

The Tomato: A Nutritious and Profitable Vegetable to Promote in Burkina Faso

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ABSTRACT

In Burkina Faso, dietary patterns lack diversification and is characterized by a low consumption of vegetables. This is attributable to rooted eating habits, limited accessibility to vegetables, and a lack of awareness regarding the positive health effects and overall well-being associated with vegetable consumption. Raising consumers' awareness about the benefits of high intake of vegetables such as tomatoes can boost vegetable demand and supply. This review aims to highlight the nutritional characteristics and health benefits of tomato consumption, as well as its socio-economic importance for the population, especially women and youth. The literature revealed that tomato is recognized as a good source of carbohydrates, proteins, fatty acids, minerals, vitamins, amino acids and phenolic compounds and has therapeutic properties that can treat diarrhea and hypertension. A number of studies have reported that tomato's consumption help reduce the risk of cardiovascular disease, cancer and diabetes. Furthermore, tomato cultivation generates substantial income for producers and so reduces seasonal unemployment and poverty in many regions. Additionally, tomato cultivation can contribute to the resilience of populations to tackle the effects of climate change by enhancing food and nutritional security.

Keywords: Tomato (*Solanum lycopersicum* L.), Food security, Health, Income, Nutrition.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a diploid plant with $2n = 24$ chromosomes, belonging to the *Solanaceae* family (Peralta and Spooner, 2000) along with other important commercial vegetables crops such as potato, pepper, and eggplant (Milne-Edwards, 1864 and Peralta and Spooner, 2000).

Tomato originates from the Andean region in South American, where wild relatives like cherry tomatoes (*Solanum lycopersicum ceraciforme*) were found (Philouze, 1986 and Gilgenkrantz, 2012). It was domesticated in Mexico before being introduced in Europe by the Spanish in 1544 (Katz, 1992). Tomato cultivation spread from Europe to South and East Asia, Africa, and the Middle East through a combination of historical, cultural, and economic factors (Elise *et al.*, 1989 and Gilgenkrantz, 2012). It is grown as an annual plant (Elise *et al.*, 1989). Like most exotic vegetables, tomato reached the Sudano-Sahelian zones during the 1930s, the colonial period (Ouedraogo, 1993 and CPF, 2011). In these regions, agriculture experienced significant changes following droughts in the 1970s, leading to the construction of numerous dams and the development of irrigated areas (Bidon, 1995). Then, tomato cultivation was gradually adopted by local populations in Burkina Faso (Ouedraogo, 1993 and Kaboré, 1994). Since then, this crop occupies an important place in the country's economy.

Tomato fruits are rich in fiber, antioxidants, minor elements (manganese, copper, etc.), vitamins (B1 and B6), offering therapeutic properties that can treat diarrhea, hypertension (Ali *et al.*, 2020). Beyond their health attributes, the cultivation of tomatoes serves as an economic engine, generating income for farmers, agro-dealers, and traders within the tomato value chain (Goka *et al.*, 2021). Therefore, tomato cultivation is a real opportunity, which can create numerous jobs for the population, as the overall vegetable sector in Burkina Faso (DGESS, 2022). Tomato cultivation can play a central role in addressing issues related to food security, public health, and poverty alleviation in the country (DGESS, 2022). Despite its importance, according to

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the agricultural statistics dashboard, tomato consumption in Burkina Faso was 1,184,000 metric tons in 2019, which corresponds to a per capita consumption of 56 kg/year or 153 g/day (DGESS, 2022). Vegetables consumption remains generally low compared to cereals (Bidisha *et al.*, 2017 and Sanou *et al.*, 2018). The expenses devoted to vegetables hardly exceed 15% of the total budget in Sub-Saharan households (FAO, 2021). This situation is due to the low availability and cost of vegetables, education and culture of populations, and the lack of awareness about the beneficial effects of vegetables on health and nutrition (FAO, 2021).

The objective of this review is to highlight key findings regarding the significance and role of tomatoes in addressing issues related to food security, nutrition, and poverty alleviation; providing policymakers with valuable insights that may inspire initiatives geared towards the enhancement and fortification of the tomato sector in Burkina Faso.

