ISSN: 2958-2326

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African Journal of Commercial Studies

Publisher's Home Page: https://ijcsacademia.com/

AFRICAN JOURNAL OF COMMERCIAL STUDIES

Research Paper | Peer Reviewed | Open Access

Product Grading system for Beverage Manufacturing Industry in Zambia

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African Journal of Commercial Studies, 2025, 6(6), 12–20
DOI Link: https://doi.org/10.59413/ajocs/v6.i6.2

Article Info

Volume 6, Issue 6

Publication history:
Accepted on 11 October 2025;
Published: 28 October 2025

Article DOI:
10.59413/ajocs/v6.i6.2

Abstract

In the highly competitive landscape of the beverage manufacturing industry which is uniquely positioned for the innovation of a product grading system, given its reliance on maintaining consistent flavor profiles, packaging integrity, and regulatory compliance. This study aimed to innovatively develop a product grading system that can be used in the beverage manufacturing industry and provide an actionable guide to foster the implementation of the system. This study utilized design-based research to develop and validate a grading system, informed by global eco-labelling practices and GSCM principles. It involved review of literature, defining grading criteria based on GSCM practices, and a weighted scoring system. The grading system was validated with experts and adjusted based on their feedback. An implementation plan, including stakeholder collaboration and public awareness, was also established. The proposed system assessed manufacturers using GSCM practices. The grading system assigns scores based on compliance, categorizing companies from A (Green) to D (Blue) for eco-friendliness. Implementation would be overseen by ZEMA and ZABS, with initial voluntary participation. The system's effectiveness was validated by industry experts, confirming its practicality, usability, and alignment with environmental goals, promoting sustainability and informed consumer choices. This study developed a comprehensive product grading system for Zambia's beverage industry, focusing on sustainability and environmental impact through GSCM practices across the sector.

Keywords: Beverage manufacturing, Eco-friendly, Innovation, Product grading system, Zambia

1. Introduction

In the highly competitive landscape of the beverage manufacturing industry (Gitari, 2023), product quality plays a pivotal role in maintaining brand reputation, consumer satisfaction, and market growth (Kosasih et al., 2024). As consumer preferences continue to evolve and regulatory standards become more stringent, manufacturers are compelled to innovate not only in their product offerings but also in the systems used to evaluate and ensure product quality (Ibrahim et al., 2024). The grading of products based on predefined standards has become an essential process that determines the overall market success of beverage products (Alfatni et al., 2013). However, the dynamic nature of consumer demands, coupled with the complexities of large-scale production, has revealed the limitations of traditional product grading systems (Fanzo et al., 2023).

The beverage industry is uniquely positioned for the innovation of a product grading system, given its reliance on maintaining consistent flavor profiles, packaging integrity, and regulatory compliance across vast product lines (IFST, 2018). Traditional grading systems, often manual and subjective, can result in variability, inefficiency, and potential quality lapses (Gonzalez Viejo et al., 2019). This study focuses on the development of an innovative product grading system that can be used in the beverage manufacturing industry and provide an actionable guide to foster the implementation of the developed product grading system within the industry.

In this regard, the study intends to enhance the accuracy, efficiency, and consistency of product grading, thereby improving overall product quality, streamlining production processes, and reducing waste (Clancy et al., 2023). This innovative grading system is designed to serve as a model for future product grading developments not only within the beverage sector but also across

other industries. Through expert insights and practical application, the study aims to provide valuable guidance on integrating modern solutions into traditional manufacturing environments to meet the evolving demands of the market. By doing so, it contributes valuable insights into how modern simpler solutions can be integrated into traditional manufacturing environments to enhance quality control and meet the evolving demands of the beverage market.

Objectives

i. To develop a comprehensive grading system for evaluating the eco-friendliness of beverage manufacturing processes in Zambia, focusing on sustainability and environmental impact.
ii. To establish clear and actionable criteria for the effective implementation of the product grading system, ensuring its adoption and usability across the beverage industry
iii. To validate and verify the effectiveness of the product grading system, ensuring accuracy, reliability, and alignment with environmental and industry standards.

