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Sustaining Frafra potato (*Solenostemon rotundifolius* Poir.) in the food chain; current opportunities in Ghana

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Abstract: Frafra potato (*Solenostemon rotundifolius* Poir.)is one underutilized crop species which is critical to improving food security in the Upper East and Upper West Regions of Ghana. Food dishes of Frafra potato (FP) are a delicacy particularly for children. The tubers have high marketing potential even compared with its counterpart, sweet potato. However, crop improvement programmes in FP have been slow leading to the current varieties being recycled for several decades. Research tools such asfield survey, focused group discussions and key informant interviews were employed to gather information on production practices, challenges and strategies to improve FP production and utilization. Information was generated from 10 focused group discussions and 270 respondents in 5 districts. Overall, FP is produced under rain-fed agriculture by less than 30% farmers on less than ¼hectare/farmer. In Bongo, Kongo and Bolgatanga environs, FP is cultivated by over 70% of households to supplement household food. Production is primarily planned for domestic consumption; contributing up to 20% of household food between Octoberto December. Consumer preference traits included tuber size, starch, low water content, taste and ease of peeling. Key problems identified were decreasing soil fertility, lack of improve varieties, labour-intensive operations, insect pests and high postharvest losses. Crop improvement should target high yielding cultivars, large tuber size, white and pink flesh and biofortification with micro-nutrients. Processing tubers into stable preservable products using low-cost roasting, dry-frying and solar dehydration methods should be evaluated. Dissemination of current improved technologies to increase productivity requires prompt attention by the Ministry of Food and Agriculture.

Keywords: *Coleus dysentericus*, Utilization, Food Security, Underutilized Crops, Challenges

1. Introduction

Frafra potato (*Solenostemon rotundifolius* Poir.) Family: Labiatae[1] is believed to have originated in Central or East Africa, but was early spread throughout tropical Africa and into South-East Asia, including India, Sri Lanka, Malaysia and Indonesia, where it is cultivated on a small scale. The crop is known in certain cycles as *Coleus dysentericus* because of the assertion that it cures dysentery [1]. Other names include: *Coleus rotundifolius*[2-4]; *Plectranthus esculentus*[5],*Coleus parviflorus*[6, 7]. Some local names include: Hausa potato (Gh), Innala (Sri La.); Kembili (Mal.);Ketang (Indon.); Koorka (Ind.); Madagascar potato (Fr.); Ratala (Sri La.); Saluga (Nig.); Sudan potato, Tumuku (Nig.); Vatke (Eth.). Frafra potato (FP) is a small, herbaceous annual, 15-30 cm high, prostrate or ascending, with a succulent stem and somewhat thick leaves having an aromatic smell resembling that of mint(Figure 1). Flowers are small, pale violet in colour, produced on an elongated terminal raceme. The tubers are small dark-brown and produced in clusters at the base of the stem [1, 8]. The composition of the raw tubers per 100 g edible portion is: water 75.6 g, energy 394 kJ (94 kcal), protein 1.3 g, fat 0.2 g, carbohydrate 21.9 g, fibre 1.1 g, Ca 17 mg, Fe 6.0 mg, thiamin 0.05 mg, riboflavin 0.02 mg, niacin 1.0 mg, ascorbic acid 1 mg [9]. Although formerly of considerable importance as a staple foodstuff in tropical Africa, FP has been largely replaced by other starchy foodstuffs such as sweet potatoes, and production has declined to such an extent that it has almost disappeared in many areas [10, 11].

