Jamaica Business Fund

Final Report

Ginger Varietal Sector Study



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Executive Summary

Once positioned as one of the top three ginger producers in the world along with India and Sierra Leone during the 1930s to 1960s, Jamaica's ginger output has since drastically declined due to insignificant levels of global production of just over 2 million tonnes, despite its quality reputation. The data indicates that production fell from 1,600 tonnes in 2013 (MICAF) to 1,274 tonnes in 2014 (FAOStat) and 789 tonnes in 2016 (MICAF), with projections for further decline in the 2017/2018 crop. This decline has been attributed to lack of coordination and organization of the industry coupled with a widespread outbreak of the ginger rhizome rot disease which has significantly impacted productivity. As such an estimated export demand of 4,200 tonnes has largely been unmet and local demand of approximately 1,309 tonnes has had to be supplied by imports amounting to 495 tonnes of dried ginger.

Strategic interventions by MICAF such as the Ginger Resuscitation and Expansion Programme have promoted the propagation, production and distribution of certified, disease-free tissue cultured planting materials as part of the process of revitalization of the industry. The local ginger varieties are in demand by high value agro-processing markets because of its flavour profile, but there are gaps in the available technical information on the varieties, which constrain planting material propagation and production efforts geared towards meeting commercial demand.

In its ongoing outreach and consultations with the private sector, the issue of ***assuring the propagation of local varieties of ginger to permit processing and export of greater quantities of these varieties***, has been identified by the Jamaica Business Fund (JBF) as an important matter to be addressed for sustainable development of the Jamaican ginger industry. This Report was therefore commissioned by the JBF to support investigation of the available information and identification of the varieties being grown in Jamaica, with specific focus on the Jamaican ginger varieties. Based on desk research, stakeholder consultations and indicative field research, the Report covers information on relevant studies conducted on Jamaican ginger varieties; their characteristics and properties;

consideration towards the establishment of GIs for Jamaican ginger; location of local varieties under cultivation, including sampling and mapping of GPS coordinates; work done on precise identification of local ginger varieties; demand for local ginger varieties; and recommendations for policy support (with specific reference to the Draft National Seed Policy), process for transfer of the concluded information to producers of tissue cultured plantlets and development of a roadmap for developing ginger varieties.

Review of the available literature on relevant studies on ginger varieties have indicated that work have been conducted mainly by the R&D Division of MICAF and the SRC, with main focus on agronomic evaluation of the Jamaica Yellow, Native and Blue planting materials under protected cover (R&D Division); molecular characterization Jamaica Blue, Jamaica Native, Jamaica Yellow and China Blue (SRC); and chemical characterization of Jamaican Yellow Tambric, Bulbous Blue, Frog Blue and Hawaiian ginger varieties (SRC). There was no available literature on phenotypic characterization of the Jamaican ginger varieties and confusion and inconsistencies in nomenclature were evident. Morphological characterization described in the Report was therefore derived through consultation with stakeholders. It is therefore recommended that work be carried out on morphological characterization of ginger by the R&D Division of MICAF and other research institutions, to conclude on nomenclature. A recommendation is also made for a comprehensive, island-wide collaborative investigation on chemical and molecular characterization study to conclusively distinguish varieties, as well as repeat of agronomic evaluations to provide conclusive yield and other relevant agronomic data.

Consideration of development of GIs for Jamaican ginger is premised on the widely accepted superior quality of Jamaican ginger. However, there is need to establish the link between quality of *Jamaican ginger varieties* and geographical location in which it is produced and other distinguishing attributes. This will be supported by the proposed island-wide characterization studies. Other considerations towards establishing GIs for Jamaican ginger as outlined by the JIPO Geographical Indications Manual are also reported.

The main location of local ginger varieties currently being cultivated across the island was ascertained mainly through consultations with RADA and farmers and this has been provided to include a constructed map of the locations of varieties. Samples of Jamaica Blue, Jamaica Yellow and Hawaiian ginger were collected from Porus (Redberry), Pike and Christiana (Brockery), Manchester, respectively. GPS coordinates are provided. Samples have subsequently been submitted to the Bodles Research Station Tissue Culture Laboratory.

From consultations with twelve (12) of the major buyers/users of ginger mainly in the seasoning, sauces, beverages, teas and baking industries, a combined annual demand for dried ginger of 140mt (700mt fresh/green ginger), was ascertained. While there was no preference for a specific variety of Jamaican ginger, the processors expressed a unanimous preference for Jamaican ginger varieties over imported substitutes, because of the superior pungency and flavour.

The cost of production (COP) for commercial production of clean planting materials under shadehouse was identified as a crucial gap and bottleneck in attracting private sector investment and as such, this has been included in the Report. Preliminary estimates for cultivation of ginger tissue cultured plantlets and rhizomes under shadehouse was ascertained from the Economic Planning Division of MICAF, based on production under 1 acre of shadehouse in Epsom, St. Mary. The COP for ginger tissue cultured plantlets cultivated in grow bags on coconut coir was estimated at $233.68/kg, based on a marketable yield of 14,605kg in year 1 and 38,945kg in years 2 (F1 rhizomes) and 3 (F2 rhizomes), and total production costs of approximately $10.5 million, $5.5 million, and $5.6 million in years 1, 2 and 3, respectively. Additionally, the COP for cultivation of tissue cultured ginger rhizome planting materials (F1 and F2) in grow bags on coconut coir under similar conditions was estimated at $156.31/kg, based on a marketable yield of 38,945kg in years 1 and 2, and total production costs of $6.7 million and $5.5 million in years 1 and 2, respectively.

