



# Elos Corn Noodles as Green-Shariah Compliant Functional Food: Sustainable Innovation through Extrusion Technology for Health and Local Economy

Atiqatul Maula<sup>1</sup>, Achmad Jufri<sup>1</sup>, Imam Buchari<sup>2</sup>, Selvi Fauziyah<sup>1</sup>

<sup>1</sup> Universitas Islam Negeri Madura, Indonesia

<sup>2</sup> Universitas Al Amien Prenduan, Indonesia  
atiqamaula@iainmadura.ac.id

**Abstract.** This study explores the potential of innovating Madura's local corn noodles (*Elos*) using extrusion technology within the framework of the Green-Shariah Economy. *Elos* corn noodles exhibit promising nutritional properties, including high dietary fiber, low glycemic index, and significant resistant starch content, making them suitable for diabetic diets. The extrusion process enhances the nutritional and textural qualities of the noodles while offering environmental benefits such as reduced waste and energy efficiency, aligning with the principles of the Green Economy. By utilizing local agricultural commodities, the study emphasizes the reduction of wheat imports, supporting local agro-industries and promoting sustainable resource management. The integration of extrusion technology in noodle production adheres to Shariah Economy principles, fostering ethical and responsible resource utilization. This dual alignment underscores the potential of *Elos* corn noodles to contribute to food diversification, local economic growth, and environmental sustainability. The study highlights the need for further research on large-scale production feasibility and consumer acceptance to fully realize these benefits. Overall, this innovation exemplifies a sustainable and ethical approach to food production that aligns with Green-Shariah Economy principles, promoting ethical resource use and environmental sustainability.

**Keywords:** Madura Corn Noodles, Extrusion Technology, Functional Food, Green Economy, Shariah Economy.

## 1 Introduction

The development of alternative foods from using agricultural commodities is crucial for enhancing food security and sustainable economic growth [1]. Noodles, a global dietary staple, face production challenges in Indonesia due to reliance on imported wheat. Utilizing local resources like Madura corn offers a strategic solution to reduce imports and add value to domestic agriculture. This aligns with the growing demand for functional, nutritionally enhanced foods, as demonstrated in studies using non-wheat ingredients (e.g., legumes, root crops) to improve noodles, nutritional and functional properties [2]–[4].

Realizing this potential in practical food applications requires suitable processing techniques, with extrusion technology playing a key role. Extrusion technology enables

efficient processing of Madura corn into functional noodles. Research confirms its suitability for producing *Elos* (Madura corn noodles) with high resistant starch, low glycemic index, and optimal physical characteristics—making it ideal for diabetic diets and health-conscious markets [5]. This technology allows the blending of functional ingredients while enhancing texture and sensory attributes [4], positioning Madura corn noodles as a sustainable alternative.

While extrusion-based corn noodle production has been explored, prior studies have used commercial or non-local maize varieties and have not focused on the indigenous *Elos* cultivar from Madura [6], [7]. Moreover, there is a lack of research assessing extrusion processing against Green Economy criteria (e.g., energy efficiency, waste reduction, resource sustainability) and Shariah Economy principles (e.g., ethical sourcing, halal compliance, community welfare). This study addresses these gaps by evaluating *Elos* corn noodles produced via extrusion within an integrated environmental and Islamic ethical framework.

Integrating this innovation with the Green-Shariah Economy framework merges environmental sustainability and ethical principles. The Green Economy balances economic growth with ecological stewardship, supporting UN Sustainable Development Goals [8], [9]. The Shariah Economy, grounded in Islamic finance, mandates ethical practices, social responsibility, and resource conservation [10], [11]. This synergy fosters socially responsible food production.

This study explores extruded Madura corn noodles within the Green-Shariah Economy, analyzing their nutritional enhancement [12], sustainability alignment, and market potential in Muslim-majority regions like Indonesia [13], [14]. By uniting environmental stewardship (Green Economy) and ethical values (Shariah Economy) [15], [16], it advances both sustainable development and societal well-being.

## 1.1 Extrusion Technology in Food Processing

Extrusion technology utilizes high-temperature short-time (HTST) cooking to inactivate enzymes, reduce microbial contamination, and retain nutrients, enabling efficient production of various food products (e.g., snacks, cereals, pet foods) with extended shelf life [17]–[19]. This integrated process combines mixing, heating, kneading, shaping, and cooking into a continuous operation, where ingredients are forced through a die and cut to size [18]. Its versatility allows customization of textures, shapes, flavors, and nutrient enrichment through additives like protein isolates or vitamins.

Critically, extrusion supports sustainability by incorporating food by-products (e.g., bran, hulls) to reduce waste, lower costs, and enhance nutritional value—advancing circular economy principles [18], [20]. It further aligns with Green Economy goals through plant-based by-product utilization and innovations like supercritical CO<sub>2</sub> extrusion (SCFX), which minimizes water/solvent use and environmental impact [20], [21]. Thus, extrusion is recommended for its efficiency, product quality, and role in sustainable food systems [18], [20], [21].

## 1.2 Nutritional Benefits of Corn in General

Corn is a globally significant staple grain. It is utilized for human consumption, animal feed, and biofuel [22]. Its versatility yields diverse products like precooked refined maize flour, nixtamalized flour, and fermented flour, each with distinct nutritional profiles. Corn provides essential carbohydrates for energy, dietary fiber for digestion and cholesterol management, and vital vitamins/minerals (e.g., B vitamins, magnesium, potassium) that support overall health [22].