Generally, FP is a relatively under-exploited food crop in the Upper East and Upper West Regions of Ghana [10, 11]. Production of FP is primarily planned for domestic consumption, with little harvest surpluses sold to

supplement household income. Earlier studies suggest that FP is an essentially subsistence crop in Districts such as Jirapa, Lambussie, Nadowli, Lawra, Nandom and Wa of the Upper West Region; and Bongo, Kassena-Nankana, Bolga, Bawku-West and Bawku-East in the Upper East Region [10, 12, 13]. Frafra potato (FP) is critical to improving food security, and a delicacy particularly for children, with a high marketing potential even compared with its counterpart, sweet potato. Despite this potential, crop improvement programmes in FP have been poor. Several other constraints to increasing FP production have been identified [12, 14]. These include rapid tuber deterioration in storage, lack of healthy planting materials, pests and diseases and declining soil fertility. High postharvest losses (20 to 40%) and lack of appropriate postharvest preservation methods were identified as key constraints during the Research and Extension Linkage Committee meeting (RELC, 2012) in Upper East Region. The tubers show natural dormancy from 3 months after harvest, becoming fibrous and begin to sprout. So far little research has been conducted to improve upon tuber size which is essential to increasing production and utilization [12].

A recent review of the state of plant and genetic resources for food and agriculture [11] showed that food security in Ghana could be under threat because of the desire to intensify mono-cropping of cash and high-value food crops. The second threat is genetic erosion; where few varieties are replacing many less competitive varieties; or a crop replaces other close substitute crops. For instance, bambara groundnut is replaced by improved cowpea and Kersting's groundnut, and Frafra potato is replaced by high yielding sweet potato varieties. A report by Nourishing the Planet Project suggests that finding ways to alleviate hunger and poverty should not always depend on only few essential crop varieties. Instead, reigniting an interest in the taste for indigenous and traditional foods can help improve nutrition, increase incomes, restore agricultural biodiversity and preserve local cultures (www.NourishingthePlanet.org).There should be concerted effort to maintain and improve these underutilized food security crops to sustain food access to rural farm families [8]. Currently, up-scaling of improved technologies for the production and utilization of FP is one critical objective of the West Africa Agricultural Productivity Project (WAAPP 2A), Council for Scientific and Industrial Research (CSIR), Root and Tuber Improvement and Marketing Programme (RTIMP), and Ministry of Food and Agriculture (MoFA) of Ghana. Some current interventions include: i) providing training and extension services on integrated pests management strategies to FP growers; ii) increasing FP production by deploying elite varieties to growers and; iii collecting, characterizing and establishing database of FP germplasm. This study seeks to review the current FP production systems and identify strategies to increase production and utilization for the largely smallholder growers. The study identifies how the participation of research-policy-extension linkages can accelerate production, technology dissemination and utilization of FP. It finally identifies strategies to improve upon postharvest handling and processing, as well as training and research needs in the FP value chain.

Figure 1. *Frafra potato at different growth stages*

2. Methodology

2.1. Description of Study Area

The Upper East Region (UER) of Ghana lies between longitude $1^0 15'$W to $0^0 5'$E and stretches from latitude $10^0 30'$N to $11^0 8'$N. The region lies in the Sudan savanna agro-ecology, which forms the semi-arid part of Ghana. The area is part of what is sometimes referred to as interior savanna, and is characterized by level to gently undulating topography. Important crops include millet, sorghum, maize, rice, sweet potato, groundnut, cowpea, soybean, cotton, onion and tomato. The sheanut tree, which grows wild is an important cash crop. It has alternating wet and dry seasons with the wet season occurring between May and October during which about 95% of rainfall occurs. Maximum

rainfall occurs in August, and severe dry conditions exist from November to April each year. Annual rainfall ranges from 800-1200 mm. There is wide fluctuation in relative humidity (RH) with as low values as 30%RH in dry season and above 75%RH in the wet season.

2.2. Scope of Study

The study was carried out from May to June 2013; coinciding with the beginning of the cropping season of FP. The research tools employed were field survey, key informant interviews and focused group discussions. Information was generated from 10 focused group discussions and 270 respondents from 10 communities in 5 main production districts. The districts were: Bawku-East, Bawku-West, Talensi-Nabdam, Bongo and Garu-Tempane. Only the major FP production communities were targeted, and most respondents have ever cultivated FP in previous 1 to 4 years. Majority of the respondents (80%) were male, of age 40 or above. Details of the communities and the number of respondents are provided in Table 1.