The Report concludes with policy recommendations, with specific reference to the Draft National Seed Policy, a proposed process for transfer of the information from the concluded Report to the producers of ginger tissue cultured plants by MICAF and recommendations towards development of a roadmap for developing Jamaican ginger varieties.

List of Abbreviations

AFLP..... Amplified Fragment Length Polymorphism

ANOVA..... Analysis of variance

BSJ..... Bureau of Standards Jamaica

CARDI.....Caribbean Agricultural Research and Development Institute

COP.....Cost of Production

CPGCA.....Christiana Potato Growers' Cooperative Association

DNA ..... Deoxyribonucleic Acid

GI ..... Geographic Indicators

HPLC..... High Performance Liquid Chromatography

HPTLC..... High Performance Thin Layer Chromatography

IAEA..... International Atomic Energy Agency

JACRA..... Jamaica Agricultural Commodities Regulatory Authority

JBF.....Jamaica Business Fund

JIPO..... Jamaica Intellectual Property Office

MICAF..... Ministry of Industry, Commerce, Agriculture and Fisheries

NCU..... Northern Caribbean University

NTCTWG..... National Tissue Culture Technical Working Group

R&D..... Research and Development

RADA.....Rural Agricultural Development Authority

SRC..... Scientific Research Council

TLC ..... Thin Layer Chromatography

UWI..... University of the West Indies

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1. Introduction

Ginger, *Zingiber officinale* Roscoe, is a herbaceous perennial crop cultivated in many tropical countries of the world including China, India, Nigeria, Australia, Jamaica, and Haiti. The world's largest producers include India, China, Nepal, Nigeria and Thailand, in descending order. It is widely known worldwide as a spice, flavouring agent, and herbal medicine and is valued for its powder, oil, and oleoresin. As a nutraceutical it is most potent between 6-7 months after planting (SRC).

Jamaican ginger is highly reputed for its high quality, uniqueness of flavour and oil content and is cultivated in areas with steep topography, cool temperatures, and soils rich in clay to include mainly areas in the parishes of Clarendon, Manchester, St. Ann, and St. Thomas. Several varieties having differing morphological, molecular and chemical characteristics are being cultivated, including the Jamaica Blue, Jamaica Yellow, Jamaica Native and China Blue, which may have trade implications.

Despite a widely accepted quality reputation and high export and local demand for Jamaican ginger (4,200 tonnes and 1,309 tonnes(dried), respectively) (MICAF), production levels have drastically declined to globally insignificant levels due to constraints related to lack of coordination and management of the industry and outbreak and spread of the ginger rhizome rot disease which has drastically reduced productivity. Strategic intervention by MICAF has included a Ginger Resuscitation and Expansion Programme with propagation and production of disease-free planting materials by tissue culture (Plates 1 and 2) for distribution to farmers. However, the required commercial production of tissue culture plantlets is constrained by gaps in available information on the local ginger varieties, their precise identification, among other issues.

Plate 1. Tissue cultured ginger plantlets (Source P. Chang, R&D Division)

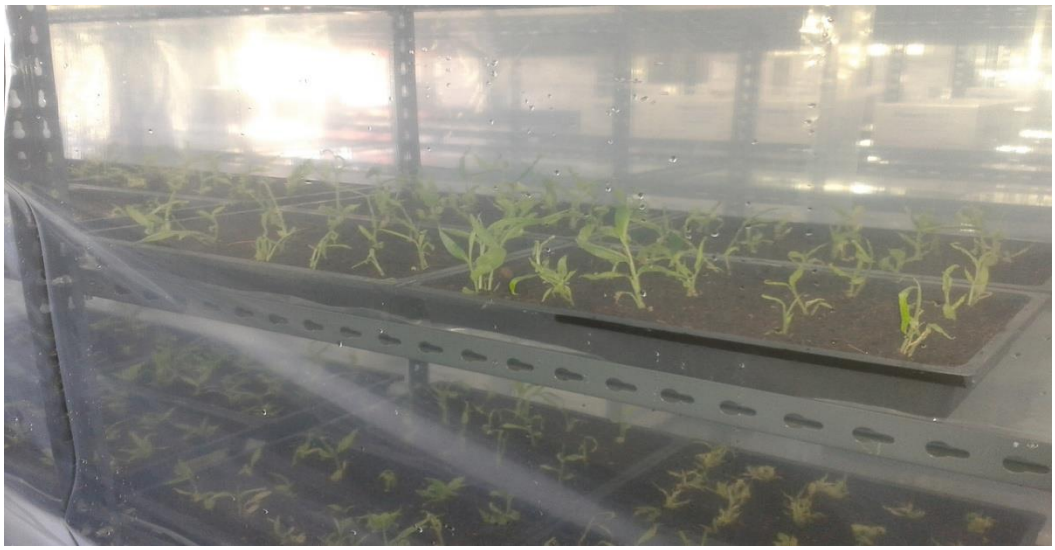

Plate 2 . Hardening of ginger tissue cultured plantlets (Source P. Chang, R&D Division)