2. Review of Literature

Quality management is essential in the beverage industry, ensuring products meet safety and consumer expectations. Systems like Good Manufacturing Practice (GMP) are vital in standardizing processes, from raw materials to final products. Integrating grading systems within quality management provides measurable criteria, enhancing consistency and improving communication with stakeholders. This also promotes continual improvement across production and quality assurance (Aadil et al., 2019). Grading systems guide consumer behavior. Nutri-Grade (NG) in Singapore and a similar system in Shanghai grade beverages based on sugar and fat content, helping consumers make healthier choices. By adopting such systems, beverage companies align with public health efforts and foster consumer trust in an increasingly health- conscious market (Shin et al., 2023).

Technology, particularly artificial intelligence (AI), enhances grading systems by automating sensory evaluations and reducing human bias. AI tools provide real-time assessments of taste, aroma, and appearance, ensuring consistent product quality. Automation can also address inefficiencies and high labor costs, ensuring higher throughput and fewer errors (Araujo & Kim, 2021). However, subjectivity in sensory evaluations presents challenges in grading taste and aroma. AI, alongside structured training for assessors, can help reduce bias. A data-driven grading system provides reliable assessments of safety, nutritional value, and sensory properties, supporting better decision-making in production (K. C. Roy et al., 2005). In this regard, standardized sensory grading is key to maintaining consistency across batches. Using a sensory lexicon and chemical reference standards, beverage manufacturers can create more objective evaluations of taste and texture, ensuring quality and customer satisfaction (Chiou et al., 2003).

Cost-effective grading solutions can optimize production without increasing costs. Mechanized grading systems with adjustable parameters offer flexibility in evaluating different beverage types and ingredients, ensuring efficiency and quality control (Preez & Pressentin, 2020). Grading systems also play a crucial role in communication through labeling. Systems like Nutri-Grade inform consumers about nutritional value, helping them make healthier choices. Transparent labeling aligns with market trends prioritizing ingredient transparency, building consumer trust (Bandara et al., 2016). Furthermore, AI and machine vision further enhance grading processes by standardizing quality assessments and improving productivity. AI-powered systems ensure consistency across batches while reducing labor costs. Moving from mechanical to AI-powered graders offers more precise evaluations, especially in sensory and nutritional grading (Cecchini & Warin, 2016; Hashim et al., 2013). Non-destructive grading methods using advanced imaging

technologies allow beverage manufacturers to assess internal product quality without damaging the product. This is particularly important for premium beverages, where maintaining product integrity is essential for customer satisfaction and brand loyalty (Matthews et al., 2012).

3. Research Methods

3.1 Research Design

This study used design-based research (DBR) which allowed the researcher(s) to collaborate with stakeholders throughout the process in order to adequately develop and validate the grading system within the context of the beverage manufacturing industry based on the Green Supply Management (GSCM) practices. This design involved reviewing of literature to understand existing-labelling and grading practices globally, then applying these insights to the Zambian context.

3.2 Literature Review and Benchmarking

A comprehensive literature review was conducted to gather information on global and national eco-labelling systems, including those in Singapore, India, the European Union, and Thailand. The review focused on their design, implementation, and effectiveness, with particular attention to how these labels guide consumer behavior towards environmentally sustainable products. Additionally, specific studies on GSCM practices were reviewed to define relevant parameters for assessing beverage manufacturers. The review informed the criteria and structure of the grading system, ensuring it aligns with international best practices while being adaptable to Zambia's environmental context.

3.3 Defining Grading Criteria

Based on the literature review and expert input, four core GSCM practices were selected to form the foundation of the grading system: Green Purchasing (GP), Green Manufacturing (GM), Green Distribution/Marketing (GD/M) and Reverse Logistics (RL). Each practice was further divided into specific assessment parameters (Table 6.3). For example, "Green Purchasing" included parameters such as the use of recycled materials and supplier environmental audits.

3.4 Grading System Design

The grading system was developed using a weighted scoring approach. Each GSCM practice was assigned a weight of 0.25 (25%), contributing equally to the overall score. The final grade was determined by calculating the weighted score for each practice and summing them. The formula for calculating the total score was:

$$GSCM\ weighted\ score = \left(\frac{X1}{Y1} + \frac{X2}{Y2} + \frac{X3}{Y3} + \frac{X4}{Y4}\right)$$

X is the number of items achieved under each variable.
Y is the total number of items under each variable.

