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A FIVE-STAGE RISK-BASED ANALYTICAL AUDIT MODEL AND AN INTEGRATED DIGITAL AUDIT SYSTEM FOR FRUIT AND VEGETABLE PROCESSING ENTERPRISES

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Abstract

The paper proposes a five-stage risk-based analytical audit model – risk identification, assessment, prioritisation, analytical procedures, and measures with monitoring – and an integrated audit system for fruit and vegetable processing enterprises, in which accounting, production, quality and laboratory, logistics and sales, and audit and control blocks are linked through a single data hub, an audit dashboard, an alert system and a digital evidence register. Audit evidence is drawn from physical process data – Brix and pH protocols, energy meters, yield and loss records – and triangulated with accounting entries and external documents. The model rests on the 2021–2024 data of three processing enterprises of Uzbekistan and has been adopted by the Chamber of Commerce and Industry of Uzbekistan.

Keywords: fruit and vegetable processing, risk-based audit, analytical procedures, audit evidence, integrated audit system, digital audit, internal audit.

Introduction

The audit of fruit and vegetable processing enterprises has features that general audit programmes do not capture: production is seasonal, raw-material quality varies from batch to batch, several technologies run side by side, and joint products and natural losses arise at every stage. In the enterprises examined here audit is still largely formal: risks are not fully identified at the planning stage, production data such as laboratory results, energy meter readings and maintenance logs are not used as evidence, and misstatements are detected late. At the same time the Law "On Audit Activity" [1], the audit development programme [2] and the recognition of the International Standards on Auditing [3] require the auditor to assess risks of material misstatement, to use analytical procedures and to obtain

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sufficient appropriate evidence, and the external quality control of audit organisations [4] requires that evidence to be documented.

Analytical procedures as audit evidence are treated by Arens and Loebbecke [5]; Makaryeva [6] and Meltonyan [7] developed them for the audit of financial results and production costs of vegetable processing enterprises, and Sharipova [8] for the processing cycle in consumer cooperation; Ridley [9] and Loudon [10] describe risk-oriented internal audit, and the FAO manual [11] risk-based inspection of food production; in Uzbekistan Akhmadjonov [12] developed the methodology of internal audit. What is missing is a model that organises the audit of a processing enterprise around its technological risks and links the auditor to the plant's own digital data.

The aim of the paper is to propose such a model – a five-stage risk-based analytical audit and an integrated audit system built on the "process – resource – product" principle – and to show its application to the data of "Asian jam" LLC, "Green world-group" LLC and "East agro international" LLC.

Materials and methods

The study draws on the 2021–2024 financial statements, production, laboratory and energy records of the three enterprises, the texts of ISA 315, ISA 500 and ISA 520 and the national legislation on audit. Grouping, comparison, monographic study, analytical procedures (trend, ratio, regression and variance analysis), expert scoring of risk probability and impact, and modelling of information flows were applied.

Results and discussion

Audit in a processing enterprise is organised on the "process – resource – product" principle: for each production stage the auditor fixes control points for existence, completeness, valuation, allocation and classification and tests the financial records against physical indicators – steam kilograms, kilowatt-hours, machine-hours, number of laboratory tests, packaging units, yield coefficient. Every conclusion is triangulated from accounting entries, technological registers and independent external documents. Table 1 shows how the audit objects, evidence and sampling are set for the resources that determine cost and margin.

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Table 1. Audit objects, key evidence and sampling in a fruit and vegetable processing enterprise

Resource	Audit object	Key evidence	Frequency and sample
Labour	Working time and shift discipline	Timesheets, shift schedule, turnstile and biometric logs	Weekly; at least 10 % of shifts
	Downtime and changeover (SMED)	Downtime code register, maintenance journals	Daily; 100 % of A-class equipment
Materials	Raw-material reception and quality	Reception act, batch passport, Brix and pH protocol	Daily; 100 % of batches
	Inventories and work in progress	Stock balances, temperature and humidity logs, inventory acts	Weekly; 100 % of A-class items
	Losses and defects	Loss norms, defect act, processing act	Monthly; 30 % sample on critical lines
	Packaging and storage	Packaging certificates, labelling protocol	Weekly; 100 % of export batches
Financial	Price formulas (bonus and penalty)	Contracts, laboratory indicators, invoices	Monthly; top-20 suppliers

Source: developed by the author.

