Childona" variety exhibited the smallest shell thickness (0.72±0.04 mm) and lowest mass range (0.7–0.9 g), and required the lowest fracture force (Fcr = 145±12 N) to produce a stable, non-destructive crack along the suture. Conversely, 'Ak Navat' had the thickest shell (1.24±0.08

mm) and the highest fracture threshold (Fcr = 385±22 N), while ‘Bodomcha’ combined a wide joint (5.0±0.4 mm) with the largest width (28.2±0.6 mm). These results establish that individual sorting and size calibration by variety are necessary before mechanical cracking, to avoid core crushing in thin-shelled varieties and incomplete cracking in thick-shelled ones.

The penetration of brine solution into the kernel cavity depends strongly on whether the shell is intact or pre-cracked, and on the width of the suture joint. Table 2 summarizes the hydration kinetics at 55°C for three representative varieties (Sinchalak, Childona, Ak Navat).

Table 2. Brine absorption kinetics (W, %) of intact versus pre-cracked apricot pits at 55°C

Soaking time (min)	Sinchalak (intact)	Childona (intact)	Ak Navat (intact)	Sinchalak (pre-cracked)	Childona (pre-cracked)	Ak Navat (pre-cracked)
0.5	2.1 ± 0.2	3.4 ± 0.3	1.5 ± 0.1	8.5 ± 0.6	12.4 ± 0.9	6.2 ± 0.4
1.0	4.5 ± 0.3	6.8 ± 0.5	3.1 ± 0.2	15.2 ± 1.1	22.1 ± 1.5	11.4 ± 0.8
1.5	7.2 ± 0.5	9.5 ± 0.7	5.0 ± 0.4	22.4 ± 1.6	31.2 ± 2.1	16.8 ± 1.2
2.0	9.8 ± 0.8	12.1 ± 0.9	6.8 ± 0.5	28.1 ± 1.9	34.8 ± 2.2	22.1 ± 1.5
3.0	14.2 ± 1.1	17.5 ± 1.2	9.9 ± 0.7	29.4 ± 2.0	35.2 ± 2.3	26.4 ± 1.8
4.0	18.1 ± 1.4	21.3 ± 1.5	12.5 ± 0.9	29.8 ± 2.1	35.4 ± 2.2	28.9 ± 2.0

A comparative operational assessment between the traditional artisanal method and the proposed mechanized continuous processing line was conducted to quantify system-level efficiencies; results are summarized in Table 3.

Table 3. Technical, economic and energy-efficiency comparison of production methods

Operational parameter	Artisanal method	Proposed mechanized method
Process continuity	Discontinuous	Continuous (automated)
Throughput (kg/hour)	7.5 ± 2.5	75.0 ± 5.0
Specific electrical energy demand (kWh/t)	12.0	8.1 (↓ 32.5%)
Specific thermal energy demand (MJ/kg)	4.82	3.47 (↓ 28.0%)
Kernel defect rate (%)	14.5 ± 1.8	2.1 ± 0.3
Product salinity uniformity (RSD, %)	24.1	3.8

As shown in Table 3, the mechanized sequence raises throughput roughly tenfold, from 7.5±2.5 to 75.0±5.0 kg per hour. Specific electrical energy demand falls by 32.5 % (from 12.0 to 8.1 kWh/t), reflecting the replacement of manual hammering with a single optimized cracking operation, while targeted heat transfer in the continuous thermal-stabilization and roasting stages reduces specific thermal energy demand by 28.0 % (from 4.82 to 3.47 MJ/kg) relative to open-cauldron heating. The kernel defect rate falls from 14.5±1.8 % to 2.1±0.3 %, and salinity-uniformity variation (RSD) falls from 24.1 % to 3.8 %, confirming that the proposed sequence not only saves energy and labor but also yields a more consistent, higher-quality product. The present results, obtained at laboratory and pilot-line scale, establish the varietal, hydration-kinetic and energy basis of the proposed sequence; remaining steps toward full industrial implementation include

mathematical modeling of coupled heat and mass transfer during thermal stabilization and roasting, long-term durability testing of the mechanical cracker under continuous operation, and sensory and shelf-life evaluation of the finished product.

