Entrepreneur-led food fortification: A complementary approach for nutritious diets in developing countries

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ABSTRACT

Small and micro food enterprises are critical implementation partners for fortification strategies that address the widespread micronutrient deficiencies in low-income countries. This paper describes the concept and practice of Entrepreneur-led Food Fortification (ElFF). It draws on the experience of a consortium of US and African food and nutrition R&D organizations, partnering with African small-scale food processors. ElFF can address major challenges faced by such enterprises by providing convincing value propositions, product distribution and marketing, and achieving business scale and nutritional impact. Through the example of entrepreneur-led production of food-to-food fortified grain-based instant porridge flour, we illustrate a framework for successful implementation of ElFF both in local markets and potential links to government nutrition strategies to address micronutrient deficiencies.

1. Introduction

Dietary micronutrient deficiencies and their impact on disease risk and long-term health disproportionally affect people living in low income and lower-middle income countries. The State of Food Security and Nutrition in the World 2021 report (FAO et al., 2021) estimated that in 2020 undernourishment in all forms affected 21% of people in Africa, 9% in Asia, Latin America and the Caribbean, whereas in North America and Europe less than 2.5% of people were affected. The report pinpoints the high cost of food as being an increasing problem for people in low-income countries to obtain nutritious diets. It identifies two specific and linked goals with respect to addressing micronutrient deficiencies: 1. Increasing the supply of fortified foods, and 2. Increasing production of foods with higher micronutrient content.

To date, governmental and non-governmental organization initiatives have largely pursued these goals through conventional fortification of food staples with chemical micronutrient premixes and biofortification, i.e. genetic or agronomic enhancement of the density or bioavailability of micronutrients in staple plant foods themselves. Whilst undoubtedly important, they are top-down approaches that can be expensive and cumbersome to implement and may not be financially self-supporting. These limitations suggest that these approaches alone cannot adequately address the scale of the problem.

There is increasing recognition that market-based strategies must play a central role in addressing micronutrient deficiencies in low-income countries, and that micro- and small-scale enterprises, in particular, have a critical role (Demmler, 2020; Henson and Agnew, 2021). Such enterprises face numerous challenges in the start-up phase. Alex Ariho, CEO of

the African Agribusiness Incubators Network and co-editor of a special issue of Agriculture for Development on agribusiness incubation in Africa, summarized these as lack of business experience, managerial and technical skills and lack of credibility with creditors and finance to afford adequate premises and essential equipment (Ariho, 2019). More specifically, with regard to the provision of nutritious foods to low income consumers by small enterprises, Henson and Agnew (2021) identified that they face three major challenges on the basis of a case study of three different types of such enterprises in Bangladesh and Kenya. These were: (1) constructing a value proposition for nutritious foods; (2) food distribution and product marketing; and (3) achieving scale of production. The latter also relates to how such enterprises can provide nutritional impact.

The aim of this perspective article is to demonstrate the potential of incubated small-scale entrepreneur food processing enterprises in resource-poor local communities to significantly impact on the nutrition and economic well-being of the communities. We use the term Entrepreneur-led Food Fortification (ElFF) to describe this concept, where ElFF is defined as: *A system driven and managed by local or regional small- and micro-food processing entrepreneurs who produce and market affordable, nutritious and consumer-desirable locally produced food staples fortified with nutrient-dense food ingredients."*

The perspective draws on our experiences in food and nutritional research identifying micronutrient-dense, plant-based ingredients as grain-product-based food fortificants and the experience of our consortium of food R&D organizations from the USA and Africa, which partners with small- and micro-food processors in the Sahel and East Africa regions. The article is structured around the three major challenges facing small food entrepreneurs identified by Henson and Agnew (2021).

2. Value propositions

A review of approaches and evidence on private sector engagement in nutrition concluded that national companies of all sizes in developing countries do not have the means nor credibility by themselves to create demand for nutritious foods with poor consumers (MQSUN+, 2018). By way of response, our consortium's partnership with small-scale food processing entrepreneurs has resulted in valuable insights into approaches and technologies that can provide nutritious food products that align with and meet local consumer demands (summarized in Table 1). Although not by themselves novel, their combination to create viable nutritious food value propositions for small food entrepreneurs is innovative and forms one of the cornerstones of ElFF. Our process of engagement consider the nutritional quality and consumer acceptability of the product as well as the costs associated with production of any product as to enhance potential business viability and sustainability for local SMEs.