BOTANY OF CULTIVATED TOMATO

Taxonomy

Tomatoes have had different name over the years. Before the scientific nomenclature, tomato was formerly known as “pommed’or” or “pommed’amour” (Peralta *et al.*, 2006). In 1753, it was classified as belonging to genus *Lycopersicum* and *Solanaceae* family by Carl Von Linné, founder of the binomial nomenclature system (Peralta *et al.*, 2006). However, in 1768, Miller proposed *Lycopersicum esculentum*, which has been used for many decades. According to Miller, tomatoes belonged in a different genus from poisonous nightshade species. Nowadays, although both names can be found in several documents, *Solanum lycopersicum* remains the most dominant of tomato plant (Blancard *et al.*, 2009). Based on information related to tomato genes, using advanced genetic research methods,

taxonomists reclassified tomatoes as belonging to the genus *Solanum* (Table 1).

Tomato plant anatomy

Depending on the variety and the cultivation mode, tomato plant height ranges from 0.4m to 2 m (Leskovar *et al.*, 1991; Rai *et al.*, 2016 and Coulibaly *et al.*, 2019). The stem has an erect or prostrate growth habit, hairy and glandular (Naika *et al.*, 2005). Leaves are spirally arranged with 3 to 7 ovate or oblong hairy leaflets (Figure 1A) (Salim *et al.*, 2020). Leaves length range from 15 to 50 cm, while leaves width ranges from 10 to 30 cm (Frery *et al.*, 2004; Rai *et al.*, 2016 and Salim *et al.*, 2020). The plant root system possesses a central pivot-rooted with numerous lateral and secondary roots (Alaguero-Cordovilla *et al.*, 2018). Root may grow deep more than 50 cm in the soil (Machado & Oliveira, 2005 and Alaguero-Cordovilla *et al.*, 2018).

The flower consists of a calyx with 5 to 6 green lobes (Toni *et al.*, 2021). The corolla is zygomorphic with yellow petals (Toni *et al.*, 2021). Androecium is composed of 6 stamens, while gynoecium possesses a multi-carpella ovary and a style which length is governed by the genotype (Maiti *et al.*, 2014) (Figure 1B). Tomato is a self-pollinated plant having anthers and pistil (i.e. male and female parts) in the same flower, but natural cross fertilization can occur due to insects and wind reaching a rate of 34 % (Solomon, 1971; Anais, 1977 and Hanna, 1999). Fruits are fleshy berries and vary in shape, diameter and color. Fruits are green and hairy at the unripe stage (Hanna, 1999; Tanksley, 2004 and Omar *et al.*, 2019). At maturity, they are usually red, scarlet, yellow or orange (Hanna, 1999; Tanksley, 2004; Omar *et al.*, 2019 and Afifah *et al.*, 2021). The fruit contains many hairy and beige seeds that are reniform or piriform in shape, like a kidney or a pear (Hulme, 1971 and Chanforan, 2010).

Table 1. Taxonomic classification of tomato (https://inpn.mnhn.fr/espece/cd_nom/124070/tab/taxo)

Classification	Scientific name	Common name
Kingdom	Plantae	Plants
Subkingdom	Tracheophyta	Vascular plants
Superdivision	Spermatophyta	Seed plants
Division	Angiosperms	Flowering plants
Class	Magnoliopsida	Dicotyledons
Subclass	Asteridae	Asterids
Order	Solanales	
Family	<i>Solanaceae</i>	Nightshades
Genre	<i>Solanum</i>	
Species	<i>Solanum lycopersicum</i>	Tomato

