IMPROVING AFFORDABILITY OF NUTRITIOUS FOODS THROUGH PACKAGING INNOVATIONS

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SUMMARY

Packaging can keep foods safe; help make them appealing, convenient, and long-lasting; and convey key information about them to consumers. At the same time, packaging is an important contributor to food system waste and a major driver of certain foods' prices in LMICs. As such, it is a sector ripe for creative disruption as part of food system transformation – to ensure safe, nutritious foods can reach the consumers who need them, in affordable forms and with limited negative environmental impact. This paper has considered in detail three packaging innovations that could be used to make nutritious foods more accessible to lower-income consumers: single-serve packaging, reusable packaging, and selling products in bulk without individual packaging.

Based on a rapid literature review, case studies, analysis of market data, and interviews with key informants, we explore different types of packaging associated with each solution (e.g., plastics, glass, paper, metal). We consider the associated packaging functionality required, costs, food safety aspects, environmental sustainability, consumer perceptions, and supply chain logistics. The focus is on particularly representative types of nutritious foods (dairy products, fortified flours and other dry foods, snacks, cooking oil, and pre-cooked meals) and on low- and middle-income countries, drawing particularly on cases and data from Kenya, Tanzania, Uganda and Bangladesh. The results show advantages and disadvantages to each option but suggest that each has situations (i.e., specific foods and contexts) for which it is promising, with bulk sales emerging as a particularly strong option.

KEY MESSAGES

- Packaging is a major driver of the cost of packaged foods in low- and middle-income countries, making it a high-potential area for innovations to increase lower-income consumers' access to nutritious foods.
- Through a rapid review and key informant interviews, we explore three different packaging-related solutions that have been proposed for better reaching lower-income consumers: single-serve packaging, reusable packaging, and selling products in bulk without individual packaging.
- The appropriateness of a given packaging solution depends on the product and context considered, and we find advantages and disadvantages to each.
- On balance, bulk sales have strong cost and environmental sustainability advantages and thus high potential—if food safety and quality challenges are properly managed.
- There is a need for more research on packaging innovations for nutritious foods in low- and middle-income countries and their varying impacts.

BACKGROUND AND OBJECTIVE

While the foundation of good nutrition is consuming a healthy diet (1), poor diets are common throughout the world, with dietary risks responsible for an estimated 22% of global deaths (2). This is particularly true in low- and middle-income countries (LMICs). For example, in many countries in Africa and South and Southeast Asia, over 70% of the population does not consume the five commonly recommended food groups on a typical day (3,4). Diet quality is particularly poor for those living on lower incomes (5–9).

Improving diet quality among lower-income consumers requires that they have access to safe, nutritious foods in desirable forms and at affordable prices. This is currently a challenge, with almost 3 billion people worldwide being unable to afford a healthy diet (4,10). Because most consumers (even in rural, agricultural areas) purchase most of their food, markets and private-sector companies play a key role in shaping food availability and affordability (11–13). Where viable business models and products can be identified, private companies could help to improve diet quality by providing safe, nutritious foods that meet customers' needs at an affordable price – as long as they do so in ways that are profitable and financially sustainable for the company. GAIN's Business Model Research Project thus aims to identify promising ways that food companies can adopt their products and approaches to reach lower-income consumers with nutritious foods.

An earlier systematic review conducted by the project (14) revealed that innovating in terms of packaging could be a high-potential way to do this, since packaging can be a considerable driver of product costs. Specifically, potential approaches include single-serve packaging (which enables consumers to purchase only a small amount at a time), using reusable packaging (e.g., glass bottles that are collected, cleaned, and reused by the retailer, distributor, or processor), or removing packaging altogether by selling foods in bulk (e.g., through dispensers or similar). The first option may improve affordability in the sense that only a small amount can be purchased at one time, though the per-unit price may be higher when compared to a larger package. The second option may improve affordability by reducing the costs of packaging, and the third option by eliminating them altogether.

To build on that work, this paper presents the results of a rapid analysis undertaken to better understand the implications of these different packaging approaches, as applied to nutritious foods in LMICs. We consider the types of products to which such approaches can be applied, their costs, environmental considerations, health and food safety aspects, and consumer acceptability, as well as which specific types of packaging materials and well suited to each application.

METHODOLOGY

This paper's analysis is based on a rapid literature review, analysis of market data, and interviews with informants at food companies. We focused the analysis on the three packaging solutions discusses in the aforementioned systematic review (14): single-serve packaging, reusable packaging, or selling products in bulk without individual packaging. They are summarised in Box 1.

BOX 1. PACKAGING OPTIONS EXAMINED IN THIS PAPER

Single-serve packaging responds to lower-income consumers' limited cash on hand by selling a small quantity of a product at a lower price than the normal package size. In addition to enabling purchase despite very low or variable levels of income, it can have other advantages for consumers: allowing for experimentation, enabling purchase of a greater variety of products, enabling purchase of products requiring refrigeration or freezing for people who lack a refrigerator/freezer, improving convenience, helping to limit household consumption, and taking less storage space (15,16). For firms, single-serve packages can expand reach to a new demographic group, lure new customers and enable brand-switching, help promote the brand, avoid increasing prices when the price of raw materials increases, and allow for making a lower-cost version available without diluting the brand's image (15–17). The approach is widespread: in India, for example, as of 2002 30% of personal care products and similar consumable goods (e.g., tea, shampoo), were sold in single-serve packaging (15), and major multinationals Nestlé and Unilever have large product lines using single-serve packaging.

Selling products in bulk, without individual packaging, is commonly used worldwide in both traditional and formal retail outlets and usually entails the use of large containers or dispensers. Where packaging is needed, some may be provided in the store (e.g., small bags) or it may be provided by the consumer. The approach can be used for grains, flours, dried legumes, seeds, nuts, oil, sugar, milk, and many other foods. For some foods (e.g., fruits and vegetables), this is the default way of selling the product in most LMICs and some high-income countries. For others (e.g., milk, oil), these foods are typically sold in packaged formats and selling in bulk can be considered an innovation. It is this latter group that we focus on here. The approach can have advantages of reducing or removing packaging costs and enabling purchase of small amounts at a time; it is estimated that such models can make products 30-50% cheaper than branded packaged goods (18).

Reusable packaging can both cut packaging costs and help reduce packaging waste. The reuse can be at the level of the consumer (i.e., cleaning one's own container and bringing it to the store) or the processor, distributor, or retailer (i.e., having empty containers sent back from retailers to the processing plant for cleaning and reuse). The former option we cover under 'bulk purchasing'. In the latter case, the empty containers can either be returned by users to a drop-off point (such as a local kiosk) or picked up from consumers' homes. According to a 2022 McKinsey report, six product segments are most prime for use of reusable packaging[1]: packaged food (dry products such as rice, flour, pasta); beverages (including existing deposit-and-return systems for reusable glass bottles); home care (e.g., detergents); retail secondary packaging/transport packaging (e.g., reusable crates for wholesale vegetable packaging); food service (food-standard containers for take-away meals); and e-commerce packaging (used in the delivery of online purchases by customers) (19,20)

We focused primarily on four LMICs (Kenya, Tanzania, Uganda, and Bangladesh) but also included insights from Indonesia, India, and Burkina Faso, as well as from the EU (and specifically Sweden) and UK, to enrich the analysis.

Literature was identified through a systematic but non-exhaustive search focusing on terms related to packaging, logistics, sustainability, and consumer preferences, as well as specific focus countries and packaging types. Sources were selected based on their relevance to the target geographies and research topic, recent publication dates, and perceived rigour; they included peer-reviewed papers, industry reports, news articles, and trade publications. Table 1 summarises the food companies from which key informants were interviewed. The companies were part of the network of Inclusive Business Partners, GAIN's partner for this study, or former project partners. They were chosen based on their geographic location, food products, and availability for interviews.