2.3. Questionnaire Design

The questionnaire captured data on demographic information, type of variety, source of sett for planting, reasons for selecting a variety, current challenges, possible training and research needs, and strategies to improve upon current utilization. Information was also generated on current forms of utilization, cooking methods, consumer preference traits and postharvest processing methods.

2.4. Data Analysis

Descriptive statistics involving frequencies, matrix ranking and central tendency were employed in data analysis and reporting. A rapid appraisal of secondary information on current crop improvement, production and utilization was conducted at the Savanna Agriculture Research Institute (SARI) and the Ministry of Food and Agriculture (MoFA) to identify knowledge gaps for future extension and research interventions.

Table 1. *Detail description of communities participating in the survey*

Districts	Communities	Numbers of focused group discussions	Number of respondents	Name ofAgriculture Extension Agent
Bawku-East	Nikongo	1	25	A. Dominic
	Tes-Natinga	1	25	
Bawku-West	Tilli-Azupupuugu,	1	25	Paul Musah
	Teshie, Kperigu-Soogo	1	25	
Bongo	Eyelibile	1	30	K. Anane
	Bongo-Soe	1	25	
Garu-Tempane	Kpatia	1	30	M. Jamal-Deen
	Tankpasi-Avusum	1	25	
Talensi-Nabdam	Sakote-Kotitab	1	30	Musah Adam
	Dasabligo	1	30	
Total = 5	**10**	**10**	**270**	

3. Results

3.1. Socio-Economic Importance

The socio-economic importance and overall contribution of Frafra potato (FP) to household livelihoods is summarized in Table 2. The discussions showed that FP is a relatively underutilized crop. The crop is produced by close to 30% farmers on less than ¼ hectare per farmer under rain-fed agriculture. The crop contributes up to 20% of household food between October to December each year. In Bongo, Bolgatanga and Kongo environs, the crop is cultivated by over 70% of households to supplement household food; albeit on less than ¼ha of farmland. It is mainly cultivated by male family heads on fertile fields to supplement household food. Production is primarily planned for domestic consumption, however some harvest surpluses are sold to supplement household income. Frafra potato is a high value crop compared with its counterpart, sweet potato. The produce is usually sold in nearby community markets but a glut never occurs.

3.2. Cropping System

The group discussions showed that FP is cultivated as a sole crop under rain-fed conditions. Planting is done on ridges using single row spacing of 15 to 25 cm between plants and 1m between ridges. Only sprouted setts are transplanted at 3-5cm deep to expose the sprout. Non-sprouted setts may never sprout again if planted. Less than 20% of farmers used double row planting on same ridge, and less than 10% used mounds. Frafra potato is preferably

planted at the onset of the rain. All the group discussions suggest that optimum yield is obtained if planted from late-May to mid-June, just after planting of early millet. Early planting is hindered by late rain and animals which destroy beds; though they do not directly feed on leaves. However, damage caused by pigs can be substantial if planted early.

Table 2. *Overall ranking of crops according to their contribution to household livelihoods*

Crop	Average farm size (ha)	% Household cultivating	Relative involvement of Women	Overall contribution to householdfood	Overall contribution to householdincome	Access to improved varieties
Maize	2.5	95	45	80	55	90
Sorghum	1.5	90	20	70	40	40
Millet	1.5	90	20	65	35	20
Rice	0.8	60	80	40	60	60
Cowpea	1	70	40	40	50	70
Soybean	1	65	75	30	70	60
Groundnut	1	60	60	50	30	20
Bambara nut	0.5	40	50	40	15	10
Sweet potato	0.9	40	15	30	70	40
Frafra potato	0.25	30	5	20	15	5
Vegetables	0.9	70	70	40	80	50