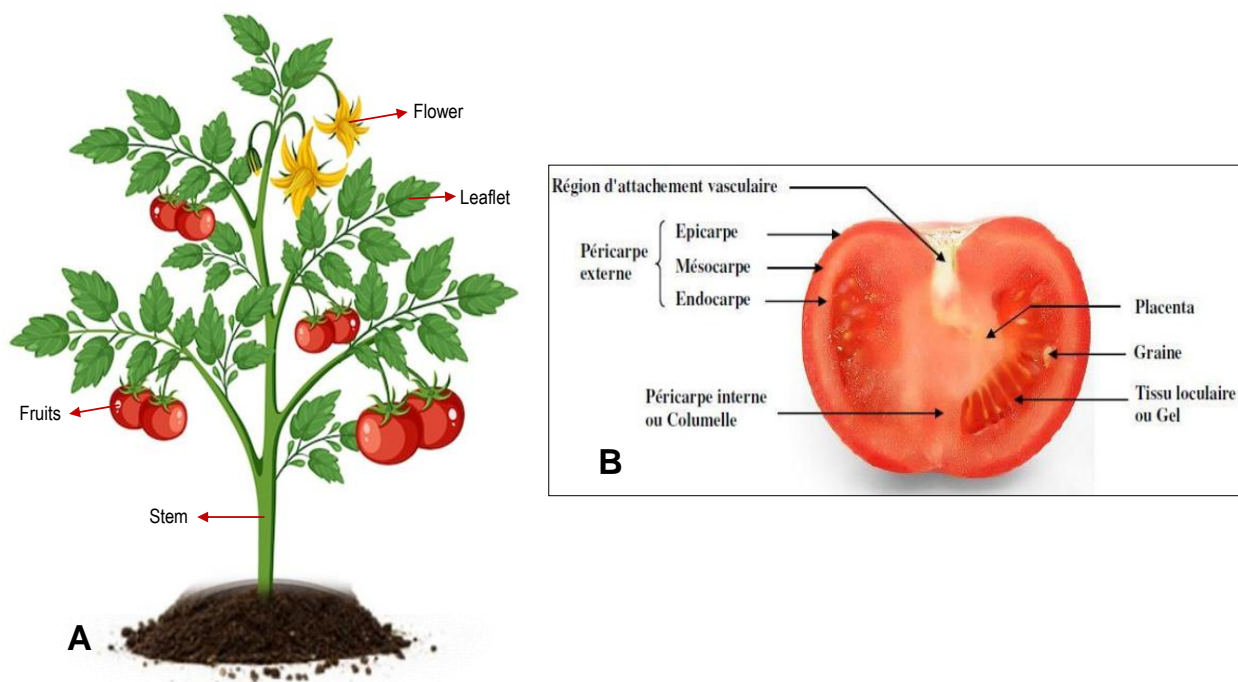


Figure 1. A, Tomato plant presenting its main parts (adapted using an image from <https://www.freepik.com>); B, cross-section of a tomato showing its anatomic structures (Chanforan, 2010)

TOMATO PRODUCTION

Tomato production trends in the world

Currently, tomato is produced in over 170 countries in the world (FAO, 2023). In 2021, it was the most produced vegetable crops in terms of quantity with a global worldwide production estimated over 189 million tons, ahead of onion (106 Million tons), watermelon (101 million tons) and cabbage (71 million tons) (FAO,

2023). From 1970 to 2021, tomato production increased by about 500% (Figure 2). This spectacular increase was mainly driven by Asian production, which accounts for 63% of global production. America and Europe each contributes for about 13 % of the world total production (FAO, 2023). The European countries, especially the Netherlands, Belgium, and Sweden, are the most productive in terms of yields (FAO, 2023).