Table 1. Companies and sectors in company which representatives were interviewed

Company Country	Company Focus Food(s)
Kenya	Orange-fleshed sweet potato-based products
Uganda	Pre-cooked beans
Uganda	Porridge flour, peanut butter and honey
Uganda	Snacks (ginger, honey, mint, and coconut toffees)
Ethiopia	Granola and oat flakes
Sweden	Whole grain flour and food products
Sweden/ Burkina Faso	Hibiscus tea/drinks

Synthesising data from all these sources, we explored packaging material suitability and functionality, packaging costs, food safety implications, environmental implications, consumer perceptions, and supply chain logistics. Before delving into these topics in detail, the next section provides an overview of food packaging more broadly.

FOOD PACKAGING: AN OVERVIEW

Food packaging serves to contain food and protect it from contamination and damage (21). It can extend shelf life, be used to provide consumers with information (e.g., on ingredients and nutritional value, certifications, and cooking and serving recommendations), make products more appealing through branding, improve traceability, enhance convenience, facilitate certain types of processing, and prevent tampering. At the same time, food packaging, particularly plastic packaging, yields considerable waste and environmental damage (22); food packaging accounts for about two-thirds of packaging waste by volume [U.S. estimate, from 1990] (21). It can also encourage the production and marketing of unhealthy foods, such as ultraprocessed foods, and contaminate food with chemicals (23). Food packaging is a major industry, worth $456 billion and projected to increase by over 60% by 2030 (24).

Ideal food packaging thus needs to contain food in a cost-effective way while maintaining food safety, satisfying business requirements, meeting consumer preferences, and minimising environmental impact. However, companies based in LMICs often face additional challenges with regards to limited availability of packaging materials and equipment, with reliance on imports being common: poor quality of available packaging materials; high prices of quality packaging materials; limited knowledge of packaging technologies, product standards, and certification; and little investment in packaging systems.

Most countries have some regulations on which packaging materials can be used for food. The main food packaging materials are glass, metals, paper, and plastics, or composites of these (21). While there is a growing interest in sustainable and biodegradable options, the transition is slow due to economic constraints and the need for better waste management systems. Traditional and informal food systems may also use materials such as banana leaves, maize husks, or wooden or ceramic vessels, but these are rarely used at scale or by formal companies. Table 2 summarises the different materials available in most LMICs.

Table 2. Summary of main packaging materials used for food in LMICs

Type	Properties	Example uses	Status in LMICs
Plastic			
Polyethylene Terephthalate (PET)	Lightweight, strong, transparent, recyclable	Bottles for soft drinks, water, salad dressings, peanut butter jars	Widely used due to durability and recyclability; lack of recycling infrastructure can lead to environmental issues
High-Density Polyethylene (HDPE)	Stiff, strong, moisture and chemical resistant	Milk jugs, juice bottles, yogurt containers, grocery bags	Preferred for strength and reusability; improper disposal contributes to pollution
Low-Density Polyethylene (LDPE)	Flexible, tough, resistant to acids and bases	Bread bags, frozen food bags, squeezable bottles	Popular for flexibility; often not recycled due to limited facilities
Polypropylene (PP)	Tough, heat resistant, moisture and grease barrier	Yogurt containers, straws, bottle caps, microwavable containers	Used for durability and versatility; often ends up in landfills
Polystyrene (PS)	Lightweight, insulating, can be rigid or foamed	Disposable coffee cups, food boxes, cutlery, egg cartons	Widely used in street food packaging; significant waste due to non-biodegradability
Polyvinyl Chloride (PVC)	Strong, oil and chemical resistant, flexible	Cling film, shrink wraps, some bottles	Commonly used for flexibility; rising concerns about toxicity and environmental impact
Glass			
Glass	Non-porous, impermeable, inert, recyclable, transparent	Jars for baby food, pickles, sauces, beverage bottles	Less commonly used due to weight and cost; valued for long-term storage and reusability when available
Metal			
Aluminium	Lightweight, strong, heat conductive, corrosion resistant, recyclable	Beverage cans, foil wraps, trays	Widely used for drinks and food storage; valued for recyclability, though recycling rates are often low
Tinplate	Thin steel coated with tin, strong, corrosion resistant	Cans for soups, vegetables, other food products	Essential for preserving foods; can be expensive and less accessible

Steel	Strong, durable, often coated to prevent rust	Food cans, bottle caps	Used for strength; more expensive and less common than alternatives
Paper			
Kraft Paper	Strong, durable, biodegradable	Grocery bags, wrapping paper	Widely used for dry food packaging; durability can be an issue in humid climates
Corrugated Cardboard	Lightweight, strong, good cushioning	Shipping boxes, pizza boxes	Common for transport packaging; valued for protection during shipping; often not recycled
Paperboard	Lightweight, printable surface, can be laminated for moisture resistance	Cereal boxes, milk cartons, snack packaging	Widely used for affordability and printability for branding; lacks proper recycling channels
Composite			
Tetrapak (aseptic packaging using paperboard, LDPE, and aluminium foil)	Combines paperboard, plastic, and aluminium; lightweight, strong, barrier to light and oxygen	Juice cartons, milk cartons	Essential for long shelf life of liquids; difficult to recycle due to mixed materials
Laminated Films	Multiple layers of different materials (plastic, aluminium, paper)	Snack bags, coffee pouches, vacuum-sealed packaging	Popular for food preservation; recycling is a challenge due to composite nature
Biodegradable / Compostable			
Polylactic Acid (PLA)	Made from fermented plant starch (usually corn), compostable, similar to PET	Clear food containers, cold drink cups, cutlery	Increasingly used as eco-friendly alternative; composting facilities are limited
Starch-Based Materials	Derived from corn, potatoes, or other plants, biodegradable, compostable	Packaging peanuts, compostable bags, food service items like plates and cutlery	Seen as sustainable; higher costs and limited composting infrastructure hinder widespread adoption

Of note, the table focuses on food packaging materials without specifying whether bisphenol A (BPA) is used in them. BPA can leach from containers into food and drink, and could have negative health consequences, particularly as an endocrine disruptor. BPA is commonly associated with polycarbonate plastics, including water bottles and food storage containers, as well as epoxy resins used as coatings inside food and beverage cans to prevent corrosion and contamination. Its use in packaging was recently banned by the European Union, but it remains legal in many LMICs. To avoid BPA, consumers and manufacturers are increasingly opting for BPA-free alternatives, including other types of plastics like polypropylene (PP) and polyethylene (PE), and alternative container linings.

While all these materials are used for food packaging, not all of them are appropriate for nutritious foods or for the packaging innovations considered here. Table 3 thus summarises the most relevant types of packaging material to be used for specific nutritious food products, by the three types of potentially affordability-enhancing packaging innovations.