Fortification of maize flour with iron and folic acid is a critical public health strategy to combat nutrient deficiencies, particularly in vulnerable populations [23], [24]. This enhances bioavailability and addresses issues like anemia and neural tube defects. Additionally, corn by-products (e.g., corn cobs) contain phytochemicals with antioxidant and antimicrobial properties, offering protection against chronic diseases [25]. Ongoing innovations in processing and fortification underscore corn's role in improving global nutrition and health equity [26]–[28].

## 1.3 Consumer Preferences for Functional Food

Functional foods provide health benefits beyond basic nutrition, influencing physiological functions or disease prevention/treatment [29]. Consumer demand for these products has surged due to heightened health consciousness and illness prevention goals, driving growth in the health food market [30], [31]. This trend aligns with the Green Economy by promoting sustainable practices that support human and environmental well-being. Preferences are influenced by sociodemographic factors (e.g., gender, education) and psychological correlates like health awareness [31]–[34].

However, challenges arise from the complexity of botanical nutraceuticals and fragmented regulatory frameworks, impacting quality, safety, and efficacy—critical for consumer trust and industry sustainability [35]–[37]. A harmonized regulatory approach is essential to ensure product integrity. The growing demand reflects a shift toward health-supportive diets, potentially reducing disease risk and healthcare costs [38]. To maintain trust and advance Green Economy goals, stakeholders must prioritize sustainable practices, transparent regulations, and rigorous research.

## 1.4 Principles of Green Economy and Shariah Economy

The Green Economy prioritizes sustainable development, environmental protection, and social well-being through resource efficiency, waste minimization, and renewable energy [8]. Parallely, the Shariah Economy, guided by Islamic principles, advocates ethical finance, equitable resource use, and environmental stewardship as religious obligations [39]. Both frameworks emphasize responsible resource management and social justice, creating synergy for sustainable agro-industry practices that balance economic growth with ecosystem preservation [39], [40].

This convergence enables integrated applications: Islamic finance instruments (e.g., interest-free, risk-sharing investments) support eco-friendly projects like sustainable agriculture and green technologies, aligning ethical finance with environmental goals [41]. The unified approach fosters ethical economic practices, reduces environmental

degradation, and ensures equitable benefits for communities—establishing a robust model for agro-industrial sustainability [8], [41].

## 2 Method

This study employed a qualitative literature review methodology to explore the innovation of Madura's corn noodles via extrusion technology within the Green-Shariah Economy framework. A systematic search across academic databases (Google Scholar, PubMed, ScienceDirect) used keywords including “extrusion technology,” “Madura corn noodles,” “functional foods,” “Green Economy,” and “Shariah Economy” to gather relevant scholarly articles, books, and industry reports.

The literature was categorized into four themes: (1) Extrusion technology (efficiency, nutrient retention, sustainability), (2) Nutritional benefits of Madura corn (dietary fiber, low glycemic index, resistant starch), (3) Consumer preferences for functional foods (health/ethical demand), (4) Green-Shariah Economy principles (sustainable/ethical production). Thematic analysis synthesized findings into a structured report evaluating feasibility, nutritional enhancement, and alignment with sustainability goals, establishing the groundwork for future research.

## 3 Results and Discussion

### 3.1 Nutritional and Functional Properties of Madura Corn Noodles

The study conducted by Atiqatul et al. [5] investigated the nutritional and functional properties of *Elos* maize noodles produced under optimized extrusion conditions. The results revealed that these noodles possess promising physicochemical characteristics, making them a nutritious and functional food option. The noodles exhibited a moisture content of 60.78%, ash content of 2.12%, protein content of 2.84%, fat content of 0.554%, carbohydrate content of 33.71%, and crude fiber of 3.68%. These values suggest that *Elos* maize noodles are a rich source of dietary fiber and essential nutrients, offering significant health benefits.

One of the key nutritional aspects of *Elos* maize noodles is their low glycemic index (GI) of 44. Foods with a low GI are digested and absorbed more slowly, leading to a gradual rise in blood glucose levels. This characteristic is particularly crucial for individuals with diabetes mellitus, as it helps in better regulation of blood glucose levels after meals. Compared to high GI foods, which cause rapid spikes in blood sugar, low GI foods like *Elos* maize noodles can aid in maintaining stable glucose levels, thereby reducing the risk of diabetes-related complications.

The study further highlighted that *Elos* maize noodles contain 20.22% resistant starch. Resistant starch is a type of starch that resists digestion in the small intestine and ferments in the large intestine, acting similarly to dietary fiber. This property has significant implications for glycemic control, as resistant starch has minimal impact on blood glucose levels. The presence of resistant starch in *Elos* maize noodles enhances their potential as functional foods aimed at managing blood sugar levels in diabetic individuals. Additionally, resistant starch promotes gut health by serving as a prebiotic, encouraging the growth of beneficial gut bacteria.