To provide affordability and foster higher probability of both business viability and impact, ElFF nutritious products are preferably based on fortification of starchy staples, as these are by far the most cost-effective food components in terms of energy density (Bai et al., 2021). Ideally, the starchy staples should be micronutrient-biofortified types. Also, where appropriate to the consumer group's nutritional needs and physiological development, wholegrain cereals should ideally be used because they contain numerous macronutrients and micronutrients, dietary fiber and bioactive compounds that are greatly reduced in refined grain products. Regular consumption of wholegrains contributes to prevention of the so-called Western lifestyle diseases of obesity, Type-2 diabetes, coronary and cardiovascular

diseases and certain cancers (Lutsey et al., 2007). Additionally, with wholegrains, processing losses are minimized, thereby further controlling costs.

The growing consumer demand in developing countries for convenient and nutritious products can be met through blending and processing of the starchy staples with nutrient-rich plant food ingredients, the strategy of food-to-food fortification (FtFF) (Kruger et al., 2020). This utilizes protein-rich pulses and micronutrient-rich vegetables and fruits as fortificants; for example, carrots and mango as sources of provitamin A. In design and prior to implementation of these FtF formulations with entrepreneurs, rigorous assessment of ingredient quality as well as micronutrient bioaccessibility has been implemented in finished products to guide final formulations. This is in recognition of the fact that many plant materials may contain inhibitors of micronutrient absorption (e.g. phenolics and phytate). In our assessments of FtF formulas currently used in Senegal, Kenya and Niger we have reported that bioaccessibility of iron, zinc and provitamin A carotenoids are similar to those observed in synthetic fortifications (Van der Merwe et al., 2019; Debelo et al. 2020; Ndiaye et al., 2020; Adetola et al., 2022).

A consumer benefit of FtFF is that the colors and flavors imparted by the food fortificants act as sensory cues that the product has been fortified, unlike conventional chemical fortificants. The blended products can be either uncooked flours or pre-cooked flours produced by high temperature-short time extrusion cooking. Extrusion cooking produces a further value-added, convenient-type "instant porridge flour", whereby the consumer simply mixes the flour with freshly boiled water to produce a nutritious porridge meal.

Key issues are whether consumers appreciate the sensory characteristics of FtF fortified products and whether they purchase them routinely at a price that will enable the entrepreneur

to make a reasonable profit. Our research in Senegal and Kenya suggest that consumers find FtF formulation acceptable and in some case prefer these products. Interestingly, when additional information is provided to consumers about the convenience and nutritional attributes of the products, they are willing to pay small premiums for instant porridge flours and conventionally fortified and FtFF flours when compared to traditional cereal flour (De Groote et al., 2018, 2020, 2021). However, FtFF without promotion currently lacks economic viability due to the relatively high cost to achieve the required contribution to micronutrient nutrient reference values (NRVs). Local cost optimization of product formulations by using blends of natural and synthetic fortificants to attain the required micronutrient content can be applied as a stopgap while food value chains for FtFF ingredients in these communities are improved to reduce input cost (De Groote et al., 2020, 2021). We are also starting to see evidence that in rural Niger where FtF concepts are being adopted through our Hub & Spoke model, composite flours produced fortificant plant materials grown at the village level are finding higher levels of sales and adoption (unpublished observation). This is important, since for these communities, access to synthetic fortificants and even food-aid can be limiting and FtF application through local entrepreneurs represents a novel way to enhance availability of nutritious foods.