As part of efforts to support sustainable development of the Jamaican ginger industry, and specifically, the propagation of local varieties of ginger to allow for value-addition and export expansion, the Jamaica Business Fund (JBF) has sought to provide support for the investigation of the available information on identification of the local varieties being cultivated in Jamaica. In this regard this Report was commissioned to include:

- *review of relevant studies on ginger with specific reference to the varieties grown in Jamaica;*
- *Assessment of the specific characteristics and properties of the local varieties compared with the Chinese, Hawaiian and any other variety that might be identified;*
- *Reporting on useful material for establishing geographical indicators for Jamaican Ginger varieties;*
- *Reporting on the location of ginger varieties under cultivation in consultation with MICAF and RADA;*
- *Representative sample collection of local ginger varieties for submission to the Bodles Research Station, with GPS mapping of sample location;*
- *Determination of work done on precise identification of ginger varieties, in consultation with the SRC;*
- *Determination of the demand for each of the identified Jamaica ginger varietals through meetings with major users/buyers of ginger;*
- *Recommendations for policy and legal changes or support with reference made to the Draft Seed Policy;*
- *Proposal of a process, for MICAF, to transfer the concluded information to the producers of ginger tissue culture plants;*
- *Recommendations towards a roadmap for developing the Jamaican ginger varieties*.

It is expected that the findings will support ongoing work being undertaken through the MICAF and will ultimately be utilized to assist the process of revitalization of the Jamaican ginger industry.

2. Review of Studies Conducted on Ginger Varieties in Jamaica

A review of the available literature indicates that a significant body of work has been conducted on Jamaican ginger varieties mainly by the Research and Development Division of MICAF and the SRC. The main focus has been on agronomic evaluation of local varieties under protected cover and molecular and chemical characterization of the varieties.

2.1 Agronomic Evaluation of Ginger Varieties and Planting Materials under Greenhouse Conditions at the Bodes Research Station

As part of work carried out under the Ministry of Agriculture's Ginger Resuscitation Project to boost local ginger production, the Research and Development (R&D) Division conducted research work to evaluate ginger planting material (tissue culture plantlets and F1 (first generation) rhizomes) of different varieties, under green house conditions at the Bodles Research Station in St. Catherine (R&D Division, 2015). The objective of the studies was to

evaluate and develop cost effective methods of rapid multiplication of clean planting material of Jamaican ginger varieties under nursery conditions.

2.1.1 Methodology

Clean planting materials were planted in coir or perlite growing media placed in sterilized plain poly plant bags. The plants were fertilized using a drip fertigation system under a specified nutrient regime applied according to the developmental stage of the crop. Regular monitoring for pests and diseases was carried out and appropriate management interventions implemented. Growth data, including tiller numbers and other pertinent information were recorded monthly. With drying down at the end of the growth cycle, fertigation was discontinued to facilitate senescence. At the end of drying down, the root mass of the ginger plants were removed and allowed to air dry. The dried plant material was then removed, cleaned of extraneous plant material and further allowed to dry before weighing.

Plate 3. Ginger planted in poly bags under evaluation at the Bodles Research Station (Source: C. Douglas, R&D Division)

2.1.2 Results

During 2010/2011, the experiment evaluated tissue cultured plantlets of Jamaica Yellow, Jamaica Blue and Jamaica Native varieties on coir and perlite growing media. Results provided from harvest data indicated that:

1. Although there was some indication that plants performed better on the coir media and that Jamaica Blue was more productive than Jamaica Yellow (in the order Jamaica Blue > Jamaica Yellow > Jamaica Native) (Appendix 2), it was found that the levels of variability observed negated any statistical differences between the two media (Appendix 3);

2. As with the analysis for the media, it was reported that the level of variability among the plots eliminated any potential differences among the varieties and as such, no significant differences in yield was shown by the varieties (Appendix 4).

Another study conducted in 2011/2012 evaluated two planting materials (tissue culture plantlets and the first generation (F1) rhizomes from work carried in the previous year) of Jamaica Yellow and Jamaica Blue varieties planted in coir under greenhouse conditions.

Plate 4. F1 Rhizomes (Source: C. Douglas, R&D Division)

Results from harvest data on the overall yield of the varieties and planting materials indicated that:

1. Although it was again observed that Jamaica Blue was more productive than Jamaica Yellow (Appendix 5), analysis of data on the mean yield/plot of the Jamaica Blue and Jamaica Yellow varieties indicated that there was no significant statistical differences ($p = 0.577$) in yield between the two varieties (Appendix 6).

2. It was observed that yields from F1 rhizome planting materials of both varieties were generally higher than the tissue-cultured planting materials (Appendix 5), but statistical analysis of the data relating to the planting material also indicated that there was no significant difference ($p = 0.255$) in yield between the tissue culture plantlets and F1 rhizome planting material used, because of the level of variability in the plots (Appendix 7).

3. Additionally, no statistically significant difference($p=0.669$) in yield was recorded for the planting material used for both the Jamaica Blue and Jamaica Yellow varieties (Appendix 8).

4. The mean yield per plant did not show any significant differences across the varieties or planting materials. The overall experimental yield per plant was 1.075 kg.