The five-stage risk-based analytical audit model organises this work. At the first stage the risks are identified – raw-material quality, seasonal stoppages, energy consumption, waste volume and packaging efficiency are the sector's main risk sources. At the second stage each risk is assessed by probability and impact; at the third the audit programme concentrates time and sampling on the high-risk sections – in high-risk periods the sample is widened, in low-volume periods the share of analytical procedures is increased. At the fourth stage the analytical procedures are performed: the change in unit cost is linked to output volume, loss level and energy consumption, the energy costs booked in the ledger are reconciled with the kilowatt-hours measured on the line. At the fifth stage corrective measures are agreed and their execution is monitored in the following audit. Applied to the three enterprises, the procedures showed that revenue growth had been accompanied by margin erosion – the gross margin of "Asian jam" LLC fell from 47.9 to 26.6 per cent over 2021–2024 and "Green world-group" LLC ended 2024 with an operating margin of –9.9 per cent – because selling and

"other operating" expenses were not traced to products and channels, while abnormal losses rose to 3.2 and 4.7 per cent respectively.

The second element is the integrated audit system, which turns the model into a permanent, real-time mechanism (Table 2). Five information blocks – accounting, production, quality and laboratory, logistics and sales, audit and control – are joined on one platform and supported by four technological components: a data hub, an audit dashboard, an alert system and an audit trail. Data are collected automatically from MES, LIMS, SCADA and WMS systems, standardised in the process – resource – product coding, analysed by trend, regression, correlation and variance methods, mapped into a "hot-spot" risk map and converted into forecasts of profit, cost, energy efficiency and waste for management.

Table 2. Structure of the integrated audit system of a fruit and vegetable processing enterprise

Block or component	Content	Audit function
Accounting data block	Entries, financial results, inventories, cost accounting	Base for reconciliation with physical data
Production block	Raw-material input, energy, processes, waste, efficiency	Source of physical evidence on cost drivers
Quality and laboratory block	Brix, pH, moisture, pesticide residues, microbiology	Evidence on raw-material quality and yield
Logistics and sales block	Packaging, storage, transport, channels, returns	Tracing of selling expenses to products and channels
Audit and control block	Plan-versus-actual deviations, risk map, test results	Planning and documentation of the audit
Data hub	Single database of production and financial data	"Single source of truth" for evidence
Audit dashboard and alert system	Real-time indicators; automatic signals on deviations	Continuous monitoring of high-risk areas
Audit trail (evidence register)	Digital evidence chain for each conclusion	Documentation for external quality control

Source: developed by the author.

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Computer-assisted audit techniques run over the whole database and flag anomalies such as a mismatch between electricity consumption and output or between laboratory results and product batches; audit is applied in five directions – energy and resource efficiency, cost, quality, environmental and financial audit – and the results reach management as key indicators with graphs. The model and the integrated system have been adopted by the Chamber of Commerce and Industry of Uzbekistan (certificate No. 01-06-30-3857 of 21 April 2026); they make it possible to detect risks at an early stage of preparing the financial statements and move audit "from inspection to management".

Conclusions

1. In fruit and vegetable processing enterprises audit evidence must come from the physical process – laboratory protocols, energy meters, yield and loss records – and be triangulated with accounting entries and external documents; the "process – resource – product" principle and the sampling scheme of Table 1 make this operational.
2. The five-stage risk-based analytical audit model directs audit time to the sector's specific risk sources and, through analytical procedures linking unit cost with volume, losses and energy, reveals the causes of margin erosion that a documentary check would miss.
3. The integrated audit system – five information blocks on one data hub with a dashboard, an alert system and an evidence register – converts audit into a real-time, digitally evidenced mechanism that supports management decisions and meets the documentation requirements of external quality control.

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