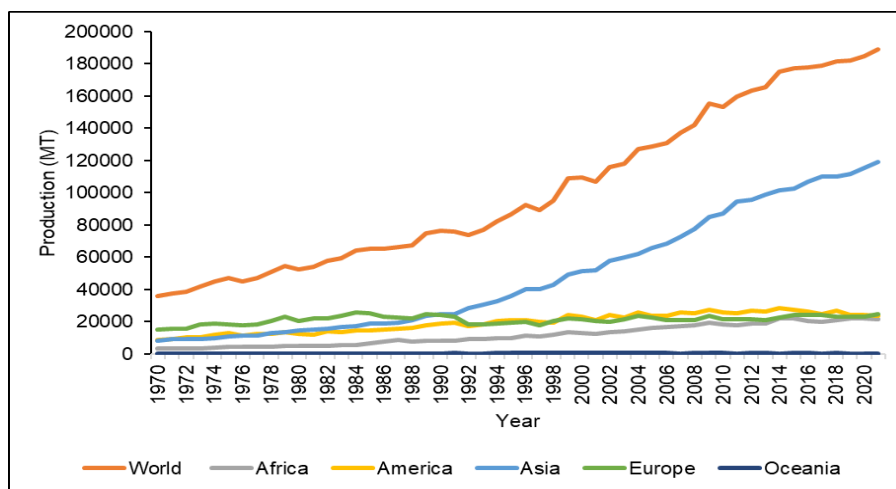


Figure 2. Evolution of tomato production in the world (FAO, 2023). MT, metric tons

Africa is ranked fourth among the continents with 11% of the global production (FAO, 2023). Its production has also evolved from 3 million tons in 1970 to 21 million tons in 2021 (Figure 2). However, tomato production in Africa remains low compared to the continent's potential and population needs. In Oceania, tomato production is also relatively low compared to other continents with less than 1% of global production (FAO, 2023) probably because of the area size.

In 2021, China and India were the leading tomato producing countries of the world with more than 67 and 21 million tons respectively (Figure 3A, FAO, 2023). With about 6 million tons produced in the same period, Egypt was ranked as the largest producer in Africa and 8th in the world (FAO, 2023). Nigeria was the 2nd largest producer in Africa and ranked 1st in West Africa. In this part of Africa, Ghana, Niger and Burkina Faso completed the list of the top 4 largest tomato producers in West Africa (Figure 3B). Tomato has become an important commercial and strategic product for these developing countries seeking to reduce imports and to develop their local processing industry. Several countries have set up processing units in this respect.

Tomato production trend in Burkina Faso

Tomato has been cultivated in Burkina Faso since many decades. Introduced in the 1930s, tomato production was concentrated in the western part of the country during the 1960s and 1970s (Bidon, 1995). It so altered the farmer's crop production system, which was mainly rain-fed, to include off-season irrigated production (Bidon, 1995). Then, the production evolved significantly from the 1980s with the construction of

many hydraulic infrastructures and irrigable lands. The area harvested evolved from 150 ha to 17 000 ha between 1970 and 2021 (Figure 4, FAO, 2023). As for tomato production, it increased from 1,400 t in 1970 to 305,000 t in 2015 (FAO, 2023). However, since then, the production has declined and stagnated around 200,000 t per year (Figure 4, FAO, 2023), probably due to diseases and pests outbreaks. The estimated average yields of 17 t/ha (DGESS, 2022 and FAO, 2023) are largely below the world average of 36 t/ha (FAO, 2023) and very far from yields obtained in countries such as the Netherlands (475.6 t/ha), Belgium (448.68 t/ha), or Sweden (436.5 t/ha) (FAO, 2023), which deploy highly sophisticated production means and high levels of input use.

Tomato is produced throughout all the thirteen (13) regions of Burkina Faso (DGESS, 2022), but the top three (3) production regions during recent years were *Boucle du Mouhoun* (36,824 t), *Centre Nord* (26,267 t), and *Hauts-Bassins* (20,032 t).

IMPORTANCE OF TOMATO

Biochemical composition

Many studies reported on the biochemical composition of tomato (Helyes *et al.*, 2006; Dossou *et al.*, 2007; Petit, 2013; Vodouhe *et al.*, 2014; Sawadogo *et al.*, 2015 and Lekhouimes *et al.*, 2022). Although the fruit is mainly composed of about 95% water, it contains a wide range of nutrients (Figure 5), which contents vary depending on the variety, the growing conditions, and the product =e.g.: fresh fruit, dried fruit, paste, soups or ketchup (Petit, 2013 and Bedad *et al.*, 2018).