Although data from the studies lend itself to interesting indicative observations on the yield of varieties as outlined, the reported high degree of variability within experimental plots effectively renders the findings inconclusive. As such, it is recommended that the experiments be repeated with appropriate adjustments in experimental design to provide conclusive data.

2.2. Evaluation of Planting Materials (Tissue Culture and F1 Rhizomes) of Ginger Varieties (Jamaica Blue and Jamaica Yellow) under Greenhouse Conditions at the Montpelier Research Station

The R&D Division of MICAF also conducted evaluation studies on planting materials of local ginger varieties to assess their performance on two types of coir under greenhouse conditions at the Montpelier Research Station, in St. James (R&D Division, 2014, 2015, 2016).

2.2.1. Methodology

In July 2014, tissue culture plantlets and first generation(F1)rhizomes of the Jamaica (Frog) Blue and Jamaica Yellow varieties were planted out in grow bags containing local or imported coir. Plants were irrigated with plain water for up to three months with weekly foliar application of 19-8-28 fertilizer commencing in the fourth week after tillers emerged in more than 90% of all the bags planted with ginger rhizomes. In September, plants were hilled and biorganic fertilizer applied at a rate of one pound per plant. This was followed by applications of Production Premium (soluble fertilizer) in October 2014 which continued weekly up to January 2015, after which plants were irrigated with water only which was discontinued by mid January 2015 to allow for drying down of the plants. Rhizomes were harvested on February 16, 2015 after about 80% of the tillers had dried down. Pest management included application of Bellis®, a highly translaminar fungicide, which was applied twice in November with 19-8-28 to mitigate against the spread of Leaf Spot disease.

2.2.2. Results

The results provided from the harvest data are provided in Appendix 9 - Table 8. Generally, planting materials of the Jamaica Blue variety produced slightly higher yields than the yellow variety on both imported and local coir. But, the performance of Jamaica Yellow planting materials was slightly higher in the local coir, while yields for Jamaica Blue was higher in the imported medium.

It is interesting to note that, as with the Bodles evaluation, the Jamaica Blue variety was generally higher yielding than Jamaica Yellow and yields were observed to be

higher in the F1 rhizome planting material than for tissue cultured plantlets. However, statistical analysis of the data should be done to determine the significance of the differences observed. It may also be useful to repeat the evaluation to provide conclusive results.

2.3. Chemical Characterization of Jamaican Yellow Tambric, Bulbous Blue and Frog Blue ginger and Hawaiian ginger (HG) by the Scientific Research Council.

This study was conducted by the Scientific Research Council to provide chemical characterization data to assist with distinguishing of the unique qualities of Jamaican ginger (Bailey-Shaw et al, 2008). A novel high performance thin layer chromatography (HPTLC) technique for fingerprinting of Jamaican ginger was developed and used to chemically characterize four varieties of ginger. The pungent principles were quantified using high performance liquid chromatography (HPLC) essential oil yields were also compared.

2.3.1. Methodology

Samples of Yellow Tambric ginger (YTG), Bulbous Blue ginger (BBG), Frog Blue ginger (FBG) and Hawaiian ginger (HG) were washed, mechanically sliced and steam dried at 49^{o}C to a moisture content of 8–10% and then milled into a fine powder. The ground ginger materials were then extracted in methanol, concentrated and filtered for HPTLC and HPLC according to the extraction procedure listed in the ISO 13685:1997(E) method for HPLC analysis of the pungent principles of ginger. The essential oil of each variety of ginger was extracted by hydro distillation and dried and the yield calculated. Statistical analysis was done using ANOVA, at a 95% confidence interval.

2.3.2 Results

The results of the HPTLC profiles of the ginger varieties showed that the pungent principles, 6-gingerol, 10-gingerol and 6-shogaol were clearly differentiated in all varieties

while 8-gingerol was present in smaller quantities. Nine distinct chemical zones were identified in the developed HPTLC chemical profiles as reference markers which may be used for authentication of the Jamaican ginger varieties. These included 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol, which were resolved as discrete bands at retention time (R_t) values 0.46, 0.49, 0.52 and 0.64, respectively. Relative to retention time value of 6-gingerol, the other pungent compounds were highlighted at relative R_t values of 1.06 (8-gingerol), 1.13 (10-gingerol) and 1.39 (6-shogaol).

The concentration(% by mass) of pungent principles in the different varieties of ginger from the HPLC analysis are provided in Appendix 10. The results indicated that 6-gingerol was four times more concentrated than the other pungent principles in all varieties. Yellow Tambric had the highest 6-gingerol concentration followed by Bulbous Blue, Frog Blue and Hawaiian ginger, respectively. 10-gingerol was the second highest dominant principle, with Bulbous Blue having the highest concentration. Statistical analysis indicated significant differences in the levels of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol among the varieties. Analysis of cumulative effects of the compounds revealed that, of the varieties, Bulbous Blue ginger was the most pungent at 1.592±0.005%, followed by Frog Blue (1.451 ± 0.048%), Yellow Tambric (1.414 ±0.032%) and Hawaiian ginger (1.037± 0.010%), respectively.