Table 3. *Characteristics of common Frafra potato varieties by respondents*

Characteristics	Varieties		
	Black type	Red type	White type
Colour	Black peel, white flesh	Red peel, white flesh	White peel and flesh
Maturity	4-5 months	4-5 months	4-5 months
Yield	Yield higher	Moderate yield	Moderate yield
Potential yield	12 to 20 bags/ha	9 to 16 bags/ha	9 to 16 bags/ha
Consumer preference	Most preferred (size)	Preferred	Preferred
Taste	Very good	Good	Good
Tuber size	Large	Medium	Medium
Soil fertility	Widely adapted	Poorly adapted	Moderately adapted
Market value	High	Moderate	Moderate
Ease of peeling	Easy to peel	Difficult to peel	Easy to peel
Storage shelf life	Poor	Good	Good
Dry weight	High dry matter	Watery flesh	Less moisture

4. Agronomy

The discussions revealed that optimum yield is obtained on well-drained, fertile sandy loams with high moisture holding capacity. Heavy clay soils and water logging conditions or fields should be avoided. Water-logging causes tuber rot and deformities which substantially reduce yields and marketable value. Organic manure can be applied to soils prior to planting but not during the growth season. Less than 10% farmers ever applied chemical fertilizer (Single supper sulphate) in FP production. Concurrent weeding and earthen-up (1-4 times) is recommended. Weeds close to plants are rouge out by hand. Gather soil close to the plant during first weeding to facilitate good root establishment which is essential for tuber formation. Once tuber formation commences, do not weed with hoe, uproot weeds by hand.

4.1. Pest and Diseases

From the discussions, farmers perceived pests and diseases as minor constraint in FP production; apparently oblivious of the potential damage they can cause. The leaves are less preferred by ruminant animals. Caterpillars and termites are the major pests at the vegetative stage.

Termites and millipedes also bore holes into tubers causing tuber rot during storage. The common disease is nematodes which cause leaf curling and stunting at the vegetative stage. In a related study, [14] identified the key pests attacking FP as sweet potato butterfly (*Acraea acerata*), white flies, leafhoppers, termites, grasshoppers, crickets and millipedes. They noticed that farmers did not practice pest control measures due to lack of technical know-how. However, controlling both foliar and soil pests increased tuber yields by 23-64% over the control plots. This study quite demonstrates the need to deploy integrated pest management strategies to reduce yieldlosses.

4.2. Access to Improved Varieties

Lack of improved FP varieties was identified as a critical problem in production. The current varieties are landraces which have been recycled for several decades. The existing varieties were identified based on peel colour: white, red and black (Table 3). In the Bongo district, some improved lines were reportedly introduced to farmers under Root and Tuber Improvement and Marketing Project (RTIMP); however these lines were not available again. Farmers therefore expressed strong expectation of getting improved varieties from Research Institutes.

4.3. Postharvest Operations

Three indices are employed to determine harvest maturity in FP. These include yellowing and drying of leaves, flowers begin to wither and drop, and expansion and cracking of ridges. These symptoms which are noticed at close to 4 months after planting should be followed by prompt harvesting to reduce postharvest losses. Timely harvesting was identified to be critical in reducing tuber rot during storage. Tuber formation occurs at a radius of about 10cm around the plant. Harvesting is done using a hoe. The soil is scooped and capsized to expose the tubers for easy plugging, and the adventitious roots are removed. The tubers are then sorted according to size (small and large) and cured by spreading under well ventilated dry shade for 2-3 weeks. The large tubers are consumed or sold whiles the small tubers are stored as sett for the next season. The white type variety has high moisture content and usually cured for 1-2week before consumption. For sett storage, the small tubers are mixed with ash or millet husk or sorghum husk, put in airtight clay pots and stored in a cold room. The pot is open only prior planting in the next season (Fig. 2a). The setts may also be wrapped in a thatch mat and hanged on a tree or under shade of summer hut (Fig. 2b); only sprouted setts are planted.