Table 3. Packaging materials of greatest relevance to nutritious foods and the focus packaging innovations

Food Product	Material	Uses	Advantages
Single-Serve Packaging			
Dairy Products	PP	Yogurt containers, milk bottles	Lightweight, good barrier properties, recyclable
Dry Foods	Laminated Films	Single-serve sachets for salt, small pouches for flour	Excellent moisture and air barrier, lightweight, customisable sizes
Snacks	Laminated Films	Snack bags, single-serve nut pouches	Keeps snacks fresh, customisable shapes/sizes
Liquids	PET	Small bottles for single-serve oil portions	Good barrier properties, recyclable, transparent for product visibility
Pre-Cooked Meals	PP	Single-serve microwavable containers	Heat resistant, maintains integrity during reheating
Reusable Packaging			
Dairy Products	Glass	Reusable milk bottles, yogurt jars	Easily cleaned, maintains product freshness, reusable multiple times
Dry Foods	HDPE	Reusable containers for flour and salt	Durable, easy to clean, moisture resistant
Snacks	Stainless Steel	Snack containers, reusable snack tins	Extremely durable, easy to clean, maintains freshness
Liquids	Glass	Reusable bottles for oils	Does not react with oil, easy to clean, reusable
Pre-Cooked Meals	Glass	Reusable jars for storing pre-cooked meals	Can be reheated, easy to clean, maintains food integrity
Bulk Packaging			
Dairy Products	HDPE	Large jugs for milk, bulk yogurt containers	Durable, impact-resistant, suitable for large quantities
Dry Foods	Corrugated Cardboard	Bulk boxes for flour (and bags), large cartons for salt	Provides good protection, easily recyclable
Snacks	FIBCs	Large bags for nuts and chips	Strong, flexible, reusable, suitable for large quantities
Liquids	Steel Drums	Bulk containers for edible oils	Extremely durable, excellent protection, reusable
Pre-Cooked Meals	Metal (Tinplate)	Large cans for beans and other pre-cooked meals	Provides good protection, preserves food for long durations, recyclable

MATERIAL FUNCTIONALITY

Effective packaging plays a crucial role in ensuring the quality, safety, and affordability of nutritious foods. The most functional packaging materials vary depending on the food type, with their durability and capacity to preserve food being two key criteria; in LMICs, not all materials are readily available from domestic suppliers, making the ease of access also an important consideration. As one key informant with an Ethiopian food company explained during an interview, 'Plastic is the only material that it is available in Ethiopia. I would like to use paper because it is better for the environment, but it needs to be imported and there are no US dollars for that.'

Figure 1 evaluates these three criteria for each of the most common packaging materials used in the focus countries (standard plastic, biodegradable plastic, glass, aluminium foil, and paper), for use in packaging dairy products, cooking oil and other liquids, flours and dried foods, snacks, and pre-cooked meals. Based on the literature and the key informant interviews, we assign a 1 to 5 score for each parameter, with 5 being the highest, as well as a total score (ranging from 3 to 15). The best-performing materials for each food category have been circled.

Food Type	Packaging Material	Durability	Preservation	Ease of Access	Total Score
Dairy	***Plastic***	4	5	4	13*
	Glass	5	5	3	13*
	Paper-based	3	4	4	11
Flours & Dry foods	***Plastic***	4	4	4	12*
	Paper	3	2	4	9
	Biodegradable Plastics	3	4	2	9
Snacks	***Plastic***	4	5	4	13
	Foil-based	5	5	4	14*
	Biodegradable Plastics	3	4	2	9
Cooking oil & Liquids	***Plastic***	4	5	4	13*
	Glass	5	5	3	13*
	Metal	4	5	4	13*
Pre-cooked meals	***Plastic***	4	5	4	13*
	Aluminium Foil	4	4	4	12
	Biodegradable Plastics	3	4	2	9

Figure 1. Material functionality assessment. Asterisk indicates the top score in the category.

Considering only durability, preservation, and ease of access, for dairy products such as milk and yogurt, ***glass and plastic*** are the best materials due to their high durability, excellent barrier properties against moisture and gases, and ease of handling. For fortified flour and other dry foods, ***plastic*** (e.g., PP, PET) is the most suitable material. Its resistance to tears and punctures, good moisture barrier properties, lightweight nature, and ease of access make it a highly functional choice for protecting and preserving dry foods. For snacks, there is a wide range of types and consistencies***. Foil-based packaging*** is an optimal functional option for some types of snacks (e.g., wholegrain and nut snack bars) due to its ability to protect food from natural light, but ***plastic*** is a very close second and tends to be most commonly used. It offers high durability and an excellent barrier against light, oxygen, and moisture, preserving the snacks' quality and extending their shelf life. In the case of cooking oil and other liquids, plastic, glass, and metal have similar functional

BOX 2. SPOTLIGHT ON PLASTICS

Plastic is ubiquitous in modern life, and over one-third of plastics globally are used in packaging, including for food and beverages. About 83% of flexible food packaging and 45% of rigid food packaging is made from plastics (23,25). However, while plastic is a very effective packaging material from a functional standpoint, it has many disadvantages including its environmental impact. Most plastic is non-biodegradable and contributes significantly to waste generation. Only 9% of the world's plastics have been successfully recycled; it is estimated that recycling will never be able to keep pace with current levels of plastic production (26). In addition, some plastics can leach harmful chemicals into food; for example, polycarbonate plastics often used in reusable water bottles and food containers can leach BPA, especially when exposed to heat (discussed in the section on food safety). Moreover, there is a growing negative perception of plastic packaging among some consumers due to these impacts. Biodegradable plastics can offer lower environmental impact, but they may not provide the same functionality and may be more expensive or not widely available in LMICs.

attributes. However, ***glass*** stands out for its high durability, especially with break-resistant options, and excellent non-reactive barrier properties, which help maintain the product's integrity. For pre-cooked meals, ***plastic*** is the most functional material due to its high durability, excellent barrier properties, and ease of handling. It effectively maintains the freshness of the meals and is convenient for consumers. (See Box 2, however, for a summary of some of the drawbacks of plastics in packaging.)

COSTS

The section considers the costs associated with single-serve packaging, reusable packaging, and bulk packaging, comparing their affordability. The focus products are dairy (e.g., milk and yoghurt), dry foods (e.g., fortified flour), snacks (e.g., dried fruits or the honey ginger toffee produced by one of the interviewees, but also applicable to other more nutritious foods), non-dairy liquids (e.g., fortified oil), and moist pre-cooked foods or meals (e.g., beans). Where possible, the assessment draws on industry data and market data to provide a detailed cost analysis of different packaging materials, considering factors such as production costs, market prices, and local conditions. However, due to data limitations and the fast-changing nature of prices, the figures given here should be seen as merely indicative.

SINGLE-SERVE PACKAGING

Costs of single-serve packaging for dairy products, fortified flour and other dry foods, snacks, cooking oil, and pre-cooked meals vary widely, but our analysis found an average cost ranging from USD 0.005 – 0.50 per unit. In addition to the costs of the packaging itself, initial costs for single-serve packaging include packaging design, packaging equipment, and labelling costs. Among the three packaging options considered, single-serve packaging has the highest recurring costs, involving the continuous supply of packaging and labelling materials, labour for packaging operations, and transportation and storage logistics for the packaging materials. Table 4 summarises these considerations.

Table 4. Estimated costs for single-serve packaging

Product Category	Dairy products	Fortified flour and other dry foods	Snacks	Cooking oil and other liquids	Pre-cooked meals
Average Standard Packaging Cost	Varies widely: $0.005 - $0.5 per unit				
Types of single-serve packaging used	Plastic bottles, paper cartons	Plastic bags, paper bags, paper boxes	Plastic bags, foil	Plastic bottles, plastic jars	Plastic bags, paper boxes
Average Percentage of Total Production Cost per Unit	12.8%	6.3%	22.0%	14.3%	20%
Initial Costs	Packaging design and labelling and purchasing of packaging materials.				
Ongoing Costs	Continuous supply of packaging materials, labour for packaging operations, transport, and storage.				