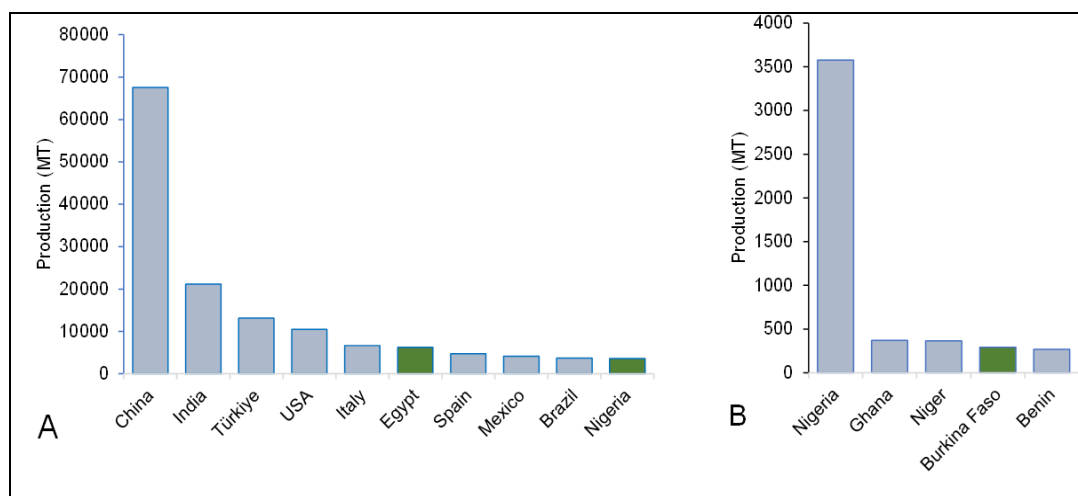


Figure 3. A, The top ten tomato producing countries in the world (including only two african countries, Egypt and Nigeria); B, the top five ones in West Africa in 2021 (FAO, 2023)

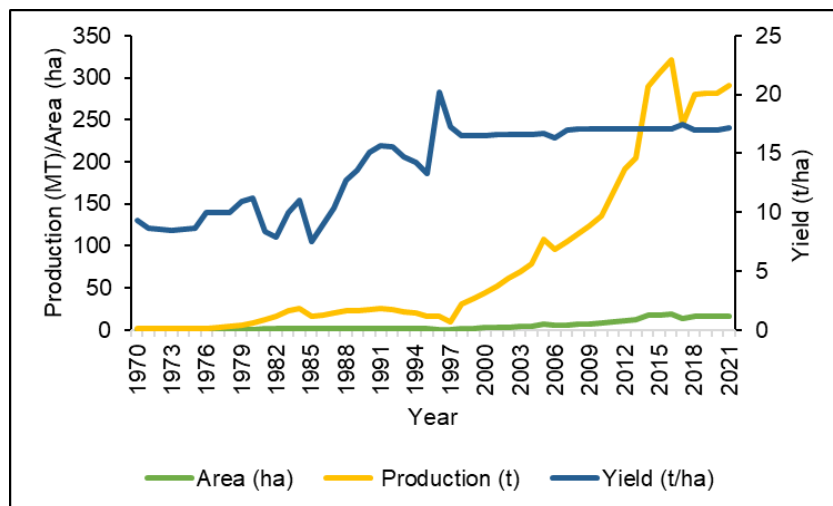


Figure 3. Evolution of tomato production (t), area (ha) and yield (t/ha) in Burkina Faso from 1970 to 2021 (FAO, 2023)