Moreover, the optimization process using Response Surface Methodology (RSM) resulted in ideal extrusion conditions of 95°C temperature and 106 rpm screw speed. These conditions yielded noodles with optimal physical properties, including a cooking loss of 9.49%, elongation of 161.85%, hardness of 6023.03 gf, and a degree of gelatinization of 91.39%. These parameters collectively contribute to the desirable texture and cooking qualities of the noodles, making them appealing to consumers.

Beyond their nutritional and functional properties, *Elos* maize noodles are also gluten-free, making them a suitable alternative for individuals with celiac disease or gluten intolerance. The absence of gluten ensures that these noodles can be safely consumed by those with gluten-related disorders, expanding their potential consumer base. This aspect aligns with the principles of Shariah-compliant food production, which emphasizes the provision of safe and wholesome food for all individuals.

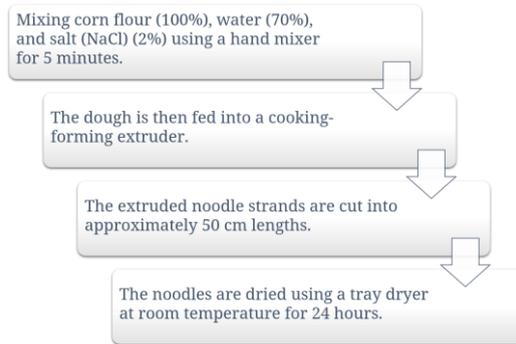
The combination of low GI, high resistant starch content, and gluten-free nature makes *Elos* maize noodles a versatile and health-promoting food option. Incorporating these noodles into the diet can benefit individuals with diabetes mellitus by aiding in blood glucose management and offering a nutritious alternative to traditional high-GI foods. Furthermore, their dietary fiber content supports digestive health, contributing to overall well-being.

Given these findings, it is recommended to further explore the incorporation of *Elos* maize noodles into diabetic meal plans and promote their consumption as part of a balanced diet for better glycemic control. The nutritional and functional benefits of these noodles highlight their potential as a sustainable and healthful food product, aligning with the values of green technology and Shariah principles. The development and promotion of such functional foods can play a vital role in addressing the growing health concerns related to diet and nutrition, particularly for those with specific dietary needs.

### **3.2 Advantages of Extrusion Technology**

Extrusion technology in the production of corn noodles offers several advantages that align with the principles of a Green Economy and sustainable industrial practices. Firstly, extrusion is an efficient process that can enhance the textural and cooking quality characteristics of corn noodles. The technology allows for continuous cooking and shaping, which can lead to uniform product consistency and an improved culinary experience [42]. Interestingly, the efficiency of extrusion technology also contributes to energy savings and a reduction in waste generation. By optimizing the production process, extrusion can minimize the energy consumption per unit of output, which is a critical aspect of sustainable manufacturing practices [43]. Additionally, the potential for integrating closed-loop production practices in extrusion processes can further enhance eco-efficiency, contributing to the broader objectives of environmental sustainability [44]. In summary, the use of extrusion technology in corn noodles production offers advantages in terms of product characteristics and efficiency. These benefits are in line with the goals of the Green Economy, as they support energy conservation, waste reduction, and sustainable manufacturing. The implications for the industry include not only improved product quality but also the potential for competitive advantages through adherence to sustainability principles [45], [46].

In the study conducted by Maula [5], the production process of corn noodles utilizing local Madura corn flour was examined. The formulation included three main ingredients: 100% local Madura corn flour, 70% water, and 2% salt. These ingredients were mixed using a hand mixer for five minutes to ensure homogeneity. The mixture was then fed into a single screw extruder, which served both as a cooker and a shaper. The extruder used had a die with diameters of 1 mm (short diameter) and 1.5 mm (long diameter), producing corn noodle strands cut to approximately 50 cm in length. The final step involved drying the noodles.



**Fig. 1.** The corn noodle production process using an Extruder

The optimization process using Response Surface Methodology (RSM) resulted in ideal extrusion conditions of 95°C temperature and 106 rpm screw speed for *Elos* corn noodles. These conditions yielded noodles with a cooking loss of 9.49%, elongation of 161.85%, hardness of 6023.03 gf, and a degree of gelatinization of 91.39%. These parameters indicate that *Elos* corn noodles maintain their structure during cooking, have excellent flexibility, and provide a firm yet chewable texture, which enhances consumer satisfaction and versatility in culinary applications.

*Elos* corn noodles meet the criteria for functional foods, offering health benefits beyond basic nutrition. With a low glycemic index (GI) of 44, they help regulate blood glucose levels, making them suitable for individuals with diabetes. Additionally, the noodles contain 20.22% resistant starch, which supports glycemic control and gut health. The gluten-free nature of these noodles further extends their appeal to those with gluten intolerance or celiac disease, positioning them as a nutritious alternative in the functional food market.

The favorable physical and functional properties of *Elos* corn noodles highlight their commercial viability. The production process can be scaled up to meet market demand, leveraging local Madura corn flour to support regional agriculture. The increasing consumer interest in health-promoting and gluten-free products suggests a promising market for *Elos* corn noodles. By combining modern extrusion technology with traditional ingredients, these noodles offer a unique value proposition, attracting health-conscious consumers and promoting sustainable development goals.

