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Processing and Quality Evaluation of Export Grade Cardamom (Elettaria cardamomum Maton) Processed at VEBARO Trading & Export Pvt. Ltd., Wayanad, Kerala

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Abstract **– Cardamom (Elettaria cardamomum Maton), known as the "Queen of Spices", is one of India's most valuable export commodities because of its unique aroma, flavor and essential oil content. The quality of export-grade cardamom depends on scientific post-harvest processing and comprehensive laboratory quality evaluation. The present study aimed to evaluate the processing operations and quality parameters of export-grade cardamom processed at VEBARO Trading & Export Pvt. Ltd., Wayanad, Kerala. The processing stages included harvesting, washing, grading, drying, polishing, sorting, quality inspection, packaging and storage. Quality evaluation was performed through physicochemical, microbiological and chemical analyses. Parameters such as moisture content, volatile oil, total ash, acid insoluble ash, extraneous matter, microbial load, pesticide residues and heavy metals were assessed according to export quality requirements. The results indicated that scientifically processed cardamom maintained desirable moisture content, high volatile oil retention and acceptable microbiological quality, meeting the prescribed export standards. The study concludes that implementation of Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and systematic laboratory quality assurance significantly improves product quality, shelf life and international market acceptance.**

Keywords **– Cardamom, Export Quality, Processing, Quality Evaluation, Laboratory Analysis, Essential Oil, Moisture Content.**

I. INTRODUCTION

Cardamom (Elettaria cardamomum Maton), is one of the most valuable and economically important spice crops in the world. It belongs to the family Zingiberaceae and is cultivated mainly in tropical regions, particularly in India, Guatemala, Sri Lanka and Tanzania. Among these countries, India has a long history of cultivating high-quality small cardamom and is recognized as one of the leading producers and exporters of premium-grade cardamom. The spice is widely appreciated for its unique aroma, pleasant flavor and therapeutic properties, making it an indispensable ingredient in the food, pharmaceutical, cosmetic and nutraceutical industries.

The demand for export-grade cardamom has increased considerably over the last decade due to growing consumer preference for natural flavors, functional foods and herbal products. Major importing countries, including the United Arab Emirates, Saudi Arabia, Kuwait, Qatar, Europe and North America, require cardamom that complies with stringent quality and food safety standards. Consequently, the spice industry has shifted from conventional processing methods to scientifically controlled post-harvest operations that ensure consistent product quality and international market acceptance.

The quality of cardamom is greatly influenced by harvesting maturity, curing techniques, drying conditions, grading, sorting, storage and packaging practices. Improper processing may result in loss of green color, reduction in essential oil and volatile oil content, microbial contamination and deterioration of sensory characteristics. These changes adversely affect both consumer acceptance and export value. Therefore, scientific processing and quality assurance have become critical components of the modern spice export industry.

Laboratory quality evaluation plays a vital role in ensuring that processed cardamom satisfies national and international food safety regulations. Export-oriented quality assessment includes physicochemical parameters such as moisture content, volatile oil, total ash, acid-insoluble ash and extraneous matter, along with microbiological analyses for Total Plate Count, yeast and mold, Salmonella spp. and Escherichia coli. In addition, chemical safety evaluation involving pesticide residues, heavy metals and mycotoxins is essential to ensure compliance with standards established by the Food Safety and Standards Authority of India (FSSAI), Codex Alimentarius Commission and importing countries.

Recent advancements in spice processing technology, including controlled hot-air drying, steam sterilization, optical color sorting and vacuum packaging, have significantly improved the quality, shelf life and safety of export-grade cardamom. The adoption of Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Point (HACCP)

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systems has further strengthened quality assurance throughout the processing chain. These technologies minimize post-harvest losses, reduce microbial contamination and preserve the characteristic aroma and flavor of cardamom.

Although several studies have reported the chemical composition, medicinal properties and processing techniques of cardamom, limited research has comprehensively integrated commercial processing operations with laboratory quality evaluation under export-oriented industrial conditions. Understanding the relationship between processing practices and quality parameters is essential for improving product consistency and ensuring compliance with international trade standards.

Therefore, the present study was undertaken to evaluate the processing operations and laboratory quality characteristics of export-grade cardamom processed at VEBARO Trading & Export Pvt. Ltd., Wayanad, Kerala. The study focuses on processing techniques, physicochemical quality, microbiological safety and compliance with export quality standards to assess the suitability of processed cardamom for international markets.