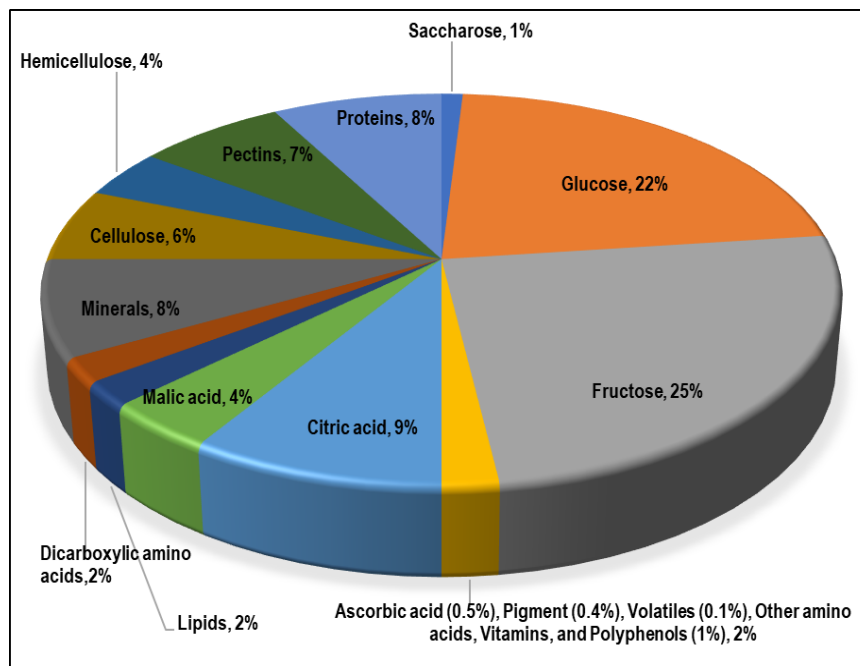


Figure 4. Proportions of the different constituents of the dry matter of the tomato (Davies et al., 1981; Petit, 2013 and Ali et al., 2020)

Tomato is a good source of carbohydrates, proteins, fatty acids, minerals, vitamins, amino acids and phenolic compounds (Davies *et al.*, 1981; Pinela *et al.*, 2012; Kansié, 2017 and Goka *et al.*, 2021). The fruits are free of cholesterol (Petit, 2013), while lipid (0.3%) and protein (1.1%) constituents are present in small amounts (Alhag Dow, 2006). The types of vitamins found in tomatoes are vitamin A, C, K, B₁ (thiamine),

B₂ (riboflavin), B₃ (niacin), B₅ (pantothenic acid), B₆, and B₉ (folate) (Chanforan, 2010). In terms of mineral elements, 23 types have been identified through various studies. They represent 8% of the dry matter and consist of major elements (magnesium, phosphorus, calcium, potassium, sodium, sulfur, chlorine) and minor elements (iron, iodine, zinc, fluorine, cobalt, manganese, etc.) (Davies *et al.*, 1981 and Ali *et al.*, 2020). Carbohydrates, predominantly fructose (25%) and

glucose (22%), constitute over 50% of the dry matter's sugar content (Davies *et al.*, 1981 and Ali *et al.*, 2020). Organic acids, important in the fruit acidity, are 10% of the dry matter and consist mainly of citric acid (60%) and 4% as malic acid (Petit, 2013 and Ali *et al.*, 2020).

Amino acids, on the other hand, represent 2 to 2.5% of the tomato's dry matter and strongly influence the fruit's flavor (Kader *et al.*, 1978). In addition to these acids, tomatoes also contain a high proportion of antioxidants, mainly composed of lycopene, β -carotene, ascorbic acid, phenolic acids, anthocyanins, and flavonoids (Borguini & Ferraz da Silva Torres, 2009; Petit, 2013 and Ali *et al.*, 2020). These compounds play crucial nutritional roles for consumers.

Culinary use and nutritional value

Tomatoes are ingredients of most common staple dishes (Aubaile-Sallenave, 1996 and Kaboré *et al.*, 2017). They can be consumed fresh in salads or cooked in sauces, soups, meat, or fish (Elise *et al.*, 1989). Additionally, tomatoes processed into pastes (Dossou *et al.*, 2007) and ketchup, are widely used to flavor many food recipes (Gilgenkrantz, 2012). Fruits can be conserved by drying or preserving in cans to ensure availability the year round (Vodouhe *et al.*, 2014).