This formula ensured that the grading system is comprehensive and flexible, allowing manufacturers to excel in some areas while gradually improving in others.

3.5 Validation and Expert Consultation

After the initial design, the grading system was presented to environmental experts from Zambia Environmental Management Agency (ZEMA), the Zambia Bureau of Standards (ZABS), and international organizations like the world Bank and UNDP. These experts provided feedback on the system's feasibility, usability, and regulatory implications. Feedback was incorporated to enhance the system's clarity, applicability, and regulatory alignment. For instance, experts suggested that ZEMA oversee monitoring activities, while ZABS issue certifications based on compliance with the grading system.

3.6 Data Analysis

Quantitative data from the pilot test were analyzed using descriptive statistics to determine the distribution of manufacturers across the grading categories (A to D). Qualitative feedback from manufacturers and experts was also analyzed to identify potential improvements to the grading system.

3.7 Implementation Plan

Following validation, an implementation plan was developed in collaboration with ZEMA and ZABS. The plan includes voluntary Participation and capacity-building initiatives of the manufacturers. Periodic reviews by ZEMA to update the system based on industry feedback and global trends. Lastly, public awareness campaigns: Initiatives to educate consumers on the benefits of eco-labelling and encourage green purchasing behavior.

3.8 Data Collection

The data collection for this study involved the use of both quantitative and qualitative methods. The primary tools for data collection included a questionnaire and interviews respectively. The questionnaire was distributed to 37 beverage manufacturing companies registered with the Zambia Association of Manufacturers (ZAM). Since the population was small, all companies were included in the study. Google Forms, an online platform, was used to distribute the questionnaire between September 2022 and February 2023. The participants were contacted through email addresses and contact details provided by the ZAM database, including roles such as Production Managers, Quality Control Managers, Transport and Logistics Supervisors, Directors, and General Managers of small beverage companies. A selected number of respondents were interviewed via phone calls. This allowed for follow-up questions and deeper insights from key respondents. Both methods provided comprehensive data to meet the study's objectives of developing and implementing an innovative product grading system in the beverage manufacturing industry. Information in relation to the procedures used in the development of the grading system was collected through review of literature.

4 Results and Discussion

4.1 The Grading System

The review of literature revealed that several countries introduced grading systems or labels to help consumers make informed choices regarding environmental and health aspects of products (Aprile & Punzo, 2022; Meijer et al., 2021). These systems are authorized by relevant national authorities and include criteria that assess either the product's content or production methods and their impact on both the environment and consumer health. For instance, Singapore launched the

Nutri-Grade label in 2021 for non-alcoholic beverages, rating them from A to D based on sugar or saturated fat content, with grade D products being the least healthy and restricted from advertising (Shin et al., 2023). In India, the Eco Mark, issued by the Bureau of Indian Standards and the Ministry of Environment, Forest, and Climate Change, certifies products as environmentally safe, aiming to promote eco-friendly production and environmentally conscious consumer choices (Trusha G. Haribhakti & Pandya, 2023).

Initially, product labels focused on consumer safety, but more recently, some nations have introduced labels highlighting environmental impacts, shaping relevant policies (Grunert et al., 2014). Additionally, growing consumer demand for eco-friendly products has driven the rise of ecolabels, which are expected to play a key role in future sustainable consumption and production strategies (Xin & Long, 2023). A study on fishery and aquaculture product labelling found that eco-labelling can address societal concerns about food production methods (Acosta & Arturo, 2022). Another study indicated that sustainability labels influence consumer choices and purchases of more environmentally friendly food and beverages (Cook et al., 2023). It is crucial that these labels are regulated by reputable authorities and are supported by a robust grading system for proper oversight. Notably, many grading systems are optional, allowing organizations to participate voluntarily (Baker et al., 2010). Table 1 provides examples of labels from various regions and countries, showing their role in raising consumer awareness and guiding manufacturers. Research suggests that government support is essential for the success of eco- labelling initiatives (CLASP, 2020).