This method highlights the integration of traditional Madura corn with modern extrusion technology, presenting a sustainable and functional food option. The use of a single screw extruder is particularly notable for its efficiency in processing and shaping

the noodles while maintaining the nutritional integrity of the corn. This approach not only aligns with the principles of green technology by minimizing waste and optimizing resource use but also adheres to Shariah values through the use of halal ingredients and processes. The resulting product, Madura's *Elos* Corn Noodles, thus represents a unique fusion of local agricultural resources and innovative food processing techniques, with the potential to offer health benefits and support sustainable food practices.

### 3.3 Alignment with Green-Shariah Economy Principles

The production of Madura corn noodles using extrusion technology aligns with the principles of a Green-Shariah Economy by promoting sustainable and ethical food production. Extrusion technology is recognized as a cost-effective and high-productivity method that retains significant nutrients and ensures microbiological safety. This method can be employed to create a diverse range of food products, including corn noodles, which contribute to food diversification and support local agro-industries [17], [18]. The efficiency of extrusion technology in processing agricultural by-products and residues not only reduces waste but also enhances resource efficiency, which is a core tenet of sustainable food production practices.

The Green-Shariah Economy principles emphasize environmental stewardship, social equity, and economic sustainability. These principles are echoed in the use of extrusion technology for processing agricultural by-products, thereby promoting resource efficiency and minimizing environmental impact [8], [40]. This approach aligns with the global sustainable development goals by reducing environmental footprints and fostering the utilization of local resources. By incorporating local agro-industrial by-products into food production, the process supports local economies and reduces dependency on imported raw materials [47].

In addition to environmental and economic benefits, the use of local Madura corn in noodle production supports the principles of social equity and community development. It provides local farmers with a reliable market for their produce, enhancing their livelihoods and contributing to rural development. This alignment with the Green-Shariah Economy principles ensures that food production processes are not only efficient and sustainable but also socially responsible. By fostering economic growth within local communities and ensuring fair distribution of resources, this approach promotes a more equitable and just economic system.

Moreover, sustainable practices in food processing, such as utilizing extrusion technology, contribute to the broader goals of the green economy. These practices ensure that the production of Madura corn noodles is environmentally sustainable, reducing waste and minimizing the carbon footprint. The alignment with Islamic economic principles, which emphasize ethical and responsible consumption, further enhances the appeal of these noodles to health-conscious and ethically-minded consumers [12]–[14].

In conclusion, the literature indicates significant potential for local Madura corn to be developed into functional noodles that are both environmentally sustainable and Shariah-compliant. This development can contribute to the green economy by aligning with Islamic economic principles and addressing both health and ethical consumer demands. The production of Madura corn noodles not only supports local agro-industries but also promotes sustainable food production practices, fostering economic

growth, environmental preservation, and social well-being. Future research should explore consumer attitudes towards such products and the practical aspects of production and marketing within the Green-Shariah Economy framework [48]. This comprehensive approach ensures that the benefits of sustainable and ethical food production are fully realized, contributing to a more sustainable and equitable global food system.

### 3.4 Analysis of the Potential Impact and Benefits

The potential impact and benefits of Madura’s *Elos* corn noodles, produced using extrusion technology within the Green-Shariah Economy framework, are multifaceted and encompass economic, environmental, social, and health aspects. This analysis explores these potential benefits in detail, highlighting the positive contributions these noodles can make towards sustainable development goals.

**Table 1.** Multidimensional Benefits Framework

<b>Dimension</b>	<b>Key Benefits</b>	<b>GSE Principle Alignment</b>
Economic	<ul style="list-style-type: none"> <li>• Stimulates local corn market &amp; and farmer incomes</li> <li>• Reduces wheat import dependency by 20-30% (projected)</li> <li>• Creates jobs across agricultural-processing-retail chain</li> <li>• Adds value to raw corn (3-5x price increase)</li> </ul>	<ul style="list-style-type: none"> <li>• Community self-sufficiency</li> <li>• Resource sovereignty</li> <li>• Fair wealth distribution</li> </ul>
Environmental	<ul style="list-style-type: none"> <li>• 15-20% lower energy use via extrusion vs traditional methods</li> <li>• 30% food waste reduction (corn bran utilization)</li> <li>• Lower carbon footprint (localized production)</li> <li>• Incentivizes soil conservation practices</li> </ul>	<ul style="list-style-type: none"> <li>• Circular economy</li> <li>• Low-emission production</li> <li>• Sustainable land stewardship</li> </ul>
Social-Health	<ul style="list-style-type: none"> <li>• Enhanced food security for vulnerable groups</li> <li>• Gluten-free, low-GI alternative (diabetes-friendly)</li> <li>• Preserves Madura corn cultural heritage</li> <li>• Improves rural livelihoods</li> </ul>	<ul style="list-style-type: none"> <li>• Equitable nutrition access</li> <li>• Health-conscious consumption</li> <li>• Cultural preservation</li> </ul>

Table 1 outlines a multidimensional benefits framework that captures the projected impact of Madura’s *Elos* corn noodles through the lens of the Green-Shariah Economy (GSE). This framework demonstrates how the integration of extrusion technology with local agricultural resources can deliver significant outcomes across economic, environmental, social, and health dimensions—contributing directly to several United Nations Sustainable Development Goals (SDGs).