Notes: Dairy: Average packaging cost percentage in Kenya, Rwanda, India of milk and yoghurt, based on four online sources. Fortified flours: Average packaging cost percentage in Kenya, Bangladesh, and Uganda of fortified wheat flour, based on seven online sources. Snacks: Average packaging cost percentage in Uganda and Indonesia of dried mango and coconut, peanut bread, honey ginger toffees, and peanut butter, based on four online sources and two KIIs. Cooking oil: Average packaging cost percentage in Burkina Faso, Ethiopia and Uganda of fortified oil and sunflower oil, based on two online sources. Pre-cooked meals: Source (27)***.***

For comparison, according to UK-based packaging industry newsletter ***Packaging Gateway***, mainly focusing on the UK's packaging sector, packaging costs for infant formula, mayonnaise, milk, ready meals, chilled desserts, and dry pet food generally range from 10-20% of production costs. For canned food and beverages like baked beans, wet pet food, and carbonated drinks, packaging costs can make up over 20% of production costs. Products with limited packaging, like bread and poultry, see packaging costs comprising around 5% of production costs (27). In the US, according to packaging company Meyers, packaging costs can account for at least 10% on average of a product's retail price (but also can vary widely) (28). Taiwanese packaging company Innorhino, which produces various types of food and other packaging, estimates that the typical company spends around 10 – 40% of the product's retail price (29). Additionally, Welpac, a South African-based packaging company, estimates that the spectrum of packaging costs is not static and varies from 10% – 40% of their customers' products' retail price (30).

To provide concrete, context-specific examples, Table 5 summarises some information on packaging costs provided by interviewees in Uganda and Kenya. In these examples, the packaging cost is 10-25% of the product's retail price.

Table 5. Example packaging costs, from key informant interviews

Product	Current Packaging	Packaging Cost	Packaging Cost as a Share of Product Retail Price
Peanut butter	Plastic jars	UGX 12,000 per 500g jar	10%
Orange-fleshed sweet potato flatbreads	Plastic pouches	KES 2 per pouch	10%
Pre-cooked beans	Plastic pouches	UGX 1000 per 500g pouch	20%
Toffees	Baking paper and foil; paper boxes for large orders	UGX 50 per wrapper	25%

Notes: At the time of the study, I USD = 130 KES = 3750 UGX, approximately.

REUSABLE PACKAGING

The most significant initial costs for reusable packaging include the purchase of the reusable containers and the initial design and production of the reusable packaging. While packaging costs are lower over time with repeated usage, the initial investment in packaging is higher than with single-serve packaging. For food companies, the most significant ongoing costs are for cleaning and sterilisation of equipment and collection and return logistics.

The main materials used are glass and sturdy plastic (namely HDPE). For glass, the purchase cost of the packaging varies widely, from USD 0.50 – 2.29 per 1 litre bottle/jar (in Tanzania, South Africa, and Bangladesh). Assuming the container is reused 20 times before being lost or damaged, the average packaging cost for consumers for reusable glass per use would be USD 0.025 – 0.11 per unit. For sturdy plastic, purchasing cost of packaging varies from USD 0.26 – 0.46 per 1 kilogram bottle/jar (Kenya and Tanzania). The average packaging cost spread over 20 uses would thus be USD 0.01 – 0.02 per unit.[1]

For company-led cleaning and maintenance, European average cleaning and sterilisation costs are USD 0.02 per bottle or jar (31); applying this, the estimated total average reusable packaging cost for glass is USD 0.045 – 0.13 per unit and use, versus USD 0.03 – 0.04 per unit and use for sturdy plastic. Sturdy plastic is therefore cheaper than glass as a reusable packaging option over 20 uses; however, glass is more durable and can likely be used long after 20 uses. However, these estimates do not include the costs of recuperation and transport to the cleaning (and refilling) facility, which may be considerable.

Initial costs involve the procurement of the basic reusable containers and initial design and production of their branding, as well as costs for anything used to store or transport them (e.g., crates); there may also be costs associated with training consumers or retailers on how to use and return them. Total ongoing costs associated with the logistics of

[1] For comparison, in Sweden, a one-litre reusable glass bottle sells for $1.83 per unit while a one-litre reusable plastic dry food jar sells for $1.93 per unit.

collecting used packaging vary widely across contexts. A 2023 study on the European deposit-return systems estimated the cost per collected reuseable package to be USD 0.022 – 0.055, including transportation, sorting, and handling costs (31).

BULK PACKAGING (REMOVING PACKAGING)

The initial costs for bulk packaging systems are usually relatively high and mainly stem from the required bulk storage containers and dispensing equipment. The main ongoing costs for the retailer include the cleaning and maintenance of the dispensing equipment; potential loss from spillage, contamination, or theft; and storage logistics to ensure quality and hygiene. Spillage may also increase the need for frequent cleaning of the area surrounding the bulk storage containers. When consumers are expected to bring their own containers to refill, costs for cleaning the reusable packaging would be borne by the consumer and are difficult to estimate, as they would likely part of regular household cleaning; one could assume it to take less than one minute of additional time per use, and negligible amounts of water and soap. However, there is also an intangible 'hassle factor' associated with needing to remember to bring the container to the retail unit, with carrying it around, and with cleaning it. One interviewed company in Uganda noted cost-cutting for both consumers and the company as a main motivation for using a bulk-sale model.

For dry foods such as flour, grains, or some snacks such as nuts, basic wholesale containers such as 100-kilogram large woven bags cost as little as USD 0.70 per unit. Bulk flour and cereal dispensers (e.g., those typically used in supermarkets) start at about USD 30 per unit. For more sophisticated dispensing 'ATMs' (automated machines that allow customers to pay and serve themselves directly), prices for dispensers range from USD 350 to 1,200 in Kenya and other East African markets (32) and slightly higher in Bangladesh, ranging from USD 400 to 1,500 (33). These can be used for liquids such as milk and cooking oil as well as flours and snacks; cleaning and maintenance costs tend to be higher, and ongoing electricity costs are also required.

Assuming an average of 10,000 dispenses during the lifecycle of the dispensing equipment, total average packaging costs for ***dry foods*** in large woven bags could range from USD <0.014 to 0.15 per kilogram sold. Estimates for cleaning woven bags are difficult to obtain as such bags are most commonly laundered manually in many low-income markets, but are likely low. Assuming longer lifecycles of 20,000 dispensers for ***liquid products*** (i.e. milk, oil, water) in more formal dispensers, average packaging costs could range from USD <0.02 to 0.075 per litre sold. While most dispensers include some kind of self-cleaning mechanism, manual cleaning and maintenance is also required; this would probably be included as part of shop staff person's routine work, but would still likely be higher than for a simpler container.

In summary, single-serve packaging offers convenience and protection of the product but incurs costs ranging from USD 0.005 – 0.50 per unit. Reusable packaging, though initially relatively expensive due to the need for durable containers and transport, storage, and cleaning equipment spreads its cost over multiple uses, reducing the per-use cost to USD 0.01 – 0.11 per unit. Bulk packaging further reduces per-unit costs by eliminating individual packaging needs, at least at the distributor/retailer level. The average bulk packaging cost ranges from USD 0.007 – 0.075 per unit, making it the most cost-effective option over time. The range is wide, however, based on how advanced the bulk dispensing is, and does not include the consumer-incurred cost for the container they use to bring the product from the store to the home, which could vary widely.

SAFETY AND HEALTH STANDARDS

There are two potential aspects to how packaging affects food safety: the packaging's ability to keep food safety from contaminants and the risk of the packaging itself contaminating the food.

For the latter concern, the main focus is on the layer of packaging that is in direct contact with the food or beverage, the so called 'food contact material'. Table 6 lists the types of materials generally approved for food contact applications based on the material's ability to resist leaching harmful substances into food and discusses potential issues with 'chemical migration', or the transferrable of chemicals into packaged food or beverages from packaging. (The applicable food and safety standards specific to the focus countries are included in the annex.)