II. MATERIALS AND METHODS

Study Area

The present study was conducted at VEBARO Trading & Export Pvt. Ltd., Wayanad, Kerala, India, an export-oriented spice processing and quality evaluation facility. The laboratory follows Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP), and quality control procedures to ensure compliance with export standards prescribed by FSSAI, Spices Board India, Codex Alimentarius, ASTA and importing countries.

Raw Material Procurement

Export-grade green cardamom capsules were procured directly from farmers and registered suppliers in the major cardamom-growing regions of Kerala. Each lot was accompanied by supplier identification and batch details to maintain traceability throughout processing.

Materials Used

Raw Materials:

- Fresh Green Cardamom Capsules

Packaging Materials

- Food-grade laminated pouches
- Vacuum pouches
- Aluminum foil bags
- Corrugated export cartons
- Polyethylene liners Laboratory Chemicals
- Distilled Water
- Sulphuric Acid
- Hydrochloric Acid
- Sodium Hydroxide
- Standard Microbiological Media

Table 1: Equipment used

EQUIPMENT	PURPOSE
Receiving Conveyor	Raw material receiving
Pre-Cleaner	Removal of dust and stones
Destoner	Removal of stones
Washing Tank	Washing Cardamom
Air Blower	Surface water removal
Tray Dryer	Drying
Hot Air Dryer	Controlled drying
Moisture Meter	Moisture Analysis
Color Sorter	Color Grading
Vibratory Grader	Size Grading
Steam sterilizer	Microbial reduction
Metal Detector	Metal contamination detection
Weighing Machine	Net weight checking
Vacuum Packaging Machine	Export Packing
Heat Sealing Machine	Sealing Packages

Cardamom Processing Method

Step 1 – Raw Material Reception

Fresh cardamom capsules were received and inspected for maturity, color, insect infestation and mechanical damage.

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Step 2 – Cleaning

Foreign matter including stones, leaves, dust and immature capsules were removed using a pre-cleaner and destoner.

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Step 3 – Washing

Cardamom capsules werewashedwith potable water to remove adhering dirt.

Equipment: Stainless Steel Washing Tank Water Temperature: 25–30°C

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Step 4 – Surface Drying

Excess surface moisture was removed using an air blower.

↓

Step 5 – Drying

Drying was carried out using a hot air tray dryer.

Recommended Temperature: 45–50°C

Drying Time:14–18 hours (may vary depending on initial moisture)

Target Moisture: 8–10% Equipment:

- Stainless Steel Tray Dryer
- Hot Air Dryer

↓

Step 6 – Polishing

The dried capsules were polished to improve surface appearance.

Equipment: Cardamom Polisher

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Step 7 – Color Sorting
Green capsules were separated using an optical color sorter.

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Step 8 – Size Grading
Capsules were graded according to size using vibratory grading equipment.

Example Grades:
- Bold
- Extra Bold
- Medium
- Small

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Step 9 – Steam Sterilization
Steam sterilization was carried out to reduce microbial contamination.
Steam Temperature: 95–105°C

Holding Time: 30–60 seconds (depending on equipment)

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Step 10 – Metal Detection
Packed cardamom was passed through a metal detector.

Detection Limits (typical):
- Ferrous: 1.5 mm
- Non-ferrous: 2.0 mm
- Stainless Steel: 2.5 mm

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Step 11 – Packaging Packaging Materials:
- Vacuum Pack
- Aluminum Foil Pouch
- Laminated Pouch

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Step 12 – Storage StorageTemperature:15–20°C Relative Humidity: <60%

Quality Evaluation
After processing, laboratory quality evaluation was performed.

Physical Analysis
- Color
- Size
- Bulk Density
- Extraneous Matter
- Damaged Capsules

Physicochemical Analysis
- Moisture Content
- Volatile Oil
- Essential Oil
- Total Ash
- Acid Insoluble Ash

Chemical Analysis
- Pesticide Residues
- Heavy Metals
- Aflatoxin

Microbiological Analysis
- Total Plate Count
- Yeast & Mold
- Salmonella spp.
- Escherichia coli

Laboratory Testing Flow Chart

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Sample Collection
↓
Sample Coding
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Physical Analysis
↓
Physicochemical Analysis
↓
Chemical Analysis
↓
Microbiological Analysis
↓
Comparison with Export Standards
↓
Quality Approval
↓
Packaging
↓
Dispatch

Table 2: Export Quality Acceptance Criteria

PARAMETER	ACCEPTANCE LIMIT
Moisture	8-10%
Volatile oil	≥4%
Total Ash	≤7%
Acid Insoluble Ash	≤1%
Extraneous Matter	≤1%
Total Plate Count	Within customer specifications
Salmonella	Absent in 25g
E. coli	Absent
Heavy Metals	Within Codex/FSSAI limits
Pesticide Residues	Below MRL
Aflatoxin	Within importing- country limits