Table 1: Some Global and National Eco-labels

Label	Region(s)/Country	Product Type
BASF Eco-efficiency	Brazil, Germany, USA	Cooling devices, building products, cleaning products, cosmetics, electronics, energy, forest products, healthcare, machinery
Thai Green Label	Thailand	Cooling devices, building products, cosmetics, electronics, paper, textiles, transportation, water
Ecomark: INDIA	India	Building products, electrical household appliances, cleaning products, cosmetics, food, forest products, packaging, textiles
EU Ecolabel	Europe, Australia, Canada, Malaysia	Cooling devices, household appliances, building products, cleaning products, electronics, forest products, textiles, tourism

During the time this research was conducted, Zambia had at least four eco-labels linked to international certifications for eco-friendly practices. These included the Wildlife Friendly Enterprise Network (WFEN) for wildlife-friendly organizations, Earthmark for travel and tourism, Green Globe for sustainable tourism and the environment, the Linking Environment and Farming (LEAF) mark for certifying farmers who enhance wildlife sustainability, the Programme for the Endorsement of Forest Certification (PEFC) for promoting forest management, and the Sustainable Agriculture Network (SAN), which certifies farms, not products or organizations, covering items such as coffee, bananas, cocoa, and flowers (Big Room, 2024). The findings of this study, in comparison with existing literature, suggest that Zambia could improve its environmental awareness efforts, particularly by introducing a grading system for the beverage industry.

Although consumers may be interested in reading labels on food packages, they are often discouraged due to information overload, time constraints, or a lack of interest (Zafar et al., 2022). To address this, labels should be concise and easy to read. Research also shows that providing consumers with both environmental information and green identity labels can effectively guide those who prefer eco-friendly products (Cook et al., 2023). With natural resources being strained by global population growth and unsustainable production methods, the development of grading systems is critical to promote sustainable practices and environmental preservation (Reddy et al., 2023).

4.2 Designing a Grading System

The proposed grading system was created using the parameters that were identified through literature, namely, Green Purchasing (GP), Green Manufacturing (GM), Green Distribution/Marketing (GD/M) and Reverse Logistics (RL). Regulators can use this system to assess beverage manufacturers. The grading method is simplified for easy use and involves a straightforward calculation using a weighted factor to determine compliance levels and the appropriate label. Companies are color-coded based on the assessment results: those scoring at least 80% on GSCM practices are awarded grade A – Green. Companies scoring between 60% and 79% receive grade B – Amber, while those scoring between 40% and 59% are graded C – Yellow. Organizations scoring below 40% are classified as D – Blue. Scores are based on a combination of any of the four GSCM practices: Green Purchasing, Green Manufacturing, Green Distribution/Marketing, or Reverse

Logistics, allowing organizations to choose which practice to integrate first. Table 2 outlines the grading and scoring system, which will be finalized once the Assessor calculates the weighted average.

Table 2: Proposed Grading and Scoring system for Beverage Manufacturers

% Range (A)	Category (B)	Weight (C)	Weighted score A*C	Grading
≥ 80	Green Purchasing, Green Manufacturing, Green Distribution/Marketing and Reverse Logistics	0.25		A – Green (Environmentally sustainable)
60-79	Green Purchasing, Green Manufacturing, Green Distribution/Marketing and Reverse Logistics	0.25		B – Amber (Intermediate)
40-59	Green Purchasing, Green Manufacturing, Green Distribution/Marketing and Reverse Logistics	0.25		C – Yellow (second stage)
<40	Green Purchasing, Green Manufacturing, Green Distribution/Marketing and Reverse Logistics	0.25		D – Blue (Initial stage)
Total		1		