Table 6. Safety implications of common packaging materials

Material	Safety implications
Plastic	Plastics can transfer chemicals into packaged food or beverages. In most cases, some of the migrating chemicals are known, while others are identified only partially or not at all. Chemical migration depends on factors such as food type, temperature, and storage time. Its impact on human health is still not well understood. Plastics can also contain additives like BPA.
Paper and board	Paper and board have very low barrier properties, as the material is porous. Migration of chemicals is therefore common and includes both those substances present in the base material as well as things like printing inks and adhesives; levels of migration may be very high. Chemical migration depends on factors such as food type, temperature, and storage time, as well as the volatility of the chemical. Paper and board that are chemically made waterproof or grease resistant are increasingly used as alternatives to plastic packaging. For example, polyfluoroalkyl substances (PFAS) are regularly used in such packaging. However, PFAS are highly persistent, and exposure can lead to adverse human health effects. Hence, extending the functionality of paper and board packaging can come at the expense of chemical safety.
Metal	When metal comes into direct contact with food, metal ions can migrate from the packaging into the food. High salt content and acidity of the food accelerate this transfer, as has been shown for uncoated food trays made of aluminium. Organic can coatings reduce the interactions between the metal and the food. However, chemicals present in these coatings (e.g., oligomers, lubricants, and crosslinkers) may migrate into food. In particular, BPA and related substances associated with epoxy coatings have been regularly detected in canned foods and beverages.
Glass	The transfer of glass constituents into food is of low concern due to its structural properties. However, lids and closures are a source of chemical migration, which is dependent on different factors, such as the material and food composition as well as the processing and storage conditions. Although the surface area of these closings is relatively small, some materials have shown high migration of substances like plasticizers.

Multimaterial (in most cases, made of paperboard, plastic polymers, and/or aluminium)	When addressing chemical migration from multimaterial food and beverage packaging, the primary focus should be placed on the material that is in direct contact with the food. However, chemicals from the outer layers of the packaging, the adhesives, and the printing inks can migrate if there is no barrier layer present. Additionally, chemicals can be transferred from the printed outside to the unprinted inside layer during production. This is because multimaterial sheets are often stored in reels, leading to chemical migration of printing ink components from the outside of the packaging into the food.
Innovative biodegradable packaging materials (such as those based on corn, cassava, potato peel, or algae) (34)	Corn starch is generally recognised as safe for food contact applications. However, the use of plasticizers and other additives needs careful consideration to avoid contamination. Cassava starch films are biodegradable and considered safe for food contact, making them a viable alternative. Potato peel-derived bioplastics are biodegradable and generally safe for food packaging. The main concern is the potential presence of contaminants from the agricultural process, which must be controlled. Algae-based bioplastics are emerging as a sustainable alternative. They are biodegradable and can be safely used for food packaging if processed correctly. The primary safety consideration is ensuring that no harmful substances are present in the final product.

SINGLE-SERVE PACKAGING

One of the advantages of single-serve packaging is its general ability to protect food from contamination up until the point of consumption. Larger packages are often open for an extended period of time, with only a small amount consumed at once, increasing the likelihood of contamination either while accessing the product or due to not resealing the package after use. In contrast, single-serve packages are usually only opened when ready to be consumed; even where some product is leftover, it is rarely stored for long due to the small quantities involved. In addition, formal (industrial) single-serve packaging is often hermetically sealed in a factory setting, resulting in low risk of contamination. It also typically contains required safety-related labelling, such as any certifications or notices related to allergens. However, single-serve items can also be sold in the informal sectors by distributors or retailers who ‘break bulk’ directly by buying something in a medium to large quantity and reselling it in small quantities, repackaging it themselves (See Figure 2 for photos illustrating this difference). For this type of packaging, the risk of contamination and spoilage is typically higher, and food safety-related labelling is rarely included.

All single-serve packaging materials should comply with regulations specific to food contact materials, to ensure that materials do not release harmful substances into food. Single-serve packaging often uses plastics like polyethylene and polypropylene. These materials are generally recognised as safe, but concerns about chemical leaching, such as of BPA, have led to stricter controls and bans in certain applications, especially in the EU. This is however not the case in many low-income countries. In the absence of national regulations, Regulation (EC) No 1935/2004 in the EU or ISO 22000 can serve as a guide; the use of certified suppliers can also help ensure compliance.

Figure 2. Formally packaged single-serve foods dangling from a storefront in Bangladesh (left) and informally packaged single-serve foods in a store in Guinea (right). ***Credit: GAIN (left) and Stella Nordhagen (right).***

REUSABLE PACKAGING:

For reusable packaging, the main food safety risk lies in the cleaning and sterilisation between uses; both product residues remaining in the container and contamination during the cleaning process pose risks, and proper protocols must be used to prevent this contamination (35). In the absence of specific legal requirements for cleaning and sterilisation of reusable packaging, general regulations on commercial food handling and storage can be applied. Where consumers are responsible for cleaning the packaging themselves, companies must establish and communicate strict cleaning protocols to consumers to prevent contamination and ensure safety.

In addition to regulations on food contact materials, reusable packaging must meet stringent hygiene and safety standards due to its repeated use. This includes compliance with good manufacturing practices and ensuring materials are food-grade and free from contaminants. Materials like stainless steel and glass are preferred due to their durability, inert properties, and minimal risk of leaching. Some plastics may also work well, but this depends on their durability and absence of harmful additives. Companies should regularly test the durability and integrity of reusable packaging to ensure it remains safe over multiple uses, and replace it with an appropriate frequency.

BULK PACKAGING (NO PACKAGING)

For bulk packaging, there is a risk of contamination while the product is in the dispenser or being dispensed. This is particularly high for less formal bulk retail systems, in which the product might not be in a well-sealed container prior to dispensing (compare Figure 3 to Figure 4 to see the differences between these types of systems).

As such, bulk packaging systems must comply with local health and safety regulations to prevent contamination during transport and storage. One key safety concern is maintaining proper cleaning and sterilisation protocols for the bulk containers, to avoid spoilage or contamination . The storage containers must also be compliant with food contact material standards and should clearly display the key food safety information about the product.

Bulk packaging also raises the risk of contamination after dispensing, due to the consumer using an unclean container or it later being exposed to contaminants through improper storage. Bulk packaging essentially transfers some of the risk for ensuring food safety from the food processor/packager to the consumer. As such, companies must educate retailers, customer-facing staff, and consumers on how to handle bulk foods to maintain food quality and safety.

Figure 3. Informal food retail bulk sale of cooking oil into customer-provided bottles in Bangladesh (left) and Kenya (right). ***Image credit: GAIN/ Yousuf Tushar (left) and Timothy Mwaura (right).***

Figure 4. Formal retail dispensers for nuts (left) and water (right). ***Image credit: Felixwong.com***

ENVIRONMENTAL IMPACT

In general, the environmental impact of packaging is usually relatively small compared to the overall environmental foodprint of the food chain, at around 1.5 – 5% of impact, though higher for beverages (37,38): that is, the carbon footprint of the food contained in the packaging is typically many times higher than that of the packaging (39). Packaging also plays an important role in reducing food waste—and thus reducing its environmental impact—by protecting food from spoilage and contamination, and thus can in some cases have a net positive environmental impact (39). However, the environmental impact of food packaging in the aggregate is not negligible, particularly when considering the volume of waste produced and the issue of leakages into the environment (e.g., plastics and microplastics ending up in the ocean). While retailers and owners often consider carbon emissions, circularity, and recyclability when selecting packaging materials, consumers may be more concerned about visible waste and environmental leakages (40). All of these factors vary widely by packaging type – though regardless of the packaging option chosen, using less packaging where feasible tends to be an environmentally friendly decision.

SINGLE-SERVE PACKAGING

Single-serve packaging is designed for one-time use and often results in higher packaging waste. While recycling of plastic food packaging is widely seen as a measure to reduce its environmental impacts, it can only be recycled to a limited extent due to its material properties, waste management processes, and chemical safety concerns. In LMICs in particular, recycling systems may not be in place or may not be cost-effective. As such, about 90% of single-use plastics globally are not recycled. Single-serve packaging made of plastic has a high environmental footprint due to this low recyclability and non-biodegradability, as well as high carbon emissions during production and disposal (38). Single-use plastic can emit approximately 1.7 to 3.5 kg CO_2 per kg of plastic produced (41). For example, producing polyethylene (PET), emits about 2.5 kg CO_2e per kg of plastic (38).