III. RESULTS AND DISCUSSION

The present study evaluated the processing operations and quality characteristics of export-grade cardamom processed at VEBARO Trading & Export Pvt. Ltd., Wayanad, Kerala. The processing sequence, including cleaning, washing, controlled hot-air drying, grading, color sorting, steam sterilization and vacuum packaging, contributed significantly to maintaining the physical appearance, aroma and overall quality of the final product. Controlled drying at 45–50°C reduced the moisture content to approximately 9.0–9.5%, which is considered suitable for long-term storage and export. Similar observations have been reported by Peter (2012), who stated that controlled drying preserves essential oil content and minimizes quality deterioration.

Laboratory analysis indicated that the processed cardamom complied with the recommended export quality

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requirements. Moisture content, total ash, acid-insoluble ash and volatile oil values were within the acceptable limits prescribed by FSSAI and international spice quality standards. Microbiological examination showed satisfactory hygienic quality, with Salmonella spp. and Escherichia coli absent in the analyzed samples. Total Plate Count and yeast and mold counts remained within acceptable limits after steam sterilization, demonstrating the effectiveness of hygienic processing and quality assurance practices.

The evaluation also highlighted the importance of pesticide residue monitoring and heavy metal analysis for export certification. The adoption of Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Point (HACCP) principles ensured that the processed cardamom satisfied food safety requirements and international trade regulations. Proper traceability, scientific storage and appropriate packaging further contributed to maintaining product quality during transportation and storage.

The findings of the present study are consistent with earlier reports by Ravindran and Kallupurackal (2001), Srinivasan (2007) and Parthasarathy et al. (2013), who emphasized that scientific post-harvest processing and laboratory quality evaluation are essential for preserving the physicochemical and microbiological quality of export-oriented spices. These studies also reported that controlled drying, steam sterilization and systematic quality control improve product safety, shelf life and consumer acceptability.

Overall, the study demonstrates that the integration of scientific processing technologies with laboratory quality evaluation provides an effective quality assurance system for export-grade cardamom. Maintaining critical quality parameters within internationally accepted standards enhances market competitiveness and strengthens consumer confidence in Indian spice exports.

Major Findings Of The Study

- Scientific processing significantly improved the quality of export-grade cardamom.
- Controlled drying preserved color, aroma and volatile oil content.
- Laboratory quality evaluation confirmed compliance with export standards.
- Steam sterilization effectively reduced microbial contamination.
- Proper grading, color sorting and hygienic packaging enhanced commercial value.
- Implementation of GAP, GMP, GHP and HACCP improved food safety and traceability.
- Scientific quality assurance increased the export suitability of processed cardamom.

IV. CONCLUSION

The present study on “Processing and Quality Evaluation of Export Grade Cardamom (Elettaria cardamomum Maton)” demonstrated that scientific post-harvest processing and systematic laboratory quality evaluation are essential for producing premium-quality cardamom suitable for international markets. The sequential processing operations, including cleaning, washing, controlled hot-air drying, polishing, grading, color sorting, steam sterilization and hygienic packaging, played a significant role in preserving the physical appearance, characteristic green color, aroma and overall quality of the product.

The laboratory analyses confirmed that the processed cardamom complied with the prescribed export quality standards for moisture content, volatile oil, total ash, acid-insoluble ash, microbiological safety and chemical contaminants. The implementation of Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Point (HACCP) principles ensured product safety, traceability and consistency throughout the processing chain.

The findings of the present study indicate that continuous laboratory monitoring, validated quality control procedures and appropriate packaging systems are essential for maintaining the quality, shelf life and export acceptability of cardamom. Adoption of advanced processing technologies and adherence to national and international food safety standards can significantly enhance the competitiveness of Indian cardamom in the global spice market.

Overall, this study highlights the importance of integrating scientific processing techniques with comprehensive quality evaluation to ensure the production of safe, high-quality and export-grade cardamom. The outcomes of this research may serve as a useful reference for spice processing industries, quality control laboratories, researchers and exporters involved in the cardamom supply chain.

Future Scope

Future research may focus on the application of advanced drying technologies, non-thermal microbial decontamination methods, rapid quality assessment techniques using artificial intelligence and spectroscopy, sustainable packaging materials and real-time traceability systems to further improve the quality, safety and export potential of cardamom. In addition, long-term storage studies and comparative evaluations of different processing methods could provide valuable information for enhancing the commercial value of Indian cardamom in international markets.

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