

The Transition towards Sustainable Diets Should Encourage Pulse Consumption in Children's Diets: Insights for Policies in Food Systems

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Abstract

Pulses play a central role in food system sustainability and can be the starting point toward sustainable diets. For a sustainable future, the promotion of pulses' consumption should begin early on, during infancy. This work's objective is to review and compile food policies that can support pulses promotion in children's diets and provide an overview of the role of pulses in sustainable diets. A search was performed in Food and Agriculture Organization (FAO) sites and Medline database of technical reports and papers from the last 10 years (2011–2021) using the following terms: “Legume”, “pulse”, “sustainability”, “environment”, “food system”, “nutrition”, “children”, and “policies”. Subsequently, actions that could support children's pulse consumption were selected and organized into the UNICEF's Innocenti Framework on Food Systems for Children and Adolescents. Finally, the identified actions were discussed according to the Framework's determinants (food supply chains, external food environments, personal food environment, and behaviors of caregivers and children). Considering the impact and feasibility of the compiled actions, reformulation of infant products with pulses and activities in school food environments seem to be priority measures because they are relatively simple to operate and have a high impact potential.

Keywords

Pulses, Sustainable diets, Food policies, Children

Introduction

As highlighted by the COP26, global food systems are operating at an industrial-scale, with excessive consumption of natural resources, while delivering poor health outcomes [1, 2]. The way food is produced, processed, packaged, transported, commercialized, and consumed is among the leading causes of environmental degradation and climate change. The current food production is responsible for utilizing around 40% of arable land, 70% of global freshwater, and answering for 80%–86% of all greenhouse gas (GHG) emissions related to food systems (which correspond to 11% of total global emissions) [3, 4]. Additionally, expanding agricultural land use contributes to deforestation and biodiversity loss [5, 6]. Still, the predominant food pattern from these systems is associated with increased availability of low-nutrient, highly processed foods, and animal protein-rich diets that have favored obesity and chronic diseases. At the same time, under-nutrition

persists in the developing world [7]. The coexistence of nutritional issues and climate changes, interacting with each other, and sharing social drivers have been called Global Syndemic [8]. Changing food systems to benefit human nutrition and health while protecting the environment is one of the biggest challenges for the next 30 years [3].

Sustainable food systems and diets can be defined as those that ensure healthy food for all, now and in the future, while not compromising the environment [9, 10]. Achieving sufficiently sustainable food systems is complex, involving the promotion of measures such as re-orientation in agricultural priorities, adopting food production practices that protect the environment, prioritizing short and seasonal food chains, advances in governance, and reducing food loss and waste. In addition, it is necessary to promote dietary changes that increase the demand for healthy foods with less environmental impact [7].

Data has shown that plant-based eating patterns are healthy and can decrease environmental impacts, especially in reducing GHG emissions and chemical fertilizer applications [11]. To adequately feed a growing world population without further degrading natural resources and worsening climate change, the EAT-Lancet commission evaluated nutritional and environmental evidence to suggest a healthy diet from sustainable food production, calling it the 'Planetary-health diet.' Accordingly, around 60% of daily protein intake should be plant protein [12]. Adopting the EAT-Lancet diet will demand a considerable change in western diets, with a rise of 100% in plant foods consumption and a reduction of 50% in red meat and sugar [7]. As such, dietary changes should be adapted to contexts and will not arise without challenges [13].

When discussing sources of dietary plant protein, it is essential to consider the dry-harvested legume crops, known as pulses. Pulses are farm-to-fork actors that promote healthy diets [14] and strong contributors to solving global food security challenges, such as hunger, malnutrition, chronic diseases, and climate change [15-17]. However, despite the critical function in food systems' sustainability, pulses' production and consumption have declined since the second half of the twentieth century [18]. Pulses are often rejected by the consumers and insufficiently used by farmers, caterers, and retailers [19]. In children's diets, pulses are also under-consumed, especially in developed countries [20]. The low intake is indirectly related to the supply chain [21] and directly linked to children's and caregivers' preferences, such as taste rejection and lack of knowledge in pulses' preparation [22, 23]. Additionally, as income increases in developing countries, there has been an alarming trend for pulses to be replaced by meat [16]. The FAO estimates an average world pulse consumption of 7 kg per person per year when the recommendation should be 15-25 kg person-year [24, 25]. Given all benefits, identifying strategies and policies for promoting pulse consumption should be amongst the top priorities of policymakers.