In contrast, recycling of paper and board is an established technology in many countries, and products made of recycled paper and board are widely used, also in contact with food. Paper and cardboard packaging are also biodegradable under the right conditions, decomposing within a few months to a year, unlike plastics which can take hundreds of years (42,43). Paper and carton packaging also have a lower carbon footprint in production, ranging from 0.7 to 3.9 kg CO_2 per kg of material for cardboard (44). Paper and carton single-serve packaging thus generally offers a better environmental profile than plastic, particularly if sourced from sustainably managed forests and effectively recycled.

Efforts are underway to develop more environmentally sustainable single-use packaging. For example, recycled PET (rPET) can have a comparatively low carbon footprint (45), and the multinational food company Unilever has efforts underway to make 100% of packaging recyclable, reusable, or compostable (Box 3). However, 'sustainable' single-use packaging can also entail increased costs and is not always readily available in LMICs, particularly for smaller companies.

REUSABLE PACKAGING

As reusable packaging involves materials designed for multiple uses, it inherently reduces packaging waste generation. In addition, reusable packaging typically consists of materials like glass, stainless steel, and certain hard plastics, which have high recyclability. These materials can be recycled multiple times without significant degradation of quality. While reusable packaging is often not biodegradable, its extended use and ability to be recycled reduce the frequency of disposal. Initial production of reusable packaging may have higher carbon emissions due to the energy-intensive processes required to manufacture durable materials. For example, producing 1 kg of stainless steel and glass emits approximately 6.15 and 1.5 kg CO_2e, respectively. However, over time, the reduced need for continuous production lowers overall emissions. For instance, reusing a glass jar 50 times can reduce its carbon footprint per use to about 0.012 kg CO_2e (47). However, some emissions are also released through the recuperation and cleaning process, particularly due to transport.

BOX 3. CORPORATE EFFORTS TO REDUCE PLASTIC WASTE

While corporations are main sources of plastic waste through the consumer products they produce, some are under increasing consumer, government, and/or investor pressure to address this. For example, the consumer goods company Unilever, which owns brands like Hellman's mayonnaise and Knorr bouillon, has pledged to make 100% of its plastic packaging reusable, recyclable or compostable by 2030 for rigid plastic and 2035 for flexible plastic. As part of this, it has been running pilot projects on bulk dispensers (mostly for toiletry products, like shampoos), that include various types of store-based dispensers, digital machines in apartment buildings or railway stations, as well as motorcycle drivers who go door-to-door with jerry cans. They report that their refill machines can offer savings of up to 20% compared to prepackaged products. The company also notes, however, that supportive regulations from government are also needed to drive the adoption of such models at scale.

Source: (46)

BULK FOOD SALES

Similarly, selling foods in bulk minimises or eliminates packaging, reducing waste. Bulk food systems typically use large containers that are either reusable or recyclable, leading to minimal packaging waste. When individual packaging is necessary, using biodegradable options such as paper bags or compostable containers can minimise environmental impact. Bulk systems generally encourage the use of consumer-provided containers, which are often reused by the consumer many times, reducing the need for new packaging. Lower emissions from reduced packaging production and efficient bulk transport systems contribute to a lower overall carbon footprint. Bulk packaging options have significantly lower carbon emissions due to the elimination of extensive packaging materials. The carbon footprint of bulk food sales is likely the lowest among the three options due to minimal packaging waste, lower carbon emissions, and the potential use of biodegradable materials.

CONSUMER ACCEPTANCE

The aesthetic appeal of packaging, including colour, shape, and design, significantly influences consumer purchase decisions. Attractive and informative packaging enhances brand perception and consumer trust (48,49). As a key informant with a food company in Uganda noted, 'Consumers won't buy a food product that does not look good in the packaging'. Packaging functionality (e.g., convenience and ease of opening, appropriate size, re-seal-ability, ability to be heated or cooled, and effects on taste or texture of food) is also considered by consumers and impacts their choice of product. Consumers also have expectations for which types of foods belong in which types of packages: for example, more high-end products tend to be associated with glass bottles and jars, whereas paper cartons and thin plastic may have more budget-product connotations.

Globally, at least certain consumers are increasingly favouring sustainable packaging options, like paper over plastic, and (particularly in high-income countries) may be willing to pay more for such options (50,51). Visibility of plastic pollution, particularly in waterways and marine areas, is one driver of this trend. To respond to this, some companies are working to use more 'minimalist' approaches and removing secondary packaging; companies are also experimenting with refillable packaging. In all cases, it is important to maintain consumers' product perceptions through familiar branding elements. (52) However, the trend in consumer demand for sustainable packaging may be weaker in LMICs. In Tanzania, for example, consumers prioritise packaging that ensures product protection, hygiene, detailed information provision, ease of opening, and reusability. (53) In Bangladesh, durability and ease of use are key characteristics for consumers (54,55). Moreover, the aesthetic and tactile experience of packaging and its price can also influence consumer preferences, potentially overriding concerns about sustainability. A 2020 survey in China, India, and Indonesia found that, when considering options to standard packaging, consumers generally preferred recyclable and compostable plastics as well as more paper-based packaging, as opposed to glass and metal containers (56).

SINGLE-SERVE PACKAGING

Single-serve packaging is highly valued by many consumers for its convenience and ease of use, particularly in fast-paced lifestyles. Consumers may also appreciate the portion control and reduced waste associated with these packages (i.e., that having a small amount ensures that the entire product is consumed before spoiling); it can thus positively influence perceptions of product efficacy. However, single-serve packaging raises significant environmental concerns due to increased packaging waste, with some consumers becoming more aware of the environmental impact and seeking more sustainable options. It can also require consumers to purchase items more frequently (and thus spend more time shopping) and can encourage inefficient use (i.e., consuming in multiples of a package size, even when less would be appropriate). Some customers may also not prefer it if they usually re-use food packaging for other purposes (e.g., to store leftovers or as a planting container) (16).

REUSABLE PACKAGING & BULK SALE

Reusable packaging and the packaging reduction associated with bulk sales are perceived positively by some consumers as they align with growing concerns about sustainability and environmental impact. Brands adopting reusable packaging can thus see improved brand perception and customer loyalty (35). For bulk sales, consumers also often assume it will entail reduced prices, increasing their approval of the approach.

Despite these positive perceptions, consumers also see practical challenges with using their own reusable packaging, such as the need to change their behaviour and bring their own containers to retail locations (and clean them at home). Where reusable containers' collection and cleaning are led by the company, as opposed to the consumer, such barriers are lower. For bulk shopping, consumers may also have concerns related to hygiene and sanitation or to adulteration or selling a lower-quality brand under the name of another (57). This may be particularly acute in settings where there are many poor-quality options available on the market and low trust in food supply chain actors (58). For example, research in Indonesia has found that cooking oil consumers prefer to buy bottled oil than refilling at the same price since bottled oil is considered more durable and able to keep quality better (59).

SUPPLY CHAIN ASSESSMENT

Identifying appropriate packaging materials also requires considering their supply chains in LMICs, in terms of local availability, feasibility of local manufacturing, and the required transportation and storage logistics. All of these have economic implications. Table 7 qualitatively summarises these considerations for the specific packaging options relevant to the nutritious food products considered here. Each packaging material presents distinct advantages and challenges. Plastic packaging, with its widespread availability and efficient logistics (due largely to being lightweight and non-fragile), tends to be feasible and cost-effective for many products. Glass, while widely produced and offering excellent durability and preservation, incurs high transportation and handling costs, limiting its economic feasibility in low-income markets. Paper-based packaging for dry foods is widely available and easy to make, transport, and store; paper-based cartons for dairy products and other liquids are less available, particularly from local manufacturers. Biodegradable plastics, though environmentally friendly, face limitations in availability and local manufacturing capacities, entailing higher costs.