Essential oil yields varied in the same order as pungency for the different varieties. Bulbous Blue ginger showed the greatest yield of 1.291 ± 0.100% followed by Frog Blue ginger with 1.206 ±0.039%, Yellow Tambric ginger with 1.055± 0.017% and Hawaiian ginger, the least pungent variety produced only 0.711± 0.063% of essential oil. Differences in yields among the varieties were statistically significant.

The ginger varieties compared were qualitatively similar in general chemical compositions as illustrated by the HPTLC, but varied significantly in essential oil content and levels of total pungency as shown by HPLC analysis. Blue varieties of Jamaican ginger were the most pungent and have the highest essential oil yields.

2.4. Molecular Characterization of Jamaica Blue, Jamaica Native, Jamaica Yellow and China Blue

The Scientific Research Council also conducted molecular characterization studies to compare the DNA profiles of the Jamaica Blue, Jamaica Native, Jamaica Yellow and China Blue varieties (SRC, 2014).

2.4.1. Methodology

DNA from the tissue cultured varieties were extracted and characterized using Amplified Fragment Length Polymorphism (AFLP) protocol and NTSYSpc 2.2 and NTedit statistics software. AFLP technology is a technique for fingerprinting genomic DNA. DNA fingerprinting is used to visualize DNA polymorphisms between samples. These fingerprints may be used as a tool for determining the identity of a specific DNA sample or to assess the relatedness between samples.

2.4.2. Results

Plate 5 is a polyacrylamide gel showing the DNA profile of the samples assessed. Tomato and sweet potato outgroups were used as controls.

The presence/absence of bands were scored and analysed by the statistical software (NTSYSpc 2.2 and NTedit) and the following conclusions made: Jamaica native ginger is genetically similar (90%) to Jamaica blue ginger, while it is less similar to Jamaica yellow (approximately 78%). China Blue was approximately 70%similar to the yellow, native and blue varieties. These levels of genetic variation implies that the Jamaica Native, Jamaica Blue, Jamaica Yellow and China Blue varieties are distinct varieties.

1 2 3 4 5 6 78 9 10 1112 13 1415161718 19 20 21 22

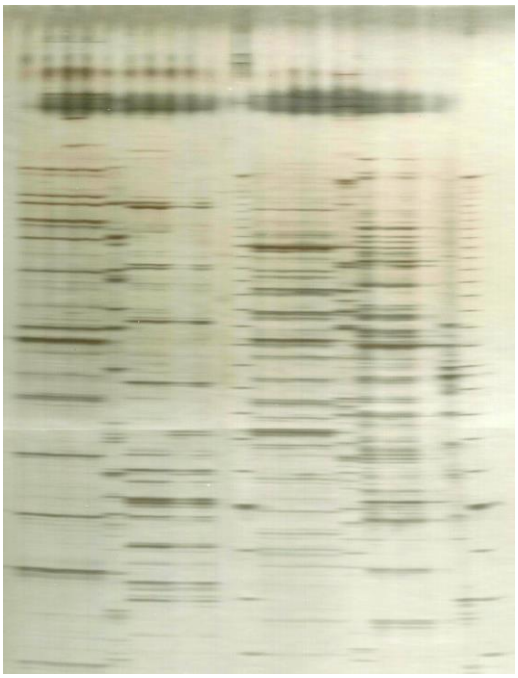

Plate 5. *AFLP products from tissue cultured ginger. Samples were loaded in the following order: Primer E-ACC and M-CAC Lane 1:Jamaica Blue 2: Jamaica Native, 3: Jamaica Yellow, 4: China Blue, 5: Tomato (outgroup), Primer E-ACG and M-CAC 6: Jamaica Blue, 7: Jamaica Native, 8: Jamaica Yellow, 9: China Blue, 10: Sweet potato (outgroup), 11: Molecular Ladder (50 Bp), Primer E-AAC and M-CTG 12: Jamaica Blue, 13: Jamaica Native , 14: Jamaica Yellow, 15: China Blue, 16: Tomato, Primer E-AGC and M-CTT 17: Jamaica Blue, 18: Jamaica Native, 19: Jamaica Yellow, 20: China Blue, 21: Tomato, 22: Molecular Ladder (50 Bp).*

3. Characteristics of Local Varieties of Ginger

The three (3) main varieties of local ginger grown and traded in Jamaica, as reported by researchers, are the Jamaica Yellow, Jamaican Blue and Jamaica Native. The other cultivated varieties are the Chinese and Hawaiian ginger.

Some general comparative morphological characteristics of these cultivars, as well as molecular characterization (conducted by the Scientific Research Council) are outlined in Table 1. There was no available literature on phenotypic characterization of the Jamaican ginger varieties. It is therefore recommended that work be carried out on morphological characterization of ginger, similar to the work conducted by the R&D Division, MICAF and

the Caribbean Agricultural Research and Development Institute (CARDI) on roots and tubers.

Chemical characterization of the Jamaica Blue, Jamaica Yellow and Hawaiian varieties of ginger revealed that Jamaica Blue was the most pungent with the highest cumulative effects of the compounds, 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaol. This was followed by Jamaica Yellow and the Hawaiian variety, respectively. Trends in essential oil content followed the same order (Jamaica Blue > Jamaica Yellow > Hawaiian) (see Section 2.3. above).