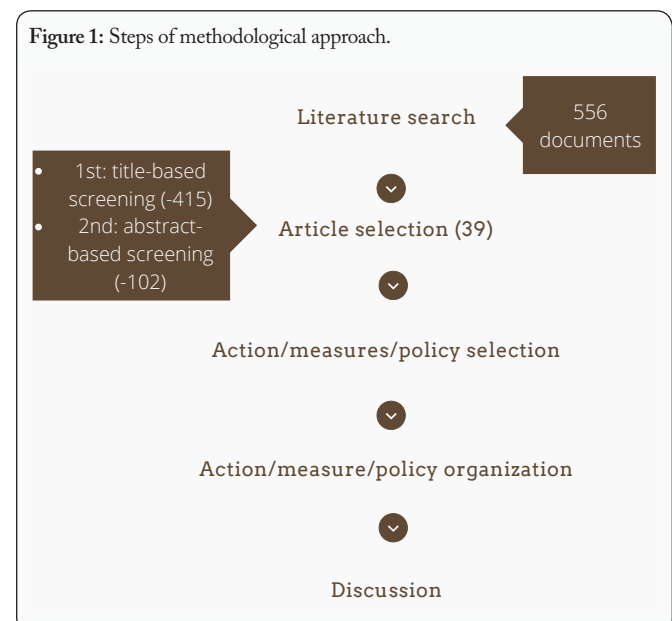
However, implementing dietary changes requires many alterations in several sectors of the food system [2]. Since food preferences develop early in childhood, this is an opportune

period to encourage healthy diets [26] and pulse consumption. Implementing actions across the food system to promote pulses' consumption by children could have significant positive impacts on both health and the environment [13, 27]. The Innocenti Framework, developed by the United Nations Children's Fund (UNICEF) and the Global Alliance for Improved Nutrition (GAIN), explains how the interaction among different actors in the food system interfere with children's and adolescents' diets [28]. It includes drivers (environmental, social, technological, demographic, political, and economic) and four determinants (food supply chains, external food environments, personal food environment, and behaviors of caregivers and children), which affect children's diets. The main objective of this work is to review and compile food policies that can support pulse consumption in children's diets from a food system perspective. We also provided an overview of the role of pulses in sustainable diets and framed the necessary actions and steps to promote pulse consumption in the context of the Innocenti Framework. The scope of this work is related to pulses, but some arguments presented here may be relevant to other plant-based foods that make up sustainable diets.

Methodology

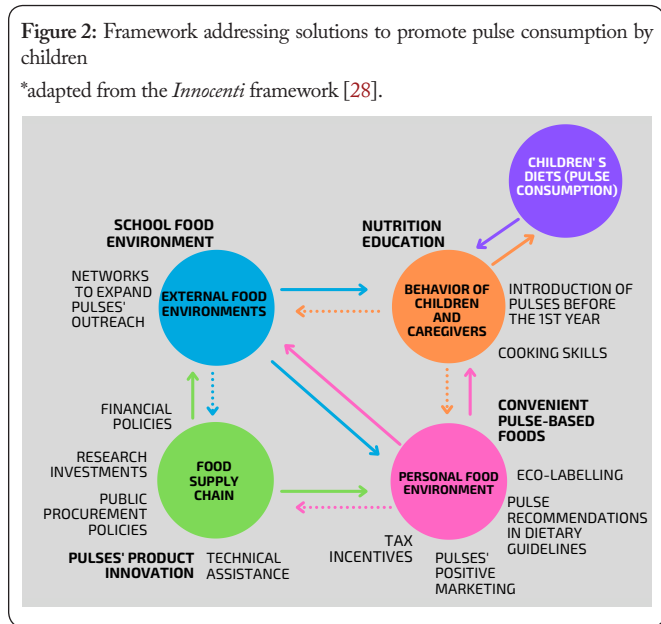
The development of the present work occurred according to the stages exemplified in figure 1. First, technical reports and articles from the last 10 years (2011-2021) were searched using the Food and Agriculture Organization (FAO) and the Medline databases. Articles outside this period were only considered if cross-referenced by the more recent references. The literature review was conducted using the following terms: "Legume", "pulse", "sustainability", "environment", "food system", "nutrition", "children", and "policies". The title of the researched documents was analyzed, and all files that dealt with data referring only to specific countries or that did not have a theme directly related to the review were excluded. After the first screening, the abstracts were read, and only documents that presented a clear path to health, nutrition, and sustain-