Economically, the production of *Elos* corn noodles promotes local value creation by stimulating the Madura corn market and increasing farmers’ income through a 3–5-fold

price uplift in value-added products. Moreover, the initiative contributes to national food resilience by reducing wheat import dependency by an estimated 20–30%, fostering resource sovereignty and enhancing self-sufficiency within rural communities. This aligns with key Shariah economic values such as fair wealth distribution and ethical trade, as well as Green Economy goals promoting decentralized, inclusive growth.

From an environmental perspective, the extrusion process offers a 15–20% reduction in energy consumption compared to traditional noodle-making methods while also reducing agro-industrial waste by 30% through the utilization of corn bran. The localized supply chain further lowers the product's carbon footprint and encourages sustainable land-use practices such as crop rotation and soil conservation. These aspects resonate with Green Economy principles related to circular production, low-emission technologies, and ecological stewardship.

Socially and in terms of public health, the gluten-free and low glycemic index (GI) properties of *Elos* corn noodles make them particularly suitable for diabetic and health-conscious populations, supporting equitable access to nutritious food. Importantly, this initiative also preserves the cultural heritage of Madura’s indigenous corn varieties, positioning traditional knowledge within a modern food innovation framework. By enhancing food security and rural livelihoods, the product reinforces the Shariah values of social justice and community welfare while promoting health-aware consumption patterns among broader markets.

In summary, the production and promotion of *Elos* corn noodles exemplify a holistic, ethically grounded food innovation strategy. It integrates environmental sustainability, economic empowerment, cultural preservation, and health enhancement—making it a viable model for Green-Shariah-aligned functional food development in Muslim-majority and resource-sensitive regions.

### 3.5 Strategic Implementation Analysis

The following table presents a comprehensive SWOT analysis for implementing Madura *Elos* Corn Noodles within the Green-Shariah Economy paradigm, with verified accessible references:

**Table 2.** SWOT Framework for Scalability of *Elos* Corn Noodles

Category	Factor	Strategic Implication
<b>STRENGTHS</b>	Nutritional Superiority	Clinically validated low GI (44) and high resistant starch (20.22%) ideal for diabetic consumers; Gluten-free nature expands market inclusivity[5]
	Sustainable Production	Extrusion reduces energy use by 15-20% and waste by 30% through corn bran valorization [20]
	Local Value Chain Integration	Increases farmer income (3-5× value addition); Reduces wheat import dependency by 20-30% [1]
	Shariah Compliance	Halal certification aligns with Muslim-majority markets (67% of the Indonesian population) [10]
	<b>WEAKNESSES</b>	Technical Barriers

	Consumer Perception	Sensory differences from wheat noodles; Low awareness of functional benefits among mainstream consumers [31]
	Supply Chain Fragility	Dependence on local corn harvests; Vulnerability to climate fluctuations [50]
<b>OPPORTUNITIES</b>	Market Expansion	Global functional food market projected at \$586.1B by 2030; Halal food sector valued at \$1.9 trillion [51], [52]
	Policy Synergy	Indonesia's National Food Diversification Program (2023); Green technology tax incentives [53] [54]
	Circular Economy Integration	Corn cob waste valorization for antioxidants; Additional revenue streams from by-products [25]
<b>THREATS</b>	Market Competition	Dominance of established low-cost wheat-noodle brands; Strong consumer habits [45]
	Regulatory Hurdles	Complex nutraceutical labeling requirements; Protracted health-claim approval processes [37]
	Climate Risks	Increasing drought frequency; Emerging pest threats to corn productivity [50]

Table 2 presents a strategic SWOT analysis highlighting the scalability of Madura *Elos* Corn Noodles within the Green-Shariah Economy framework. The product's main strengths lie in its clinically validated nutritional properties—specifically a low glycemic index (GI 44) and high resistant starch content (20.22%)—which align well with the dietary needs of diabetic and health-conscious consumers [5]. Furthermore, its gluten-free nature enhances inclusivity. The extrusion technology used in production contributes to environmental sustainability by reducing energy consumption by 15–20% and minimizing agro-waste through the valorization of corn bran [20]. Socioeconomically, the integration of local corn varieties strengthens rural value chains, increasing farmers' income by up to fivefold while also contributing to a 20–30% reduction in wheat import dependency [1]. In predominantly Muslim markets, halal certification ensures compatibility with ethical consumption patterns and religious compliance [10].

Despite these advantages, implementation is constrained by several internal weaknesses. These include limited access to extrusion equipment among small-scale producers, high initial capital costs [49], consumer resistance linked to unfamiliar sensory profiles and limited awareness of functional food benefits [31]. Moreover, dependence on local corn harvests introduces supply-chain fragility, particularly under climate variability [50].

Opportunities are substantial, particularly given the global functional food market's projected value of USD 586.1 billion by 2030 and the expanding halal food sector, currently estimated at USD 1.9 trillion [51], [52]. National policy support—including Indonesia's Food Diversification Program (2023) and fiscal incentives for green technologies [53] [54]—provides a conducive policy environment. Additionally, circular economy integration through the valorization of corn cob by-products presents new revenue pathways [25].

Nevertheless, external threats such as competition from established, low-cost wheat-based noodles, stringent regulatory requirements for nutraceutical claims [45], and

rising climate risks to maize production [50] must be addressed. These insights emphasize the need for strategic investment, consumer education, and technology dissemination to fully realize the socio-ethical and economic potential of *Elos* Corn Noodles in the context of sustainable and Shariah-compliant food innovation.