3. Distribution and Marketing

Nutritionally fortified flours are a highly suitable product for ElFF. These dry flours have a long storage life, up to 6 months at ambient temperature, unlike other nutritious foods like meat and dairy products that have to be refrigerated, frozen or sterilized, which are energy-intensive and hence costly processes, often beyond the reach of small-scale food processors. More generally, as ElFF are business enterprises based in local communities, the distribution

chains are short, giving their products a cost advantage over imported competitor products and keeping profits in the local economy. Data from an entrepreneur in Senegal, Touba Darou Salam, concerning the sale location for its instant porridge flour product revealed that sales by the company's associates from their own homes was the single largest sector, with door-to-door sales also being important (O'Brien et al., 2022). These can be considered as forms of direct marketing and selling to consumers. Sales through local markets were also important. Of note is that many families in such food-insecure communities are dependent to a greater or lesser degree on food assistance. In the case of the Touba Darou Salam enterprise, a local faith-based organization that distributes food to the needy, and other governmental and non-governmental organizations are also major customers.

4. Achieving scale

4.1 Entrepreneur incubation

Achieving a viable scale of operation is necessary not only for the sustainable economic success of the food processing enterprise, but equally importantly to have a significant impact on the nutritional status of local communities in developing economies. As such, business/technology incubators become critical partners in the creation of new- and mentoring of existing micro-, small- and medium-size (SSME) food processors in the adoption of suitable food and nutritional technologies and approaches where formal infrastructure is lacking to support local industry. In these communities, medium-size enterprises typically produced around 5 tons of product per day, small-size enterprises produced around 1 ton per day and micro-enterprises around 200 kg per day.

ElFF, in particular, requires entrepreneur processors to have the know-how that enables them to use more advanced food processing and ingredient technologies needed to create enhanced

nutritional products. Further, they must produce products of consistent quality and that consumers want to purchase. To meet these needs, our collaborations have developed and refined a business/technology incubation system we call the "Hub-and-Spoke Food Innovation System" (Hamaker et al., 2018). The Hub, which is a local national agricultural or food research institute or university, nurtures and provides the entrepreneur processors with food technology and processing knowledge and business support through training, joint product development activities, and technical backstopping. The "Spokes" are either urban entrepreneur processors or rural women and youth association micro-type enterprises.

Ideally, the Hubs should also be responsible for ensuring that the processors conform to food manufacturing standards and that their ElFF products meet the required contents of nutrients. These activities can be sustained through a system of usage fee or commission on sales. This way, economies of scale and consequent cost minimization will be achieved as the Hub will be providing this service for numerous enterprises.

Through the Hub-and-Spoke system, some 26 processors in the Sahel region and East Africa have been incubated to produce and successfully sell nutritionally fortified foods into the marketplace (Table 2). As shown, in Dakar, Senegal the Institut d'Technologie Alimentaire (ITA), acts as the Hub and has mentored the largest Spoke to date, which is the Touba Darou Salam food processing enterprise, referred to above. In Niger, the Hub is at the Institut National de la Recherche Agronomique du Niger (INRAN), which has mentored 16 enterprises both in urban and rural locations. Rural processor associations of approximately 30-40 women now sell fortified and non-fortified products in local markets and for events such as weddings and funerals. At each of the rural sites, processor associations have under

their own initiative trained women in peripheral villages to be processors, thus creating secondary and even tertiary processing sites.

From our experience, having even a minimal extended support of processing businesses greatly reduces chances of business failure. There is a need for technical and business support and training that can be fulfilled in a low-cost way by local agricultural research centers or universities.

4.2 Entrepreneur case study

As the Touba Darou Salam food processing enterprise in Senegal is the currently largest producer of fortified staple grain foods of the entrepreneurs mentored, it was selected for case study. The methodology employed involved interviews with the owners of the enterprise and surveying key stakeholders such as including farmers, processors, retailers, and medical personnel, by means participatory focus group activities (O'Brien et al., 2022).

The study revealed that the manufacture of fortified instant porridge flours can be an economically viable business for small-scale entrepreneurs. In 2019, Touba Darou Salam produced nearly 200 tons of flour with a market value of around US$ 300,000. The business, which is connected to a women's network of traders and sellers, has grown steadily since its inception in 2016, as evidenced by it gaining of a second extrusion cooker in 2020 and the advent of competitor companies in the region. The income generated by this business impacts more than 1000 women, several hundred of whom are involved in product sales. Other beneficiaries are both upstream, i.e. local farmers, and downstream, mainly retailers but also through health clinics where the instant fortified porridge flour is sold. Interviews conducted with the women revealed that whilst the largest use for this additional income is

towards education of their children, there is a potential impact to diet quality, diversity and overall nutritional impact as 66% also use it to purchase staple foods, and 25% and 19% to purchase meat and fruits and vegetables, respectively.