Fig 2a. *Frafra potatosetts are mixed with ash, millet/sorghum husk and stored in clay pot sealed with cow-dung , pot is opened prior to planting;* ***2b.*** *setts are wrapped in thatch mat and stored under shade*

4.4. Utilization

The tubers may be consumed by households as main meal, snack and sometimes under emergency situations. FP is rarely roasted or fried. The black type variety is preferred due to its large tuber size and good taste. The main consumer preference traits were tuber size, starch, low water content, taste/aroma and ease of peeling. The following describes how the tubers are processed for consumption:

1. Boiled before peeling: the tubers are washed thoroughly, boiled and the peel is raped by hand and consumed. This may be eaten alone, with a pepper and salt sauce or with groundnut.
2. Peeled before boiling: the peel is raped by foot, pounding or kneading and boiled. Some oil and spices are added and the food served to the family. Among the Frafra households, this may be eaten with ‘Nkogre’; a special soup made of millet, groundnut and some spices.

3. Boiled and stirred: the peel is raped by foot, pounding or kneading before cooking. It is then over-boiled and pounded into a thick mass called 'piesesam', which is consumed with stew or sauce.
4. Parboiled for storage: large tubers are selected and the peel is raped by foot, pounding or kneading before parboiling or blanching. After parboiling, the tubers are sun-dried for future use. This is usually cooked latter with beans.

Table 4. *Crop improvement targets requiring research and extension interventions in Frafra potato*

Areas requiring improvement	Target areas	What specific improvement is required
1. Crop improvement	All varieties	Replace the existing 3 landraces
2. Production practices	Extension	Disseminate agronomic technologies to improve yield
3. Genetic conservation	Research	Germplasm collection, characterization and conservation
4. Vegetative, molecular and In-vitro techniques	Research	Molecular, budding, and approach, cleft and splice grafting methods,
5. Maturity period	All varieties	Reduce maturity from 4-5 months to 3 months
6. Taste	All varieties	Increase sweetness, aroma and starch level, and reduce moisture content of red type
7. Size	All varieties	Genetic methods to increase tuber size
8. Agronomic practices	Extension	Cultivar selection, time of planting, spacing, fertilizer rate
9. Ease of peel	All varieties	Peel should be easy to rape off
10. Sensory colour	Black type	More bright-colour sensory appeal, orange-colour flesh
11. Fibrousness	All varieties	Eliminate or increase natural dormancy period
12. Shelf life	All varieties	Introduce improved storage and processing methods
13. Nutritional	Research	Bio-fortification with vitamins, orange-flesh colour
14. Utilization	Extension	Increase awareness on health benefits and utilization among urban consumers
15. Value addition	Processing	Evaluate parboiling, blanching, dehydration, roasting and frying options and packaging methods
16. Training	Extension	Good Agricultural Practices (agronomy, pest management, soil fertility and postharvest managements)

4.5. Processing

Frafra potato has natural dormancy which poses as major challenge in terms of preserving the fresh tubers. The tubers become fibrous by 3 months after harvest and begin to sprout. The tubers are therefore parboiled and dried to prolong shelf life. However, this indigenous method of preservation requires lots of improvements and packaging to enhance the marketable value. There is no established method of inhibiting or prolonging the natural dormancy. There is need to evaluate different food preservation and packaging methods to improve the marketable shelf life.

4.6. Research Gap

From the focus group discussions, Table 4 summarizes the critical areas requiring improvement by research and extension. These research and dissemination strategies however will require time and resources to achieve reasonable success. Nonetheless, overall improvements of these targets can propel production and utilization of FP.

4.7. Constraints to Production

Table 5 enumerates the key constraints to include low yield, lack of improved varieties, decreasing soil fertility, labour intensive production, poor soil fertility, insect pests and high postharvest losses. From the matrix ranking, the most critical constraints were lack of elite varieties and high labour requirement, followed by low yield, poor soils and high postharvest losses. Though higher prices at harvest turn to compensate for these challenges, nonetheless close substitute crops such as sweet potato is easy to produce with same resources. Other constraints include lack of planting materials and early dormancy.