As mentioned in the previous section, tomatoes contain many important nutrients that are beneficial for the health and well-being of consumers. The consumption of 100 g of tomato provides up to 20 calories (Ali *et al.*, 2020), representing about 1% of daily needs. Additionally, tomatoes provide a wide range of beneficial effects, such as reducing the risk of cardiovascular disease, cancer, and diabetes (Giovannucci, 1999; Lairon *et al.*, 2005; Lecerf, 2006; Battu, 2014; Cheng *et al.*, 2017 and Ali *et al.*, 2020). These beneficial effects result from antioxidant and micronutrients roles such as lycopene, minerals, fibers, and vitamins, which are essential for the functioning of the body and its resistance to diseases. The intake of fibers stimulates digestion and facilitates intestinal transit (Slavin, 2005), while vitamins promote cells growth (Ali *et al.*, 2020). Tomatoes are known as an excellent source of vitamins (Figure 5) that allow them to play a therapeutic role in case of deficiency or in relation to several diseases such as cancer, thanks to the antioxidant properties of vitamins C and E (Ali *et al.*, 2020; Ahmad *et al.*, 2023 and Liu *et al.*, 2023). Rich in minerals, tomatoes contribute to the proper functioning of various body functions, such as maintaining the body's acid-base balance (Gharibzahedi and Jafari, 2017), the formation of vital organs, nerve transmission, and regulation of blood pressure (Ali *et al.*, 2020). Chlorine facilitates the filtration of waste from the body, and sulfur protects the liver from fat accumulation.

Thanks to its richness in potassium, tomatoes help reduce high blood pressure (Ali *et al.*, 2020).

Lycopene, a carotenoid found in tomatoes, can be very beneficial against diabetes, colon, prostate, and breast cancer (Lecerf, 2006 and Cheng *et al.*, 2017). The consumption of dietary lycopene is part of the strategies for managing patients with diabetes. Studies have shown that lycopene stimulates an increase in insulin level, a decrease in glucose level, and an improvement in lipid profiles in diabetic mice (Liu *et al.*, 2023; Rasal *et al.*, 2023 and Uchenna *et al.*, 2023). It also improves kidney function and antioxidant activities (Ahmad *et al.*, 2023 and Liu *et al.*, 2023). Therefore, tomato is a very nutritious food that can prevent many physiological disorders.

Socio-economic importance

Tomato cultivation concerns about 30% of vegetable farmers in Burkina Faso. Its business appears to be highly profitable, from the production sector for small farmers, to the processing and market ones. Its production generates significant financial income for producers and helps reduce seasonal unemployment in rural areas (MAHRH, 2007; Tapsoba *et al.*, 2016 and Goka *et al.*, 2021). Despite being susceptible to various pests and diseases, tomato farming is highly profitable (Table 2). Therefore, tomato farming is a real added value to the rainy season cereal production, providing farmers with additional financial income to improve their living standards (Tapsoba *et al.*, 2016), and thus significantly contributing to the resilience of populations by alleviating poverty and food insecurity (Ba *et al.*, 2019).

Along with other vegetable crops, tomato farming employs approximately 620,000 people in Burkina Faso, of which 35% are women (Dione *et al.*, 2021). In addition, the tomato sector provides many jobs related to transportation, processing, and commercialization of production, in which women predominate (90%) (Dione *et al.*, 2021). However, the low local transformation of production remains a major challenge for the tomato industry in Burkina Faso, urging traders to produce exportation. Thus, in 2018, tomato exportations generated approximately 50 billion CFA francs in revenue for Burkina Faso (MAAH, 2019). Of about 560 tons of fresh tomato exported annually, more than 500 tons go to Ghana (~90% of total exports), making that country the largest importer of the Burkinabe production. Although the tomato value chain needs more organization, the production of this fruit-vegetable already presents significant socio-economic benefits for the country.