Table 7. Supply chain considerations of different packaging materials

Food Type	Packaging Material	Availability	Manufacturing	Transportation	Storage	Economic Implications
Dairy Products	Plastic	High	Established, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Glass	Moderate	Centralised, costly	Heavy, high cost	Requires careful handling, costly	Moderate Cost (High Initial Cost but lower over time)
	Paper-based	Increasing	Growing, moderate	Lightweight, low cost	Easy, moderate cost	Moderate Cost
Fortified Flour & Dry Foods	Plastic	High	Established, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Paper	High	Established local production, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Biodegradable Plastics	Limited	Limited	Similar to plastic, moderate	Similar to plastic, moderate	High Cost
Snacks	Plastic	High	Established, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Foil-based	Moderate	Limited, costly	Lightweight, moderate cost	Requires careful handling, moderate cost	High Cost
	Biodegradable Plastics	Limited	Limited	Similar to plastic, moderate	Similar to plastic, moderate	High Cost
Cooking Oil & Liquids	Plastic	High	Established, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Glass	Moderate	Centralised, costly	Heavy, high cost	Requires careful handling, costly	Moderate Cost (High Initial Cost but lower over time)
	Metal	Moderate	Limited, moderate	Lightweight, moderate cost	Easy, moderate cost	High Cost
Pre-Cooked Meals	Plastic	High	Established, efficient	Lightweight, low cost	Easy, low cost	Low Cost
	Aluminium Foil	Moderate	Limited, costly	Lightweight, moderate cost	Requires careful handling, moderate cost	High Cost
	Biodegradable Plastics	Limited	Limited	Similar to plastic, moderate	Similar to plastic, moderate	High Cost

CONCLUSION

This paper has considered in detail three packaging innovations that could be used to make nutritious food more accessible to lower-income consumers: single-serve packaging, reusable packaging, and selling products in bulk without individual packaging. Based on a rapid literature review, case studies, analysis of market data, and interviews with key informants, the paper has explored functionality, costs, food safety, environmental sustainability, consumer perceptions, and supply chain logistics. The focus has been on particularly representative types of nutritious foods (dairy products, fortified flours and other dry foods, snacks, cooking oil, and pre-cooked meals) and on LMICs, drawing particularly on cases and data from Kenya, Tanzania, Uganda and Bangladesh.

Table 8 summarises some of the main advantages and drawbacks of each option. For single-serve packaging (usually plastic, HDPE, or PET), main drawbacks include the higher per-unit cost of the products and the environmental burden of the waste produced; while the later issue could be mitigated through the use of biodegradable materials, this may entail higher costs and be logistically infeasible in many LMICs, where such materials are not widespread. Reusable packaging (usually glass, stainless steel, or durable hard plastic) offers many advantages but entails logistical challenges to manage returns and appropriate cleaning, which can also increase costs. Subsidies, hub approaches to coordinate logistics, and other incentives could facilitate the uptake of such models by firms, and consumer education on the benefits of such models and assurances on cleaning protocols could facilitate uptake among consumers, as could price incentives. Finally, bulk sales also offer cost, sustainability, and flexibility advantages, but face challenges with regards to product contamination and consumer uptake. Investing in high-quality dispensing containers (usually hard plastic, metal, or glass) or equipment (and maintenance of it) and training staff and consumers on proper handling and storage of the products pre- and post-sale can help to mitigate these challenges, and price incentives can encourage consumer uptake.

Table 8. Summary of advantages and disadvantages of the different approaches

Approach	Advantages	Disadvantages
Single-Serve Packaging	• Convenient for and widely accepted by customers • When done in alignment with appropriate regulations, strong food safety protections • Strong on food preservation and shelf life • Supports consumer experimentation and brand promotion • Efficient supply chain logistics, largely due to reliance on cheap, light plastics • Can helpfully control consumption (e.g., limit portion sizes)	• Relatively high cost (per unit) compared to other options • Environmental impact: High plastic waste and pollution • Potentially decreasing consumer acceptance due to environmental issues • Supply chain interruptions can lead to unexpected unavailability of various packaging materials in focus countries • Dependency on importation: Lack of appropriate locally available packaging solutions • Entails more frequent purchasing • May encourage inefficient use

Reusable Packaging	• Lower per-unit costs over time (despite high initial costs) • Environmental sustainability due to less waste • Positive consumer associations due to sustainability • Strong on food preservation and shelf life when well implemented	• Initial high costs, with significant upfront investment in containers and cleaning equipment • Risk of contamination if not properly cleaned and maintained • Potentially slow consumer adoption due to safety concerns or additional effort (in cases where consumer returns container) • Complex logistics for return and cleaning when done by the firm; lower consumer uptake when done by the consumer
Bulk Sales	• Lower per-unit costs over time • High environmental sustainability due to less packaging waste; potentially less consumer-level waste due to being able to buy only amount needed • More flexibility for consumer (ability to buy any amount) • Supports consumer experimentation	• Requires initial investment in dispensing equipment and ongoing costs for maintaining hygiene standards • Higher risk of product loss and contamination or adulteration without proper handling • Shelf life may be shorter, and spoilage may be higher • Consumer hesitance to adopt due to perceived inconvenience and hygiene concerns • Consumer education on product handling and cleaning required • May not provide key product information that would normally be included on packaging, such as certifications and ingredients • Issues with traceability and brand impersonation • Only suitable for certain products

Considering the overall aim of improving affordability of nutritious foods for lower-income consumers, and ideally doing so without negative environmental or food safety impacts, bulk sales emerges as a generally strong option – as long as the food safety risks can be adequately mitigated. Investments are needed in developing improved technologies for bulk dispensing solutions, including ways (such as smartphone apps) to support traceability and ensure consumers can access the necessary information about a product that would normally be provided on packaging labels. There is also scope for documenting and exchanging best practices for bulk packaging systems' uptake and use, including the economic considerations that make them a viable business model for both consumers and firms. Local policymakers or other development actors could also consider providing subsidies or other financial incentives for their adoption by retailers, or for upgrading existing low-quality dispensing solutions.

The logistical costs of supplier-led reusable packaging systems may make them infeasible for low-infrastructure markets, and particularly for small firms, though they may be well suited to larger firms that can handle the challenge and fixed costs, or where there is already infrastructure in place. For example, Coca Cola and its subsidiaries use refillable glass bottles in many LMIC markets, such as in East Africa, overseeing a large network of local distribution centres that cheaply distribute to, and collect from, small shops and kiosks (60–62). While soft drinks are not a nutritious food, similar models could be applied to milk, yoghurt, or similar products. Such approaches may also be more feasible at the food service level, where a greater volume is consumed by a single client (i.e., a restaurant or hotel).

While single-serve packaging has many advantages for consumers, in LMICs there are currently few cost-effective, widespread options that can mitigate its environmental harms. It may still remain a good option, all things considered, in settings where contamination or spoilage is particularly likely (e.g., hot and humid remote rural areas) or particularly essential to avoid (e.g., for therapeutic foods given to infants and young children or those who are ill); where trust in food retailers is low and adulteration or food fraud are common; and for products that are easily adulterated or copy-catted with lower-quality versions in ways that cannot be verified by consumers (e.g., for fortified foods).

This rapid review faced numerous evidence gaps, particularly with regard to LMIC-specific data on the packaging innovations examined, including their prices and consumer perceptions of them. Indeed, there has generally been limited research on food packaging's multifarious effects in LMICs, and more is needed (22). In particular to support uptake of these approaches among LMIC companies, there is a need for additional research on the business models supporting them and how and under what circumstances they can be cost-effective and feasible for the firms involved.