Plate 6. Jamaica Yellow variety

Table 1. Comparative morphological and molecular characterization of Jamaican ginger and Chinese and Hawaiian ginger varieties

Variety	Morphology	Molecular Characteristics
Jamaica Yellow	yellow flesh; smaller (than Jamaica Blue) rhizomes; thinner (than Jamaica Blue) in diameter; fibrous; pungent	Genetically distinct
Jamaica Blue	blue flesh; larger (than Jamaica Yellow) rhizomes; darker skin colour; thicker in diameter; fibrous; pungent	Genetically distinct
Jamaica Native	yellow flesh (paler than Ja. Yellow); smaller (than Jamaica yellow rhizomes; fibrous; pungent	Genetically similar (90%) to Jamaica blue; approximately 78% similar to Jamaica yellow
Chinese	two types - pale yellow and blue flesh; large rhizomes (larger than Jamaican Yellow and Blue); less fibrous; higher water content; less pungent than Jamaican varieties	Chinese Blue is, approximately 70% similar to the yellow native and blue varieties.
Hawaiian	yellow flesh; medium-sized rhizomes (larger than Jamaican varieties and smaller than Chinese); fibrous; less pungent than Jamaican varieties	-

**Phenotypic characteristics described are based on personal communication with stakeholders due to unavailability of supporting literature.*

Plate 7. Jamaica blue variety

Plate 8. Hawaiian ginger

4. Location of Ginger Varieties under Cultivation in Jamaica

The major ginger-growing areas in Jamaica are found at approximately 450-900 meters above sea level, in the hilly areas of central Jamaica where the parishes of Manchester, Clarendon, St. Ann, Trelawny meet. However, the crop is known to grow well from sea level to over 1500 meters above sea level, on many soil types in Jamaica, particularly on clay loams having a high organic matter content. It requires at least 1500mm of rainfall per year with a short dry season at harvesting time (RADA, 1999). There are approximately 1,521 ginger farmers in Jamaica who cultivated 268 hectares of ginger in 2016, in plots from 0.1 to 4 hectares (FAO/Thompson, 2017).

Based on consultation with MICAF and RADA, the main location of ginger varieties currently being cultivated across the island include:

- Clarendon - *Frog Blue/Jamaica Blue, Yellow Tambric/Jamaica Yellow and Chinese
  (Kellitts; Spalding (Silent Hill, Moravia)
- Hanover - Jamaica Yellow and Jamaica Blue
  (Cascade Hill; Cash Hill; Patty Hill)
- Manchester - Jamaica Yellow, Jamaica Blue, Chinese and Hawaiian.
  (Christiana; Coleyville; Pike; Porus)
- Portland - Jamaica Yellow and Jamaica Blue
  (Milbank; Cornwall Barack)
- St. Andrew - Jamaica Yellow
  (Salisbury Plain; Mavis Bank)
- St. Ann - Jamaica Yellow and Jamaica Blue
  (Cave Valley)
- St. Catherine - Jamaica Yellow and Jamaica Blue
  (Guys Hill; Above Rocks)

- St. Elizabeth - Hawaiian
  (Accompong Town; Elderslie; Jointwood

- St. James - Hawaiian
  (Maroon Town)

- St. Mary - Jamaica Blue
  (Rosend)

- St. Thomas - Jamaica Yellow and Jamaica Blue
  (Johnson Mountain)

- Trelawny - Jamaica Yellow
  (Highgate Hall; Crownland; Lorrimers)

- Westmoreland - Jamaica Yellow
  (Williamsfield; Little London;
  Bethel Town; Leamington)
  *(*Note: There was confusion on the designation of 'Frog Blue' vs. Jamaica Blue and 'Tambric Yellow'/Jamaica Yellow; reference to 'Frog' Blue and 'Tambric Yellow' was only done for varieties named in Clarendon).*

  The map provided in Fig 1. below indicates the main location of ginger varieties being cultivated across Jamaica (constructed based on the information outlined above).