Table 2. Estimated budget and profit of tomato production for 1,000 m² in Burkina Faso

1. Working capital				
Designation	Unit cost (FCFA)	Quantity per 1 ha	Quantity per 1,000 m²	Total amount per 1,000 m² (FCFA)
Seeds (100 g)	10000	200	0,2	2000
Compost (Sac de 50 kg)	6000	400	40	240000
Chemical fertilizer (Sac de 50 kg)	35000	6	0,6	21000
Pesticide (Emacot) (Sachet de 50 g)	500	24	2,40	1200
Plot rental (ha)	400000	1	0,1	40000
Clearing (ha)	25000	1	0,1	2500
Plowing (ha)	60000	1	0,1	6000
Nursery installation (ha)	20000	1	0,1	2000
Transplanting (ha)	100000	1	0,1	10000
Fuel for irrigation (liter)	850	2500	250	212500
Irrigation labor	400000	1	0,1	40000
Pesticide treatment	5000	6	3	15000
Fertilizer application (ha)	60000	1	0,1	6000
Staking	15	33000	3300	49500
Weeding (ha)	150000	2	0,2	30000
Earthing up (ha)	30000	1	0,1	3000
Harvest (ha)	150000	1	0,1	15000
Total 1				695700
Contingencies 1 (10%)				69570
2. Investment funds				
Designation	Unit cost (FCFA)	Number of use campaigns	Amortization per Campaign	Amount (FCFA)
HP water pump 2,5 CV	100000	5	20000	20000
Sprayer	25000	5	5000	5000
Irrigation piping	200000	5	40000	40000
Total 2				65000
Contingencies 2 (10%)				6500
3. Output				
Designation	Yield (kg/ha)	Expected production (kg/1,000 m²)	Average price per kg (FCFA)	Total price
Revenue	20000	2000	600	1 200 000
Total expenses				836770
Profit				363230

Nota bene : This budget is established based on data from a survey of tomato producers (FAO, 2023) and a website (www.combien-coute.net/tomates/burkina-faso/, accessed on 27 September 2023). This table provides guidance for those who wish to engage in commercial tomato production. The figures may vary depending on the period and production area.

CONCLUSION

This review highlighted the importance of tomatoes in both nutritional and economic aspects to stimulate its production and consumption. Tomatoes contain minerals, vitamins, essential amino acids, lycopene, and dietary fibres that are essential for the great functioning of the human body. The tomato industry is promising,

offers economic opportunities for young farmers and women, and can contribute to food security and poverty alleviation. However, several challenges remain to be addressed to maximize the benefits of this crop. These include the development of adapted cultivars, the crop protection, produce processing and conservation, and better organization of the tomato market and value chain.

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الملخص العربي

الطماطم: محصول خضر مغذٍ ومريح ينبغي الترويج له في بوركيننا فاسو

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الفينولية، ولها أيضا خصائص علاجية مثل علاج الإسهال وارتفاع ضغط الدم. وأفادت عدد من الدراسات أن استهلاك الطماطم يساعد على تقليل خطر الإصابة بأمراض القلب، والأوعية الدموية، والسرطان، والسكري. علاوة على ذلك، تدر زراعة الطماطم دخلاً كبيراً للمنتجين، وبالتالي تقلل من البطالة الموسمية، والفقر في العديد من المناطق. بالإضافة إلى ذلك، يمكن أن تساهم زراعة الطماطم في تعزيز قدرة السكان على مواجهة آثار تغير المناخ من خلال تعزيز الأمن الغذائي.

الكلمات المفتاحية: الأمن الغذائي، الصحة، الدخل، التغذية، الطماطم.

تفتقر دولة بوركيننا فاسو إلى التنوع، وانخفاض معدل استهلاك الخضروات ويرجع ذلك إلى العادات الغذائية المتجذرة الموروثة، ومحدودية الوصول إلى الخضروات، ونقص الوعي بشأن الآثار الصحية الإيجابية المرتبطة باستهلاك الخضروات. ولذلك فإن رفع مستوى وعي المستهلكين بفوائد تناول كميات كبيرة من الخضروات مثل الطماطم يمكن أن يزيد من معدلات العرض والطلب على الخضروات. تهدف هذه الدراسة إلى تسليط الضوء على الفوائد الغذائية، والصحية لاستهلاك الطماطم، فضلا عن أهميتها الاجتماعية، والاقتصادية للسكان وبصفة خاصة النساء والشباب. وقد كشفت الدراسات أن الطماطم تعد مصدر جيد للكربوهيدرات، والبروتينات، والأحماض الدهنية، والمعادن والفيتامينات، والأحماض الأمينية، والمركبات