Figure 1: Steps of methodological approach.



ability, or addressed issues related to pulses' benefits, were included. Considering this methodology, 39 documents were selected that contained relevant information. In the second step, the actions and measures (which included policies, programs, and campaigns) were selected. We prioritized the inclusion of actions addressing the needs and conditions of the child population and flexible enough to address different age groups and socioeconomic conditions. After selecting the measures, we organized and discussed them according to the Innocenti Framework determinants (Figure 2), which are: food supply chains, external food environments, personal food environment, and behaviors of caregivers and children.

Results and Discussion



The role of pulses in sustainable diets

According to Miller et al. [29], sustainable diets' definitions and parameters usually involve four main domains: cultural relevance, environment, food accessibility, and public health. Identifying solutions that address all domains simultaneously is an effective way to promote sustainable diets. In this sense, pulses appear as a suitable solution, fitting into all domains.

Pulses are ancient plants cultivated by humans included across cultures and cuisines worldwide [16]. Unlike other crops, pulses have a capacity for symbiotic atmospheric nitrogen (N) fixation, which permits a more sustainable cultivation system by reducing synthetic N fertilizer usage. This self-sufficiency represents an environmental advantage since N fertilizers lead to GHG emissions [21] and globally are a significant source of eutrophication [3]. When pulses are integrated into cropping systems, GHG emissions can be up to seven times less per unit area than other crops [30].

Also, pulses cultivation increases soil carbon sequestration, which contributes to partial absorption of atmospheric CO₂ while promoting soil biodiversity, recovering or improving soil fertility [16]. These benefits are only available when pulses are included in cropping systems (e.g. via inter-crop-

ping, crop mixtures, conservation agriculture, agroforestry, and others). In these contexts, pulses can enhance yield, reduce pests and diseases, and increase the resilience of food production systems [31].

Pulses are among the most nutritionally valued crops on the planet. In developing countries, where animal protein is inaccessible for part of the population, pulses represent an inexpensive source of dietary protein. When used to replace dietary animal protein, pulses can mitigate the pressure on natural resources, such as land and water, and indirectly reduce GHG emissions associated with livestock management [18]. In developed countries, pulses could partially (or totally) replace animal proteins, providing environmental and health gains [32]. Harwatt et al. [33] predicted that if the American population substituted beef for beans in a hypothetical situation, considering equivalent calories and proteins, the US could reach up to 74% of the 2020 GHG reduction target.

Unlike other nutrient-dense foods such as fruit, vegetables, and animal protein, pulses have storage advantages over fresh products, staying wholesome over long shelf-life periods, without cold chain requirements. This renders pulses suitable for the reality of low-income settings and represents a substantial benefit in terms of food waste [34, 35]. Therefore, pulses are an affordable and environmentally friendly source of protein [34], that can fit in different socioeconomic contexts.

Pulses also have demonstrated a significant role in preventing and controlling frequent diseases worldwide, such as obesity, diabetes, cardiovascular diseases, and cancer [36, 37]. In children's diets, pulses' consumption helps to achieve daily intake recommendations for protein, fiber, and minerals. Furthermore, pulses may help prevent childhood obesity and be an effective alternative to control glycemic response in diabetic children [20]. Due to all its advantages, pulses emerge as a crucial food in sustainable diets.

Promoting pulses' consumption in childhood

Promoting pulses' consumption in childhood requires the governance of a set of actions with multiple complexity levels. In food policy development, it is essential to identify potential entry points for changes, focus on critical areas of intervention, and list the priority actions [38-40]. Adopting the Innocenti Framework's structure allowed a clear identification of entry points for changes and enabled a systemic view of policy decisions (Figure 2). In table 1 the actions that can support pulse consumption in childhood are compiled, and in the following sections, these actions are presented and discussed.