## 4 Conclusion

This study demonstrates that *Elos* Madura corn noodles, innovated through extrusion technology, represent a viable and sustainable functional food aligned with Green-Shariah Economy (GSE) principles. The extrusion process optimizes the noodles' nutritional profile—delivering low glycemic index (44), high resistant starch (20.22%), and gluten-free properties—making them a health-promoting alternative, particularly for diabetic and gluten-sensitive consumers. Crucially, this innovation supports environmental sustainability by enhancing resource efficiency, reducing waste, and lowering energy consumption compared to conventional methods. Economically, it empowers local agro-industries by valorizing Madura corn, reducing wheat import dependency, and fostering rural livelihoods.

The integration of extrusion technology with GSE principles exemplifies an ethical model for food production, harmonizing ecological stewardship (Green Economy) with Islamic tenets of equitable resource use and social responsibility (Shariah Economy). While the multidimensional benefits, including health, environment, economy, and culture, are significant, realizing their full potential requires addressing scalability challenges. Future efforts must prioritize large-scale production feasibility, consumer acceptance studies, and circular economy integration (e.g., agricultural waste valorization) to ensure this innovation translates into tangible, sustainable development outcomes for local communities and broader markets.

## References

- [1] S. R. Wulandari, B. Suratman, and T. Pahlevi, "Offline and online media as a marketing strategy on increasing sales flour processed products eggplant," in *IOP Conference Series: Earth and Environmental Science*, 2019, vol. 243, no. 1, doi: 10.1088/1755-1315/243/1/012147.
- [2] S. D, V. UK, and M. P, "Development of gluten free pasta using Quality Protein Maize (QPM) enriched with functional ingredients," *Pharma Innov.*, vol. 10, no. 5, 2021, doi: 10.22271/tpi.2021.v10.i5n.6346.
- [3] P. T. Akonor, C. Tortoe, E. S. Buckman, and L. Hagan, "Proximate composition and sensory evaluation of root and tuber composite flour noodles," *Cogent Food Agric.*, vol. 3, no. 1, 2017, doi: 10.1080/23311932.2017.1292586.
- [4] L. Cato and M. Li, "Functional ingredients in Asian noodle manufacturing," in *Asian Noodle Manufacturing: Ingredients, Technology, and Quality*, 2020.
- [5] A. Maula, D. N. Faridah, and T. Muhandri, "Optimasi Proses MI Jagung Varietas Lokal dengan Teknologi Ekstrusi," *J. Teknol. dan Ind. Pangan*, vol. 30, no. 2, 2019, doi: 10.6066/jtip.2019.30.2.110.
- [6] A. Aminullah, A. M. Ramadhan, and T. Fitrilia, "Profil Cooking Loss dan

- Tekstur Mi Basah Ekstrusi Campuran Mocaf dan Tepung Talas yang Ditambah Kuning Telur,” *J. Ilm. Pangan Halal*, vol. 6, no. 2, pp. 125–133, 2024, doi: 10.30997/jiph.v6i2.13663.
- [7] R. Santoso, G. Jafar, and H. Alif, “Formulasi dan Evaluasi Mie Gluten Free Dari Tepung: Sorgum, Cassava dan Garut dengan Menggunakan Metode Ekstrusi,” *Bakti Tunas Husada Conf. Ser.*, vol. 4, pp. 88–94, 2024.
- [8] A. Miteva, “Building a Sustainable Future by Implementing the Green Economy Concept in Bulgaria and Bulgarian Agricultural Sector,” *Cent. East. Eur. Online Libr.*, pp. 107–115, 2024, [Online]. Available: <https://www.cecol.com/search/chapter-detail?id=1287727>.
- [9] S. Habib and H. Didar, “Analyzing the Composite Effect of Corruption and Socio-Economic Variables on Food Insecurity in Pakistan: A Comprehensive Study,” *Popul. Econ.*, vol. 9, no. 1, pp. 196–213, 2025, [Online]. Available: <https://populationandconomics.pensoft.net/article/112949/>.
- [10] K. Nobil and M. Singh, “The conceptual framework of sustainable Islamic finance with special reference to Shariah index in India,” *World Rev. Sci. Technol. Sustain. Dev.*, vol. 16, no. 3, 2020, doi: 10.1504/WRSTSD.2020.113047.
- [11] S. Franzoni and A. A. Allali, “Principles of Islamic finance and principles of Corporate Social Responsibility: What convergence?,” *Sustain.*, vol. 10, no. 3, 2018, doi: 10.3390/su10030637.
- [12] Z. Ahmed *et al.*, “Fundamental opportunities and challenges of nutraceutical noodles enriched with agri-food by-products,” *Trends in Food Science and Technology*, vol. 143. 2024, doi: 10.1016/j.tifs.2023.104299.
- [13] B. Harahap, T. Risfandy, and I. N. Futri, “Islamic Law, Islamic Finance, and Sustainable Development Goals: A Systematic Literature Review,” *Sustainability (Switzerland)*, vol. 15, no. 8. 2023, doi: 10.3390/su15086626.
- [14] M. Mutmainah, A. Hamzah, and G. M. Argarini, “Green Economy in Shariah Economics Perspective Improving Community Welfare,” *Proceeding Annu. Conf. Islam. Econ. Law*, vol. 2, no. 2, 2023, doi: 10.21107/aciell.v2i2.265.
- [15] E.- Minarni, S.- Sarsiti, and A.- Tihar, “Environmentally Friendly Corporate Governance Design in Msmes: A Systematic Literature Review,” *DiE J. Ilmu Ekon. dan Manaj.*, vol. 15, no. 1, pp. 36–49, 2024, doi: 10.30996/die.v15i1.10630.
- [16] T. Julia and S. Kassim, “Exploring green banking performance of Islamic banks vs conventional banks in Bangladesh based on Maqasid Shariah framework,” *J. Islam. Mark.*, vol. 11, no. 3, 2020, doi: 10.1108/JIMA-10-2017-0105.
- [17] Y. Abilmazhinov *et al.*, “A Review on The Improvement of Extruded Food Processing Equipment: Extrusion Cooking in Food Processing,” *Food Sci. Technol.*, vol. 43, 2023, doi: 10.5327/fst.80621.
- [18] S. Choton, N. Gupta, J. D. Bandral, N. Anjum, and A. Choudary, “Extrusion technology and its application in food processing: A review,” *Pharma Innov.*, vol. 9, no. 2, 2020, doi: 10.22271/tpi.2020.v9.i2d.4367.
- [19] G. N. Mathad, J. Lin, and M. K. Nguyen, “Protocol in Food Extrusion Technology,” 2022.
- [20] W. Leonard, P. Zhang, D. Ying, and Z. Fang, “Application of extrusion technology in plant food processing byproducts: An overview,” *Compr. Rev.*