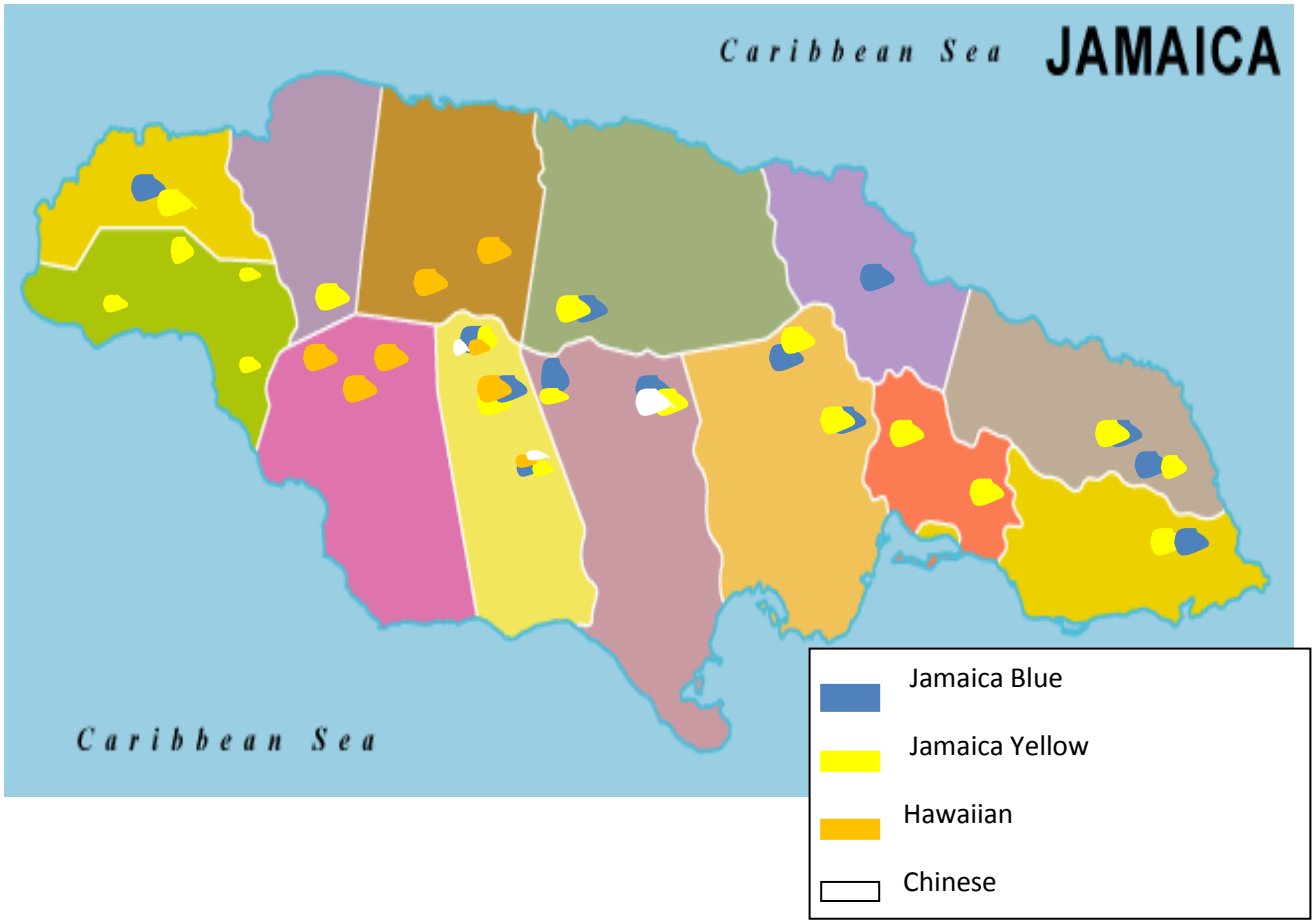

Fig. 1 Map showing the main location of ginger varieties being cultivated across Jamaica (2017) (constructed based on the information provided by RADA).

Sample Collection

Samples of Jamaica Blue, Jamaica Yellow and Hawaiian ginger were collected from Porus (Redberry), Pike, and Christiana (Brockery), Manchester, respectively (Plate 9). See GPS coordinates provided in Figures 2-4 below. The samples were subsequently cleaned, packaged and submitted to the Bodles Research Station to facilitate tissue culture propagation.

Plate 9. Sample - ginger varieties

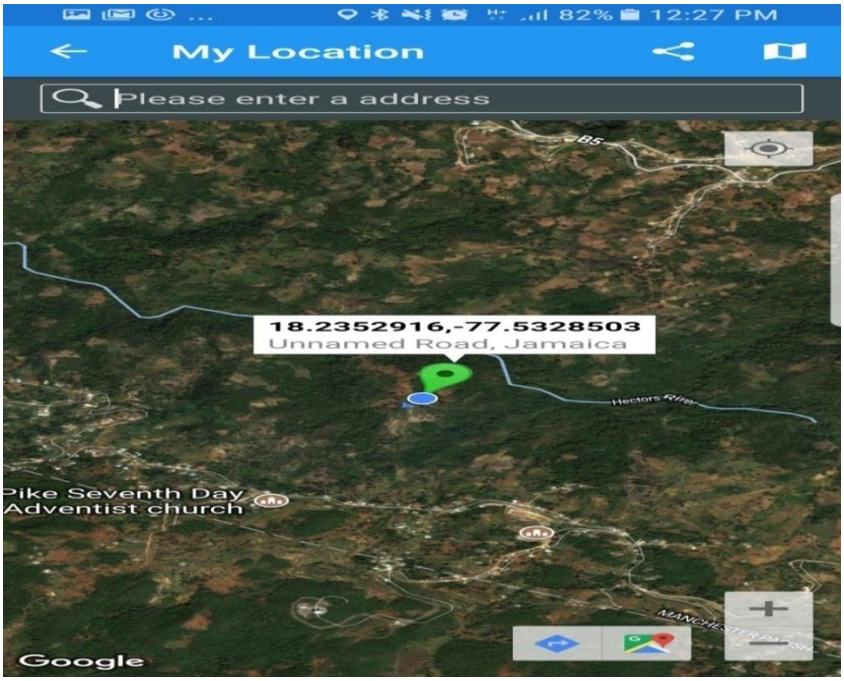

Fig 2. GPS coordinates of area in Pike, Manchester from which Jamaica Yellow variety was collected.