Research in Senegal and Kenya is currently being undertaken to estimate the potential impact of purchase of the fortified instant porridge flours by consumers on their nutritional status and that of their families. The porridge flours are formulated so that a 50 g serving of the porridge provides more than 20% of an adult's NRV for vitamin A, iron and zinc.

5. Complementing with other interventions to address micronutrient deficiencies and national nutritional strategies

The US Agency for International Development (USAID, 2018) describes several categories of food-based interventions to deliver micronutrients: Mass fortification - addition of micronutrients and vitamins into widely consumed basic foodstuffs; Targeted fortification – micronutrient addition to foods that a specific population or age group eats; Commercial-driven fortification - food manufacturers fortify their products with micronutrients to increase marketability; plus Agricultural approaches such as biofortification and dietary diversification and modification. ElFF interfaces and can enhance translation of each (Fig. 1), delivering targeted fortification strategies using commercial platforms. Its reliance on natural micronutrient-rich plant foods also allows it to boost dietary diversification and serves as a commercial outlet for biofortified foodstuffs, enhancing their potential adoption by local farmers. Additionally, ElFF can add to the efficacy of governmental fortification schemes and more interface with national nutritional strategies.

Implementation of ElFF should be constantly monitored and success metrics should consider both impact to the availability of nutritious foods in a community or region as well as to the increased economic impact created by the activities. We propose that successful implementation and potential for direct nutritional impact be assessed based on the quantity of fortified food purchased from the enterprise per population size of a local community. Similarly, the economic impact, and indirect benefit to nutritional goals, would be assessed based on the number of person hours of primary and secondary employment by the enterprise per population size of a local community. It is important to monitor these or similar metrics in the context of active ElFF activities as direct nutritional assessments, while critical, are not as feasible to do on regional or national scales in parallel to ElFF activities. However, when nutritional studies are completed we feel that the metrics proposed to monitor ElFF activities can be used to better understand changes in micronutrient status driven by an improved food and economic environment.

6. Conclusions

Entrepreneur-led Food Fortification complements existing food-based initiatives to address micronutrient deficiencies like conventional (mass) fortification and biofortification and can link to national government nutrition strategies of developing countries. Moreover, it can be financially self-sustaining as illustrated in Fig. 2. This is because ElFF can capture local market dynamics through its insight into and matching of consumer demands and food ingredient supply. This enables continuous product improvement and cost optimization, coupled with retention of income generated within communities, in addition to directly improving people's nutrition. A key element required for ElFF commercial success and

impact at scale is technical and business incubation through local national food-type institutes.

CRediT author statement

JRNT, conceptualization, writing-original draft; MGF, conceptualization, writing-review & editing; CN, conceptualization; DT, conceptualization; VKM, conceptualization; HDG, writing-review & editing; CO'B, writing-review & editing; TJR, conceptualization; BRH, conceptualization, writing-review & editing

Competing interests

The authors declare no competing interests.

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CAPTIONS TO FIGURES

Fig. 1 Characteristics of Entrepreneur-led Food Fortification and relationship with other food-based interventions to deliver micronutrients. The categorization of interventions is according to USAID (2018). Filled arrows indicate direct links and open arrows indicated indirect links with other food based interventions.