Actions in the food supply chain

The food supply chain enrolls activities and players related to food production, storage, distribution, processing, retail, and markets. Food producers and suppliers, guided by several factors, choose food to grow, deliver, and sell. Therefore, they choose which foods will be available in the food environments. Incentives and disincentives for certain foods' production directly impact the quantity, quality, and food price available [28]. Thus, interventions across food supply chains can improve pulses' availability, affordability, and acceptability.

Table 1: Policies that support the inclusion of pulses in children's diets.

Determinants	Actions	Responsibilities	References
Food supply chain	Financial policies	Governments	[42]
	Research investments	Governments, academy	[42]
	Technical assistance	Governments	[42]
	Government procurement	Governments	[43]
	Product innovations	Food industries, academy, governments	[24]
External food environments	Nets to expanding pulses' reach	Governments, retailers	[14]
	School food environments	Governments, public and private schools	[52]
Personal food environment	Pulses' positive marketing	Governments, NGOs*, retailers and food industries	[24]
	Convenient pulses' products	Food industries, academy	[24]
	Recommendations in food guidelines	Governments	[27, 55]
	Labeling	Governments, retailers, food industry	[13]
	Tax incentive	Governments	[50]
Behavior of children and caregivers	Nutritional education	Schools, health professionals, health centers, caregivers, nurseries, NGOs	[72, 73]
	Pulse cooking skills	Caregivers, schools, NGOs, health centers	[63, 64]
	Introduce pulses in complementary diet before the first year	Caregivers, health professionals, nurseries	[20, 68]

* NGOs, non-governmental organizations

For more sustainable diets, nutrition and environmental cost should guide the decisions within the agri-food systems, and the governments must align agriculture policies with nutrition policies [41]. However, food production investments and research have prioritized staple crops and oil-seeds over other crops with more considerable nutritional potential [13]. Compared to cereals, pulses have unstable yields and low returns, in part because they have been broadly forgotten in investments [21, 30]. Policymakers should provide strategies to sustainably support pulses' integration into cropping systems, encouraging the production of locally adapted pulses. Suggested necessary actions that enable sufficient and consistent pulses' supplies would be: encouraging research in public and private sectors to develop high-yielding, abiotic/biotic stress-resistant varieties of pulses; support to smallholder producers by extension services and technical assistance, the supply of technologies and inputs; provide access to financing resources, and laws assuring fair prices [42]. Supporting pulse production needs to be accompanied by measures to increase demand. Governmental procurement can align supply chains for sustainable pulses' production. The procurement, followed by the distribution, has been an efficient initiative to stimulate the local food chain [43]. A program of procurement and distribution operated in Brazil between 2003 and 2019, promoted an increase in the income of small producers, improved the quality of food for beneficiaries and, promoted crop diversification [44]

Policies that promote pulses in value chains

Experts considered that measures focusing on the pulse supply chain have a high potential to promote sustainable food systems if incentives for short food chains and domestic production are available [45]. In addition, policy analysts

claim that to observe an effective impact of pulses' production in sustainability, governments should clearly determine goals and indicators for the long-term, provide legislation and infrastructure, promote intersectoral articulation, and encourage the creation of value chains [46]. Considering this, the development or reformulation of food products using pulses from sustainable and local farming systems can have a high potential impact on food sustainability. Governments can favor the construction of these value chains through policies and agreements with the food industry, supported by the academy.

Most food ingredients used by the food industry are derived from wheat, corn, or soy. This may result in products with a poor nutritional profile, rich in starch, sugar, and fat. Product reformulation towards more nutritious, healthy, and sustainable foods is crucial, and pulses provide several opportunities to be utilized in processed foods, enhancing their nutritional quality and adding technological properties [47]. However, a limitation in adding pulses to food products is overall consumer acceptance [48]. Thus, product reformulation with pulses should mostly target younger consumers whose taste preferences are not yet established [35]. Enriched processed foods with pulses can fortify these products naturally, improving micronutrient intakes by children. In this sense, pulses have a remarkable chance to be added, for example, to infants' and toddlers' foods [24]. The children's nutritional needs should be central in creating such food products, and if these are developed using a child-centered approach, it increases their likelihood of uptake.