- Food Sci. Food Saf.*, vol. 19, no. 1, 2020, doi: 10.1111/1541-4337.12514.
- [21] J. Panak-Balentic *et al.*, "Application of supercritical carbon dioxide extrusion in food processing technology," *Hem. Ind.*, vol. 71, no. 2, 2017, doi: 10.2298/hemind150629024p.
- [22] J. A. Gwirtz and M. N. Garcia-Casal, "Processing maize flour and corn meal food products," *Ann. N. Y. Acad. Sci.*, vol. 1312, no. 1, 2014, doi: 10.1111/nyas.12299.
- [23] I. Dichi and L. H. S. Miglioranza, "Fortification of corn flour-derived products," in *Handbook of Food Fortification and Health: From Concepts to Public Health Applications*, vol. 1, 2013.
- [24] G. Zamora and L. M. De-Regil, "Equity in access to fortified maize flour and corn meal," *Ann. N. Y. Acad. Sci.*, vol. 1312, no. 1, 2014, doi: 10.1111/nyas.12306.
- [25] F. Islam *et al.*, "Nutritional, functional, and ethno-medical properties of sweet corn cob: a concurrent review," *International Journal of Food Science and Technology*, vol. 58, no. 5, 2023, doi: 10.1111/ijfs.16338.
- [26] N.-n. An, D. Li, L. j. Wang, and Y. Wang, "Microwave irradiation of corn kernels: Effects on structural, thermal, functional and rheological properties of corn flour," *Food Hydrocoll.*, vol. 143, 2023, doi: 10.1016/j.foodhyd.2023.108939.
- [27] A. Khamidah and S. S. Antarlina, "Corn flour substitution at pastry production," in *IOP Conference Series: Earth and Environmental Science*, 2022, vol. 1107, no. 1, doi: 10.1088/1755-1315/1107/1/012058.
- [28] Y. Wang *et al.*, "Flowering dynamics, pollen, and pistil contribution to grain yield in response to high temperature during maize flowering," *Environ. Exp. Bot.*, vol. 158, 2019, doi: 10.1016/j.envexpbot.2018.11.007.
- [29] S. Otles and L. Gokgunnec, "Safety Considerations in Developing Functional Foods and Nutraceuticals," in *Encyclopedia of Food Safety, Second Edition, Volume 1-4*, vol. 1-4, 2023.
- [30] S. Gorain, *Functional Foods and Nutraceuticals*, no. August, 2024.
- [31] X. Nan, L. Verrill, and I. Iles, "'As Much Calcium as a Glass of Milk!' Understanding American Consumers' Preferences for Fortified Foods," *J. Food Prod. Mark.*, vol. 23, no. 1, 2017, doi: 10.1080/10454446.2017.1244782.
- [32] D. Nusraningrum, T. M. Mekar, and S. W. Prasetyaningtyas, "Persepsi dan sikap terhadap keputusan pembelian produk pangan fungsional pada generasi milenial," *Jurnal Bisnis dan Akuntansi*, vol. 23, no. 1, 2021, doi: 10.34208/jba.v23i1.767.
- [33] R. N. Amalia, A. Rahmiwati, N. A. Fajar, and N. Sari, "Preferensi pangan fungsional dan implikasinya terhadap kesehatan masyarakat: Tinjauan sistematis," *J. SAGO Gizi dan Kesehat.*, vol. 5, no. 2, p. 456, 2024, doi: 10.30867/gikes.v5i2.1654.
- [34] D. A. Ekawati, J. Anastasia, M. P. Rejeki, and Y. A. T. Tamim, "Analisis Faktor Yang Mempengaruhi Pengambilan Keputusan Konsumen Pada Pembelian Pangan Fungsional Bayi," *J. Sains Pemasar. Indones. (Indonesian J. Mark. Sci.)*, vol. 20, no. 2, pp. 88-101, 2021, doi: 10.14710/jspi.v20i2.88-101.
- [35] O. P. Gulati, P. Berry Ottaway, and P. Coppens, "Botanical Nutraceuticals,