Parameters against which organizations will be assessed are in Table 3 and Figure 6.1 shows the proposed label to be issued to participating manufacturers, depending on the outcome of the assessment by the Assessor.
To calculate the grade within which a manufacturer would fall, the following equation should be used:

$$\textbf{GSCM weighted score} = GP + GM + GD/M + RL$$

$$\textbf{GSCM weighted score} = ((0.25 \cdot \frac{X1}{Y1}) \cdot 100 + (0.25 \cdot \frac{X2}{Y2}) \cdot 100 + (0.25 \cdot \frac{X3}{Y3}) \cdot 100 + (0.25 \cdot \frac{X4}{Y4}) \cdot 100)$$

$$\textbf{GSCM weighted score} = 25(\frac{X1}{Y1} + \frac{X2}{Y2} + \frac{X3}{Y3} + \frac{X4}{Y4})$$

$$\textbf{GSCM weighted score} = \sum_{i=1}^{4} (\frac{Xi}{Yi})$$

Where;
X = number of items achieved under one variable
Y = Total items under each variable
For example, under GP, eight items are recorded for assessment. A manufacturer may score 100% on all the items. However, if the manufacturer scores seven out of eight, the Assessor will calculate (0.25 x 7/8) 100 to obtain the score under GP. The same will apply to all the other GSCM practices variables. The total outcome is the weighted score to determine the range within which a manufacturer falls.

Table 3: GSCM Practices and assessment parameters

GSCM Practice	Assessment parameters
Green Purchasing	Using recycled or non-toxic material, supplier adoption of EMS, supplier clean production education, supplier prior green involvement, green specifications, supplier environmental audit, demanding raw materials with minimal environmental destruction, whole life cycle assessment of in puts
Green Manufacturing	Less energy consumption, life cycle assessment to determine product environmental load, use of non- hazardous materials, reduced solid waste, air pollution, less water usage, less energy usage, eco-design, recyclable product manufacturing
Green Distribution/Marketing	Eco-labelling, Eco-packaging (biodegradable material-based packaging), eco-warehousing, efficient transportation, eco- transportation
Reverse Logistics	Reuse, recycle, consumer education on recycling and reuse initiatives

Once the range is determined, the grade will be assigned to the manufacturer, following the colour code provided in Figure 1 which illustrates an attainment of Grade B after assessment.

Figure1: Label for grading system

4.3 Criteria for the effective implementation of the developed grading system

Operationalizing the Grading System

In Zambia, ZEMA (Zambia Environmental Management Agency) is responsible for regulating environmental protection and controlling pollution to safeguard human, animal, plant, and environmental health (ZEMA, 2023). Given that beverage manufacturing has a direct impact on both human and environmental health (Hampton et al., 2021), it is recommended that ZEMA oversee the monitoring of beverage manufacturers' activities. Meanwhile, the Zambia Bureau of Standards (ZABS) is the authority responsible for issuing certifications. ZABS defines certification as verifying that products, processes, or systems comply with required standards (ZABS, 2023). Therefore, ZABS would oversee the issuance of grading labels, working in coordination with ZEMA.

The proposed grading system, detailed in Table 2, along with the GSCM (Green Supply Chain Management) practices and assessment parameters in Table 3, will help grade beverage manufacturers. Initially, participation in the system will be voluntary, allowing manufacturers time to become familiar with the grading system and the benefits of adopting GSCM practices. The system can be introduced gradually, with periodic reviews by ZEMA to improve monitoring and grading processes. Eventually, a self-assessment online system can be implemented, allowing manufacturers to evaluate themselves and receive grades. ZABS and ZEMA can maintain a database, updated regularly, tracking manufacturers that have adopted GSCM practices.

Color coding will help stakeholders assess how well a company integrates GSCM practices, motivating organizations to adopt a more sustainable mindset. Companies that achieve full GSCM integration can receive awards or be publicly recognized, as ZABS currently does for companies meeting its certification standards (Venter, 2018). Periodicals can also be published to educate the public and guide organizations interested in GSCM practices.

Stakeholder Buy-In

Consumers make purchases for various reasons, including maintaining their lifestyle, joining a social group, strengthening their identity, or expressing their cultural values (P. Roy & Datta, 2022). These motivations can be influenced by changing consumer attitudes. Studies show that a consumer's attitude toward advertising, the brand, and perceived value are key factors in predicting the success of marketing campaigns (Alsharif et al., 2022). Advertising can be used to shift consumer attitudes towards green products, even if they are sold at a premium, by emphasizing the health and environmental benefits (Šostar & Ristanović, 2023). Advertising methods can include media messages, packaging labels, promotions, and incentives (Hlavinka & Gomez, 2007). However, not all promotional strategies are equally effective; some consumers view promotions as an opportunity, while others may see them as marketing for lower-quality products (Qi et al., 2022).