Packaging can keep foods safe; help make them appealing, convenient, and long-lasting; and convey key information about them to consumers. At the same time, it is an important contributor to food system waste and a major driver of certain foods' prices in LMICs, and may have negative unintended effects on human and planetary health. As such, it is a sector ripe for creative disruption as part of food system transformation – to ensure safe, nutritious foods can reach the consumers who need them, in affordable forms and with limited negative environmental impact.

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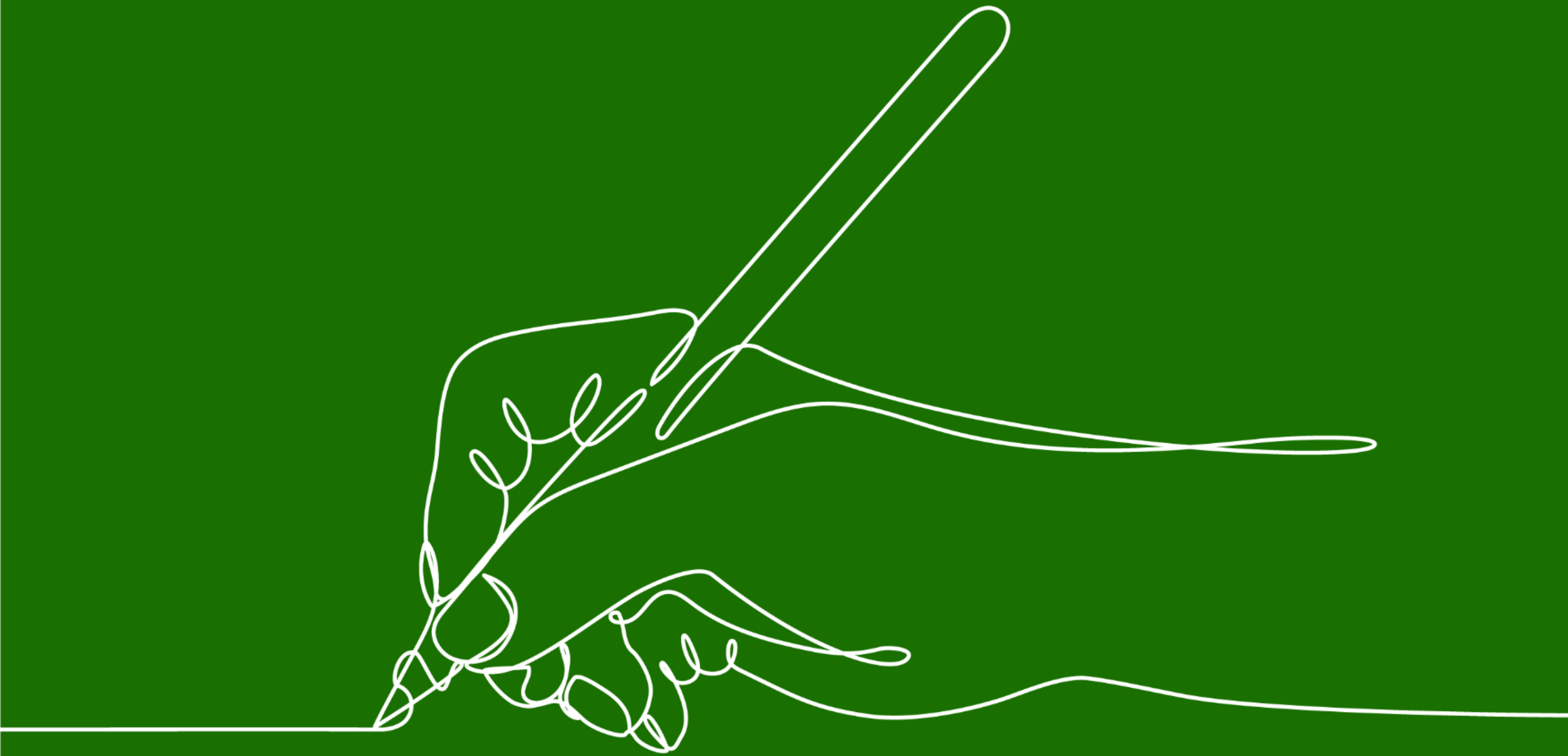
ANNEX. FOOD SAFETY REGULATIONS AND STANDARDS

The table below provides an overview of relevant food safety regulations and standards (local, national, and international). Regulations and standards concerning food safety are evolving continuously; these reflect those in use in early 2024.

Country/ Region	Regulations and Standards
EU	Regulation (EC) No 1935/2004: Framework regulation on materials and articles intended to come into contact with food. Ensures that food contact materials do not transfer harmful substances to food. Commission Regulation (EU) No 10/2011: Specific measures for plastic materials and articles intended to come into contact with food. Includes a list of authorized substances that can be used in the manufacture of plastic food contact materials. Regulation (EC) No 2023/2006: Good Manufacturing Practice (GMP) for materials and articles intended to come into contact with food. Ensures that the manufacturing process is controlled to prevent contamination.
Kenya	Kenya Bureau of Standards (KEBS): - KS EAS 38:2007: General standard for food hygiene. - KS 1798-1:2019: Food safety management systems – Requirements for any organization in the food chain. Public Health Act (Cap 242): Regulates food safety, including the packaging of food products, to ensure public health. Standards Act (Cap 496): KEBS is responsible for developing standards for food packaging materials and ensuring their compliance.
Uganda	Uganda National Bureau of Standards (UNBS): - US 1659:2017 – General standard for food hygiene. - Draft US 1659:2022 - Materials in contact with food; Requirements for packaging materials - US EAS 38:2014 – East African Standard for the labelling of prepackaged foods. The Food and Drugs Act (Cap 278): Regulates the sale, manufacture, and packaging of food to ensure safety and prevent contamination.
Zambia	Zambia Bureau of Standards (ZABS): - ZS 719: Part 1-3:2006 – Food safety management systems. - ZS 165:2005 – Labelling of prepackaged foods. Food and Drugs Act (Cap 303): Governs the safety and quality of food, including packaging materials.
Bangladesh	Bangladesh Standards and Testing Institution (BSTI): - BDS 1702:2002 – General standard for food hygiene. - BDS 1325:2018 – Standard for labelling of prepackaged foods. The Pure Food Ordinance, 1959: Ensures the purity of food by regulating its manufacturing, packaging, and labelling. The Bangladesh Food Safety Authority (BFSA): Established under the Food Safety Act (2013) oversees the implementation of food safety standards, including packaging materials to ensure they are safe for food contact.

International Standard	ISO 22000: This standard for food safety management systems also includes provisions relevant to food packaging materials. ISO 18602:2013: Packaging and the environment – Optimization of the packaging system.
US	FDA Regulations (CFR Title 21): Governs materials intended for food contact, including specific rules for different types of packaging materials. - 21 CFR Part 174-186: General provisions and specific regulations for indirect food additives. - 21 CFR Part 110: Current Good Manufacturing Practices (cGMP) in Manufacturing, Packing, or Holding Human Food.
China (available packaging in countries of study mostly comes from China)	National Health Commission (NHC): Oversees food safety standards. - GB 4806.1-2016: General safety requirements for food contact materials and articles. - GB 9685-2016: Standards for the use of additives in food contact materials.



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ABOUT GAIN

The Global Alliance for Improved Nutrition (GAIN) is a Swiss-based foundation launched at the UN in 2002 to tackle the human suffering caused by malnutrition. Working with governments, businesses and civil society, we aim to transform food systems so that they deliver more nutritious food for all people, especially the most vulnerable.

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