Fig. 2 Entrepreneur-led Food Fortification value chain

Table 1. Identified consumer nutritious food value propositions for small/micro-scale food processing entrepreneurs in Africa

Consumer demand	**Value proposition - Approach/Technology**	**Justification**
Low cost	Nutritional fortification of starchy staples Food-to-Food Fortification (FtFF) supplemented with conventional fortification	Starchy staples are the least costly of foodstuffs
	Wholegrain foodstuffs	Minimal processing losses
	Dry flour products	Long storage life without refrigeration
	Short supply chain	Lower cost than comparable imported products
Good taste	Meals based on local grains and where appreciated on wholegrains	Drive consumer demand, Satiety
	Local fruit ingredient inclusion	Attractive flavors, natural colors; Consumer recognition
Convenient	Pre-prepared meals –blends of staples and macro- and micronutrient-rich foods	Minimal preparation time
	Pre-cooked ready-to-eat meals – Instant flours produced by extrusion cooking	Minimal cooking time
Healthy and natural	Pulses, fruits and vegetables as Food-to-Food fortificants	Rich sources of protein, vitamins, minerals and phytochemicals; Translation of health messages by association to local plant foods
My culture	Meal products based on traditional porridges, gruels and local ingredients	Appeal to tradition
	Meal products made with local starchy staples such as millets and sorghum	These grains are well-adapted to cultivation in local environments Appeal to tradition
My community	Foodstuffs produced by local farmers	Providing a steady markets for local small-holder farmers Keeping income within the community

Table 2: Summary of small fortified food enterprises (spokes) in Africa incubated by local institutions (hubs) through the Hub-and-Spoke Food Innovation System

Hub/Local institution	Spoke/Food processing enterprise location	Funding	Year Initiated	Type of support received	Status	Food products
INRAN – Niger		***INTSORMIL (USAID) & Feed the Future Innovation Lab for Sorghum and Millets (SMIL) & McKnight Foundation***		***Technical support, Equipment***	***Ongoing***	
		Primary rural spokes - Niger				
	Falwel		2013	Technical support, Equipment, Business Training	Actively selling	Fortified flours, Dégué (Millet couscous+yoghurt), Couscous, Nutrient-dense snacks
	Tera		2013	Technical support, Equipment, Business Training	Actively selling	Fortified flours, Dégué, Couscous, Nutrient-dense snacks
	Sherkin Houssa		2013	Technical support, Equipment, Business Training	Actively selling	Fortified flours, Dégué, Couscous, Nutrient-dense snacks
	Gadan Iya		2015	Technical Support, Equipment, Business Training	Actively selling	Fortified flours, Dégué, Couscous, Nutrient-dense snacks
		Primary urban spokes - Niger (10)				
	Local Niamey Processors	SMIL	2005	Technical support, Business training	Actively selling	Fortified flours, Dégué, Couscous,

						Nutrient-dense snacks
IRSAT – Burkina Faso		***SMIL & McKnight Foundation***			***Ongoing***	
		Primary spokes - Burkina Faso				
	Lebda		2013	Technical support, Equipment	Actively selling	Fortified flours, Dégué, Couscous, Nutrient-dense snacks
	Amdemtinga		2020	Technical support, Equipment	Actively selling	Fortified flours, Dégué, Couscous, Nutrient-dense snacks
IER-Mali		***Feed the Future Innovation Lab for Sorghum and Millet & McKnight Foundation***			***Ongoing***	
		Primary spoke – Mali				
	Dioila		2020	Technical support, Equipment	Actively selling	Fortified Flours, Dégué, Couscous, Nutrient-dense snacks
ITA-Senegal		***INTSORMIL (USAID) & Feed the Future Innovation Lab for Food Processing and Post-harvest Handling***		***Technical support, equipment***	***Ongoing***	
		Primary spokes – Senegal				
	Touba Darou Salaam		2015	Technical support, Equipment, Facility	Actively selling	Instant fortified flours

	Processing Unit			renovations		
	EKYAN Processing Unit		2020	Technical support, Equipment,	Initial incubation – Product Formulation, Not yet selling	Instant fortified flours
University of Eldoret - Kenya		***Feed the Future Innovation Lab for Food Processing and Post-harvest Handling***		***Equipment, Technical support, Facility renovation***	***Initial incubation – Product Formulation, Not yet selling***	***Instant fortified flours***
University of Nairobi - Kenya Mango Processing		***Rockefeller Foundation***		***Equipment, Technical support, Facility renovation***	***Ongoing***	***Dried mango chips, Fruit leathers, Mango juice, Mango yogurt, Mango pulp, Mango jam***
		Primary spokes – Kenya				
	Masii Processing Group		2018	Equipment, Technical support	Actively selling	Dried mango chips
	Karurumo Processing Group		2018	Equipment, Technical support	Actively selling	Mango juice, Dried mango chips, Mango jam
	Kawala Processing Group		2018	Equipment, Technical support	Trained, Not actively Selling	
	Association of Kenyan Mango Traders		2020	Equipment, Technical support	Trained, Not actively selling	Mango pulp
Nelson Mandela African Institution of Science and Technolo		***Rockefeller Foundation***		***Equipment, Technical support, Facility Renovation***	***Ongoing***	
		Primary spokes – Tanzania				