Actions in food environments

Food environments are the food system interface related

to food availability, accessibility, convenience, and desire [49]. The set of environmental, economic, social, and cultural characteristics converge to form the food environment in a community [50]. These can be divided into external and personal food environments.

Food environments are crucial places to implement interventions for dietary changes because they contain the scope of options that can influence consumers' choices, with massive potential of impact [49]. Shaping food environments through measures and policies that determine food availability, price, and attractiveness can facilitate choices consistent with sustainable diets [2].

External food environments

The external food environments comprise the factors that interfere with food availability [28]. This dimension of food environments has a more direct relationship with the food supply chain. Dynamics of supply are directly responsible for increasing the availability of pulses in food environments. Studies that have examined how food availability shapes dietary intake have found a strong positive relationship between healthy food availability and its consumption [51]. Therefore, it is fundamental to create structures that improve connectivity between rural, peri-urban, and urban supply and demand. It is also important to link small and medium pulse producers with food processors and retailers (including schools, kindergartens, and municipalities) or directly with the consumers. These are essential measures to expand the reach of pulse grains, pulse products, and pulse meals [13, 14].

In terms of shaping children's diets, the school food environment is a decisive space due to its strong influence on infant feeding. Schools have a highly favorable environment to promote and provide pulses for children and adolescents by making these foods available in school settings [50]. In this sense, an excellent action to promote pulses' consumption among children is to make pulses more accessible and convenient in schools by incorporating pulses in school feeding programs, increasing pulses frequency at schools' menus, and offering pulse-based meals and snacks. Both developed and developing countries could adopt similar measures [52]. This is the case of Portugal, which in 2017 made the vegetarian option mandatory on the menus of public canteens and cafeterias [53]. Such attitude allows an increase in the availability of pulses in schools, as they emerge as the main source of protein in these meals [54].

The school food environment is also an essential player in the food system due to its impact on other dimensions. For example, the food procurement for school meal programs can support local food supply chains and favor sustainability [52]. In addition, schools are the ideal place to carry out actions that can positively impact the behavior of children and caregivers, such as nutritional education and cooking skills. In the school food environment, nutrition education can go beyond the transmission of information and encompass strategies for behavior change [55]. A systematic review of European studies found strong evidence that multi-component interventions in school food environments, coupling the rise of the avail-

ability of healthy foods with educational actions and some parental involvement, can improve healthy food consumption among children [56]. In this context, a set of strategies that combine information with increased exposure of pulses at the school menu could effectively increase their consumption in children's diets.

Personal food environment

Personal food environment encompasses the factors that interfere in food choices at the individual and household levels, such as cultural factors, food cost and affordability (economic access), convenience, desirability, and information [28].

Food prices are an essential determinant of food demand. In recent years, overall pulse prices tended to rise, namely due to production's inability to increase at the same pace as the population [57]. Measures already mentioned in the food supply chain to encourage pulses' cultivation may reduce the prices. Also, fiscal measures, mainly through taxes and subsidies on food, may impact prices and influence consumers' purchasing and consumption choices. In high-income countries, subsidies to nutrient-rich foods tend to improve the diet's quality. Subsidizing pulses could increase the purchase and consumption of these foods. However, a subsidy to the pulse's price applied in India has not significantly increased consumption. Further studies are needed to assess this measure's effectiveness, especially in low and middle-income countries [50].

Food promotion is another factor that interferes with personal food choice. This type of strategy is usually underused by policymakers [2]. Studies point that food promotion actions strongly influence children's preferences, nutrition knowledge, and consumption patterns [58]. A dedicated campaign developed by governments encouraging pulse consumption may positively impact dietary choices. Marketing concerted to educational approach supported by policy from health, education, and environmental ministries could be highly effective. Also, disclosure strategies tailored to children and caregivers, such as branding, social marketing campaigns, and cooking contests, could be good initiatives developed by both the public and private sectors [24].

A significant restriction for pulse consumption is their long preparation time [27], which indirectly lowers the availability of home-cooked pulses in children's diets. Innovations to reduce cooking time and produce more practical or "ready-to-eat" pulse-based foods could stimulate higher consumption [24]. The number of pulse-based innovative food products has risen substantially in the last decade [48].