Table 5. *Overall ranking of critical constraints in Frafra potato production*

Identified constraints	Matrix ranking	Overall rank
Lack of elite varieties	*******	7
Labour-intensive operations	******	6
Poor soil fertility	*****	5
Low yield	****	4
High postharvest losses	***	3
Lack of planting materials	**	2
Pest and diseases	**	2
Limited market access	*	1

Farmers were first asked to identify the important constraints, and further rank the identified constraints from most important to least important.

5. Discussion

Earlier study by [10], noted that Frafra potato (FP) is

becoming endangered in many communities even in the major producing districts of Ghana. Thus, FP was likely to fall out of the food basket if research and production strategies were not put up to salvage this crop. This led to some adaptive research during Root and Tuber Improvement and Marketing Project (RTIMP I) from 1999 to 2004. This somewhat culminated into research to generate some basic recommendations to improve production and utilization of the crop. Some research progress include: identification of critical problems of production and intervention programmes[12]; performance of different genotypes and response to fertilizer (NPK) and time of planting [15]; effect of seed weight and spacing on yield [13]; agronomic performance and integrated pests management strategies [14]; and germplasm collection and characterization of different accessions[8]. Fifty-six accessions of FP from the Northern, Upper East and Upper West Regions of Ghana have been collected and are being conserved at the CSIR-Plant Genetic Resources Research Institute. Morphological characterization of the germplasm has been carried out on field grown genotypes [8]. However, plant breeding efforts to improve the tuber size to a commercially attractive grade still lags behind [12,16]. Though, recent experiments have demonstrated the potential of mixing genetic materials of different FP using vegetative propagation. Recently, [16]found that with the exception of the approach grafting, all the grafted plants from cleft and splice grafting produced leaves and shoots. The splice grafting recorded highest number of leaves and plant survival. The dormant buds used in budding recorded higher number of leaves, longer shoots and plant survival. Only the approach grafted plants established union between the stocks and the scion, while the cleft and splice grafting failed to establish a union.

Overall, the foregoing discussions apparently suggest that farmers have continuously recycled the existing land races which are low yielding and produce numerous small size tubers. Rapid genetic improvements can be possible since vegetative propagation methods such as approach, cleft and splice grafting and budding methods have shown some positive results. The most critical constraints identified were lack of improved varieties, labour-intensive production operations, poor soils and high postharvest losses. Current interventions such as the West Africa Agricultural Productivity Project (WAAPP 2A) should attempt to bridge current research and extension gaps identified in Table 4. This will require the active participation of Research Institutes of the Council for Scientific and Industrial Research (CSIR), Universities, Ministry of Food and Agriculture (MoFA) and farmers to achieve reasonable results. Deployment and up-scaling of improved technologies to increase production and utilization of FP is required. These should include Farmer Field Schools and trainings on good agronomic practices (GAP), integrated soil fertility management, IPM strategies, and postharvest handling. The integration of interventions by the WAAPP 2A and ongoing Root and Tuber Improvement and Marketing Programme (RTIMP) needs to be synchronized to achieve desirable results. Another research gap yet to be addressed is the integration of FP into the different farming systems of the savanna zone, such as rotation and intercropping compatibility. Processing tubers into stable preservable products, packaging and promoting the utilization should as well be considered. There is urgent need to evaluate simple low-cost roasting, blanching, dry-frying and solar dehydration methods to improve shelf life and sensory quality to reduce current postharvest losses.

6. Conclusion

This study demonstrates the need for interventions to sustain Frafra potato in the food chain of Ghana. Overall interventions to achieve household food security should not concentrate on only few major staples crops. Various traditional and underutilized crop species need to be included in local and national agricultural food policies and programmes. They are essential to conserving agro-biodiversity as well as providing special diets and food preference needs of the indigenes of where they are cultivated. The CSIR-Savanna Agriculture Research Institute, and the Upper East and Upper West Regional Directorates of Agriculture need to collaborate to accelerate research and technology dissemination on this essential but underutilized food crop.

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