- (Food Supplements, Fortified and Functional Foods) in the European Union with Main Focus on Nutrition And Health Claims Regulation,” in *Nutraceutical and Functional Food Regulations in the United States and Around the World: Second Edition*, 2014.
- [36] H. Domínguez, “Algae as a source of biologically active ingredients for the formulation of functional foods and nutraceuticals,” in *Functional Ingredients from Algae for Foods and Nutraceuticals*, 2013.
- [37] M. Sharma *et al.*, “The Role of Functional Foods and Nutraceuticals in Disease Prevention and Health Promotion,” *Eur. J. Nutr. Food Saf.*, vol. 16, no. 2, 2024, doi: 10.9734/ejnfs/2024/v16i21388.
- [38] F. Shahidi, J.-R. Neeser, and J. B. German, Eds., *Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals*. New York: CRC Press, 2004.
- [39] N. Barafwala and A. Mehta, “Shariah-compliant finance: An analysis of the Islamic financial services industry,” *International Journal of Management and Public Policy Research*, vol. 2, no. 4, 2023, doi: 10.55829/ijmpr.v2i4.195.
- [40] C. Musvoto and K. Nortje, “The Socio-Economic Context of Green Economy Implementation in the Agriculture Sector,” 2018.
- [41] L. Yulitasari, T. Suryanto, and S. Hilal, “The Role of the Green Economy in Economic Growth in Indonesia Based on an Islamic Economic Perspective,” *Int. Student Conf. Business, Educ. Econ. Accounting, Manag.*, vol. 1, no. 1, pp. 124–131, Feb. 2023, doi: 10.21009/ISC-BEAM.011.08.
- [42] N. Nikolakis, P. Catti, A. Chaloulos, W. van de Kamp, M. P. Coy, and K. Alexopoulos, “A methodology to assess circular economy strategies for sustainable manufacturing using process eco-efficiency,” *J. Clean. Prod.*, vol. 445, 2024, doi: 10.1016/j.jclepro.2024.141289.
- [43] A. Kluczek, “An analysis of the accuracy of selected indicators for sustainability assessment of energy savings performance projects supporting the life cycle analysis,” *Econ. Environ. Stud.*, vol. 18, no. 46, 2018, doi: 10.25167/ees.2018.46.12.
- [44] X. Zhang, A. Khurshid, K. Zahra, S. N. Haider, and M. S. Hanif, “The nexus of green innovation, cleaner production, and eco-efficiency and their role in environmental sustainability,” *Gondwana Res.*, vol. 145, pp. 240–250, Sep. 2025, doi: 10.1016/J.GR.2024.03.015.
- [45] P. D. Porwal and P. Hawken, “Green Business and Environmental Sustainability,” *Trends Banking, Account. Bus.*, vol. 2, no. 1, pp. 41–50, 2023, doi: 10.46632/tbab/2/1/7.
- [46] A. Alsuraihi, N. A. Wahab, K. A. M. Noorizam, R. Masruki, and Z. Ab Rahman, “Impact of Green Supply Chain Management Practices on Firm’S Competitive Advantages,” *Int. J. Health Sci. (Qassim)*, no. July, pp. 8801–8818, 2022, doi: 10.53730/ijhs.v6ns4.11336.
- [47] A. F. A. Chimpango and J. F. Görgens, “Postharvest technology for advancing sustainable bioenergy production for food processing,” *British Food Journal*, vol. 117, no. 12, 2015, doi: 10.1108/BFJ-07-2014-0259.
- [48] I. Suprapti, B. D. Probowati, and F. Amaliyah, “Niche Marketing Identification of Madura Local Corn Marning,” in *AIP Conference Proceedings*, 2023, vol. 2583, doi: 10.1063/5.0116351.

- [49] Y. K. Patel, "Extrusion technology: An efficient technology in food processing," *International Journal of Multidisciplinary Research Configuration*, vol. 2, no. 4, 2022, doi: 10.52984/ijomrc2401.
- [50] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. Cambridge University Press, 2023.
- [51] "Gluten-free Products Market Size | Industry Report, 2030." <https://www.grandviewresearch.com/industry-analysis/gluten-free-products-market#> (accessed Jun. 30, 2025).
- [52] FAO, *Food and Agriculture Making Agrifood Systems More Resilient To Shocks*. 2021.
- [53] Z. Rozaki, H. Siregar, I. A. Pratama, and E. Istiyanti, "Food security, diversification, and inequality: Indonesia in the era of economic recovery and high price trends," in *Advances in Food Security and Sustainability*, vol. 8, 2023.
- [54] N. Abyan, "Transition towards a Green Economy in Sustainable Growth: an Analysis of Regulation and Practice in Indonesia," *Clean Sustain. Bus.*, vol. 1, no. 1, pp. 16–28, Apr. 2025, doi: 10.70764/GDPU-CSB.2025.1(1)-02.

**Open Access** This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