Conclusion

We have identified the key physical, structural and hydration properties of nine apricot varieties grown in Uzbekistan: shell thickness ranging from 0.72±0.04 mm (‘Childona’) to 1.24±0.08 mm (‘Ak Navat’), corresponding fracture forces of 145±12 N to 385±22 N, and pre-cracked brine-absorption rates up to 2.8-fold higher than intact pits. The ‘Childona’ variety, combining the thinnest shell, lowest mass and lowest fracture force, is most suitable for mechanized salted-kernel production.

The proposed continuous method — calibration, mechanical pre-cracking, controlled saline soaking, thermal stabilization, and roasting — raises throughput from 7.5±2.5 to 75.0±5.0 kg per hour, reduces specific electrical energy consumption by 32.5 % and specific thermal energy consumption by 28.0 % relative to the traditional artisanal method, lowers the kernel defect rate from 14.5±1.8 % to 2.1±0.3 %, and improves salinity uniformity (RSD from 24.1 % to 3.8 %), providing a scientifically grounded basis for the industrial scale-up of shurdanak production from apricot processing waste.

Future research will focus on:

- Mathematical modeling of coupled heat and mass transfer during thermal stabilization and roasting
- Long-term durability and throughput testing of the mechanical cracker under continuous industrial operation
- Sensory evaluation and shelf-life assessment of the finished product

References

1. Artikov, A.A. Study of the temperature field in the kernel of oil-containing stone fruit crops / A.A. Artikov, A.F. Safarov, T.R. Shomurodov, K. Kh. Gafurov // Universities News. Food Technology. – 1991. – No. 1–3. – P. 174–175.
2. Baymetov, K.I. Features of cultivation of local varieties of apricot in Uzbekistan / K.I. Baymetov, M.K. Turdieva, P. Nazarov. – Tashkent. – 2011. – 26 P.
3. Yamaletdinova, M.F. Analysis of the physical characteristics of apricot kernels / M.F. Yamaletdinova, M.S. Narziyev // Universum: Technical Sciences. – 2019. – No. 5 (62). – P. 45–48.
4. Yamaletdinova, M.F. Experimental studies for studying the process of water absorption of apricot seeds / M.F. Yamaletdinova, M.S. Narziyev, D.N. Hikmatov // Academicia – An International Multidisciplinary Research Journal. – 2020. – Vol. 10, No. 10. – P. 931–938.
5. Yamaletdinova, M.F. System approach to the analysis of processes carrying out on technological line of production of salted stone from apricot fruit / M.F. Yamaletdinova, M.S. Narziyev, D.N. Hikmatov // International Journal of Advanced Science and Technology. – 2032. – Vol. 29, No. 11. – P. 2028–2032.

6. Akhone, M.A. Apricot Kernel: Bioactivity, Characterization, Applications, and Health Attributes / M.A. Akhone, A. Bains, M.M. Tosif, P. Chawla, S. Fogarasi // Foods. – 2022. – Vol. 11, No. 15.
7. Nema, P.K. Apricot kernel characterization, oil extraction, and its utilization: a review / P.K. Nema [et al.] // Food Science and Biotechnology. – 2023. – Vol. 32. – P. 249–263.
8. Mahde, N.F. Using apricot seed kernels for the development of supplemented cakes / N.F. Mahde, M.I. A. Fayed // Caspian Journal of Environmental Sciences. – 2022. – Vol. 20, No. 5. – P. 911–918.
9. Sheikh, M.A. Effects of controlled microwave heat treatment on the compositional attributes, antioxidant potential, and anti-nutritional components of apricot kernel flour / M.A. Sheikh [et al.] // Journal of Food Measurement and Characterization. – 2025. – Vol. 19, No. 3. – P. 1859–1873. – DOI: 10.1007/s11694-024-03079-4.
10. Allobergenova, A. Research Progress on Drying and Processing Technologies of Apricot Fruits and Secondary By-products in Central Asia / A. Allobergenova, S.B. Esanov, A.A. Sharipov // Journal of Food Engineering and Technology. – 2024. – Vol. 13, No. 2. – P. 112–118.