Manufacturers need to identify what works best for their specific product, market, and location and adopt green production practices. Lin & Hao (2020) recommend three steps: (1) fostering environmental awareness, (2) addressing specific environmental issues through technical measures, and (3) improving management and personnel. Support for manufacturers is critical, including financial assistance, behavioral change management, and capacity building, as noted in a study by Switch Africa Green (2020) on the manufacturing sector in several African countries. Support can include renewable energy options, such as wind or natural gas, and access to funding or tax incentives for acquiring green technology to reduce environmental impacts (Qadir et al., 2021). While the initial costs may be high, the long-term benefits will help African countries achieve net-zero emissions by 2050 and improve competitiveness on the global market (Stern & Valero, 2021).

4.4 Validation and Verification of the Grading System

In 2023, South Africa's Ministry of Health issued a draft regulation on food labeling, including mandatory disclosure of sugar content in beverages (Charlton et al., 2024). Similarly, Singapore's Ministry of Health introduced a mandatory Nutri-Grade label to indicate sugar and fat content in beverages (Shin et al., 2023). The development, promotion, and review of Singapore Standards are overseen by the Singapore Standards Council (SSC), in collaboration with industry experts (SSC, 2024).

Validating and verifying a grading system is an essential part of the design process. While it may be simple to create a system, ensuring its effectiveness in solving real-world problems is more challenging (Baker et al., 2010). The grading system in this study was developed through a three- step process: first, identifying the problem and researching GSCM practices in Zambia's beverage industry; second, developing a concept for implementation and monitoring under ZABS and ZEMA; and third, presenting the system to environmental experts for validation.

Experts from organizations such as ZEMA, the World Bank, UNDP, and AGRA (Alliance for a Green Revolution in Africa) provided feedback on the system's feasibility, usability, and policy contributions. After incorporating expert suggestions, the grading system was finalized. Experts praised the system's practicality and simplicity, recommending that ZABS act as the system's custodian while ZEMA handles regulatory oversight. ZEMA expressed interest in integrating the study's findings into Zambia's Environmental Management Act No. 12 of 2011, particularly in relation to product labeling under statutory instrument No. 65 of 2018, which currently covers pesticide and toxic substance labeling.

5 Conclusion and Recommendations

This study successfully developed a comprehensive product grading system tailored to the beverage manufacturing sector in Zambia, with a strong emphasis on sustainability and environmental impact. The grading system addresses the need for a standardized framework to evaluate the eco-friendliness of manufacturing processes, helping the industry align with global environmental standards. By establishing clear, actionable criteria through Green Supply Chain Management (GSCM) practices, Green Purchasing, Green Manufacturing, Green Distribution/Marketing, and Reverse Logistics, the system ensures that beverage manufacturers can adopt and implement sustainable methods that are both measurable and transparent.

Furthermore, the proposed system is designed to be user-friendly, with a color-coded grading structure (Green, Amber, Yellow, and Blue) that reflects varying levels of environmental sustainability. This will foster industry-wide awareness and motivation, encouraging manufacturers to strive for higher eco-friendly performance. The collaboration with regulatory bodies such as the Zambia Environmental Management Agency (ZEMA) and Zambia Bureau of Standards (ZABS) is critical in ensuring the system's effective rollout, certification, and ongoing monitoring.

Validation and verification processes involving expert feedback from key stakeholders have reinforced the system's practicality, reliability, and alignment with both environmental and industry standards. The system is positioned to not only guide manufacturers towards greener practices but also empower consumers to make more informed, eco-conscious purchasing decisions. Ultimately, this grading system is expected to contribute significantly to sustainable industrial development in Zambia's beverage sector, supporting the global movement towards greener economies.

Declaration of Competing Interests

The authors declare that they have no conflicting interests.

Funding

This study did not receive any specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Data Availability statement

The data used to support the findings of this study are available upon request, from the corresponding author.

Acknowledgements

I am grateful to all the study participants.

Ethical considerations

The article followed all ethical standards appropriate for this kind of research and as prescribed by the ethics committee of the University of Zambia.

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