gy - Tanzania	Mbora Leki Tatu Food Processing Group		2018	Technical support, Equipment, Business training	Actively selling	Fortified flours
	Kiusaki Food Processing Group		2018	Technical support, Equipment, Business training	Actively selling	Fortified flours
	Inuka Food Processing Group		2018	Technical support, Equipment, Business training	Actively selling	Fortified flours
	Halisi Products Ltd		2019	Technical Support, Equipment, Business training	Not actively selling	Instant fortified flours

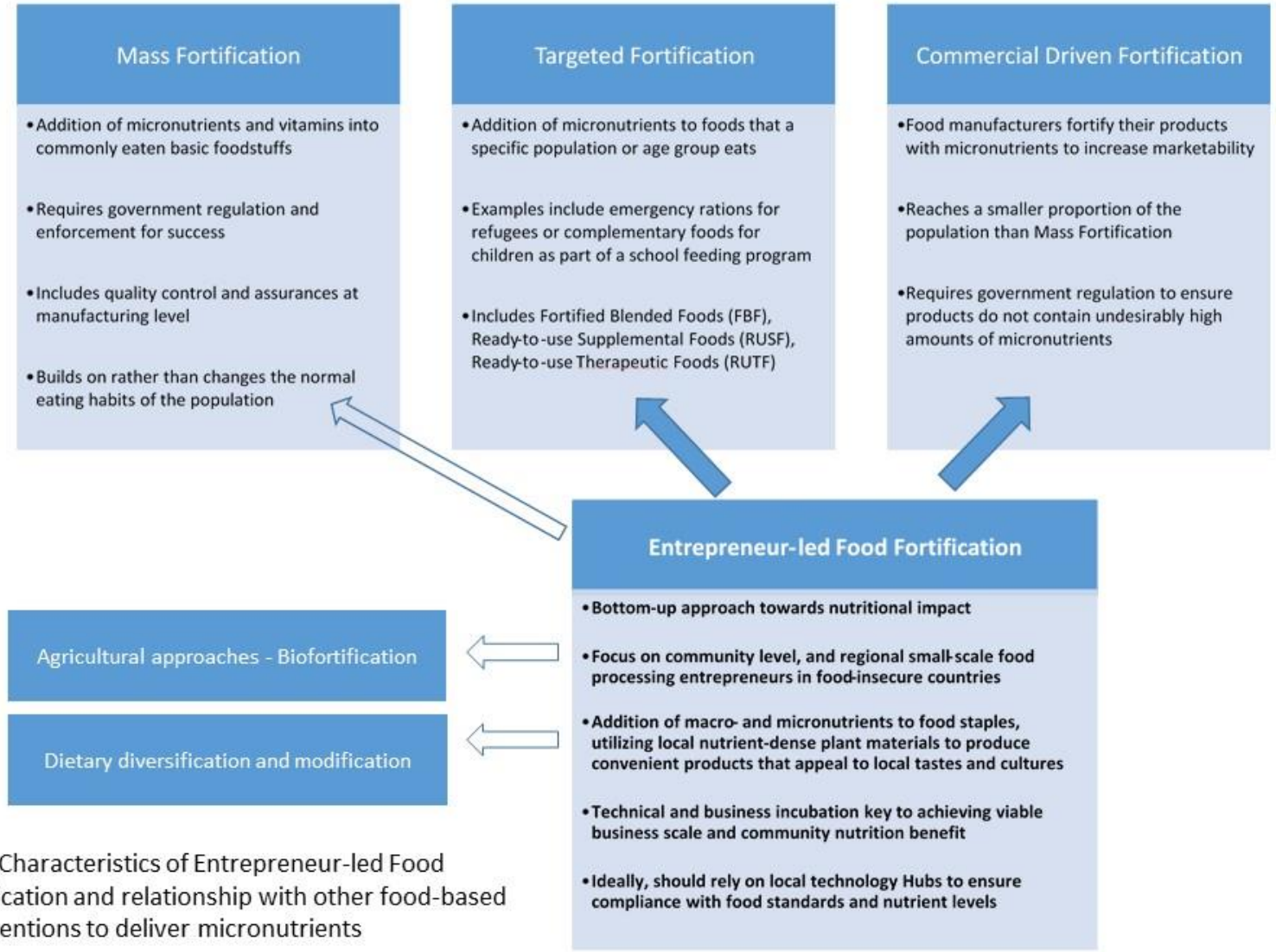

Fig. 1 Characteristics of Entrepreneur-led Food Fortification and relationship with other food-based interventions to deliver micronutrients

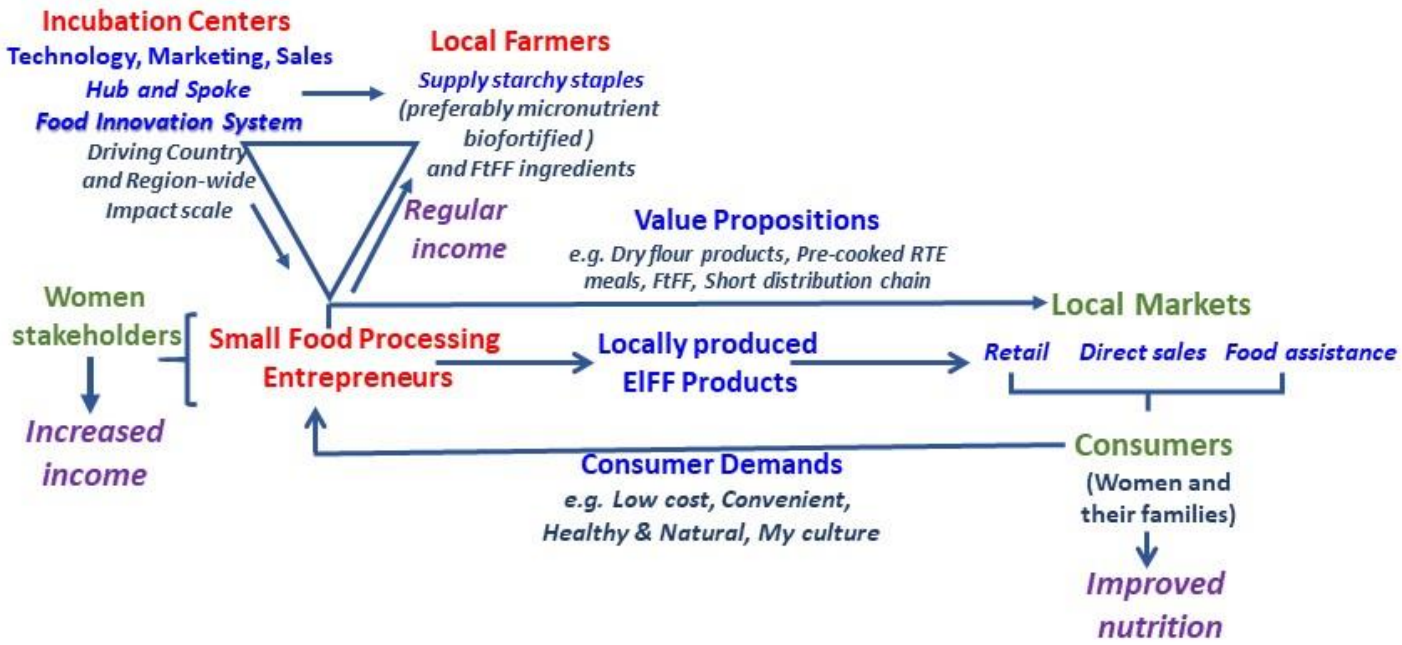

Fig. 2 Entrepreneur-led Food Fortification – Value chain