Regarding consumer information, a significant measure is to include pulse recommendations for children in national food guidelines. Dietary guidelines and nutritional recommendations provide information that influences individuals' food choices, orient food policies and industry decisions [55]. We recently compiled pulses' recommendations for children in food guides from several countries [20]. Another measure is to promote ecologically friendly labels that showcase the benefits of pulse products. According to European Union legislation, several nutrition claims should be applied for products that

use pulses as an ingredient [59]. Also, pulses' products present, in general, a lower environmental cost while offering higher nutritional density when compared with similar products available in the market [60, 61]. If this type of information is displayed on labels, it should encourage consumers to make more sustainable food choices. Of course, before this becomes a reality, further research is needed to clearly define the sustainability properties of foods [49]. Besides shaping consumer preferences, nutrition labels can encourage the industry to reformulate the products [13].

Actions related to the behavior of children and caregivers

Children and caregivers' behavior is the factor that most directly influences children's diets. Parents and caregivers need to be oriented and supported to develop healthful home food environments and prepare healthy meals addressing children's food preferences [62]. The younger the child, the higher the parents' and caregivers' responsibility for infant feeding and the parents' knowledge, skills, experience, income, and time, all influence the food that is purchased, prepared, and provided [28]. With regards to pulses, low cooking and preparation skills continue to be a relevant barrier for their consumption [22]. Literature suggests that developing pulse cooking skills and enhancing pulses' flavor through preparation may increase their consumption among children [63, 64]. Pulse cooking skills can be taught as a means of nutrition education for children and caregivers in schools and community kitchens [55]. Also, the dissemination of pulse recipes and cooking books, especially when tailored to children's preferences, could help parents, caregivers, and schools to introduce pulse in children's diets. A recent example was developed by the H2020 project TRUE [65].

Another efficient way to promote pulse consumption is to rescue the food cultural heritage of traditional populations. The vast geographical range of pulses allowed the development of many delicious dishes across countries [16]. There is a richness of traditional pulse-based dishes that are often a staple to children around the world. These and other recipes adapted to contexts and modern family routines can be vehicles for promoting pulse consumption. One example of this type of initiative came from the Slow Food movement that has been working to preserve the local culinary traditions across the globe. A cookbook with traditional and modern European pulse recipes was recently organized by Slow Food Deutschland [66].

Personal preferences and tastes are also crucial for pulse acceptability. In many contexts, consumers reject pulses due to digestive intolerance, lack of habits, and taste rejection [23, 27, 67]. Here, introducing healthy and diverse foods in the complementary feed may help form taste preferences and good eating habits later in life [68]. Babies have an innate fondness for sweet and salty tastes and an aversion to bitter taste [69]. Thus, the introduction of pulses at an early stage is crucial for the lifelong acceptance of these foods. According to most recommendations, pulses should be introduced into infant feeding before the first year of life [20]. However, in some places there is a belief that pulses are not suitable for young children

[27]. In these cases, it is important to emphasize that after domestic processing (e.g., soaking and cooking) to remove anti-nutritional compounds, pulses are an excellent complementary food to help infants and young children meet their daily nutritional demands [70].

Finally, an extremely relevant action that can promote pulses consumption is education in food and nutrition for children and caregivers. Nutrition education must stimulate critical analysis of food choices and help to develop skills that favor a healthy lifestyle [71]. It is considered an essential component in improving children's food patterns, positively impacting children's nutrition status [72, 73]. A nutritional education program to raise awareness about pulses' benefits, enrolling children and caregivers, would be highly effective.

Conclusion

Pulses can improve infant nutrition with a low environmental cost, and promoting pulse consumption in childhood may be the first step for sustainable diets adoption. A set of policies can promote pulses in children's diets while enabling more sustainable food systems. The implementation of these policies requires coordination actions and decisions about priorities. Considering the impact and feasibility of the identified actions, reformulation of infant products with pulses and actions in school food environments seem to be good measures because they are relatively simple to operate and have a high impact potential if well-articulated within the system.

Conflict of Interest

Authors declare no conflict of interest.

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Authorship

Our article represents the original work of the authors, which contributed significantly to the work's conception. Evla D.F. Vieira did the design, data interpretation, analysis, and writing. Marta W. Vasconcelos, Ana M. Gil & Ana M. Gomes did a critical revision of the article, read and approved the version of the manuscript. No authorship has been omitted.

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