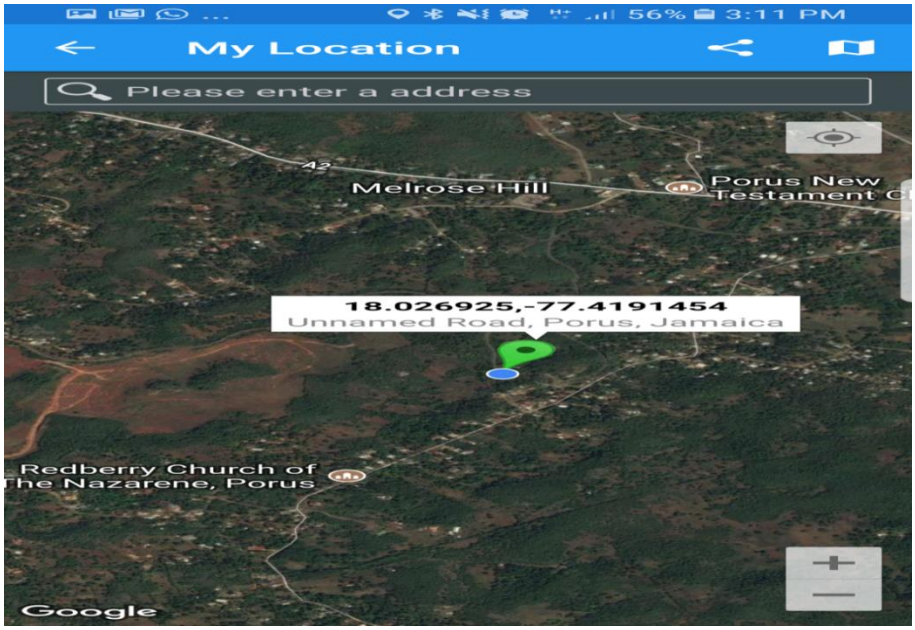

Fig. 3. GPS coordinates of farm area in Redberry, Porus, Manchester from which the Jamaica Blue sample was collected.

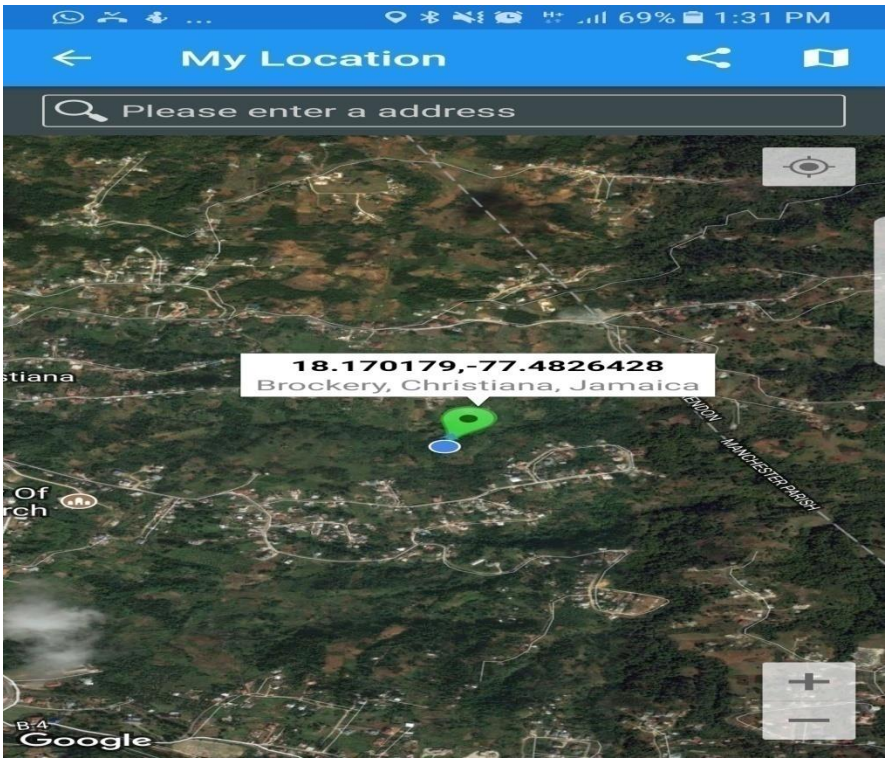

Fig. 4. GPS coordinates of farm area in Brockery, Christiana from which Hawaiian ginger was collected.

5. Demand for Jamaican Ginger Varieties

World ginger production was 2.16 million tonnes in 2014, with top producers being India, China, Nepal, Nigeria and Thailand, in descending order (FAOStat). Global sales from crushed or ground ginger exports, amounted to US$86 million while export sales of ginger that was neither crushed or ground amounted to US$574.7 billion in 2016 (International Trade Centre). Correspondingly, despite having a global reputation for quality with superior pungency and flavour, ginger production in Jamaica has declined drastically over the years due to lack of coordination and strategic management of the industry and outbreaks of the rhizome rot disease. Jamaica's ginger production (dried) was only 1,274 tonnes in 2014 (FAOStat), which steadily declined to 789 tonnes in 2016 (Data Bank, MICAF) and with predictions for a significantly reduced volume of production for the 2017/2018 crop (Export Division, MICAF).

According to the Ministry of Agriculture, Jamaican ginger has an export demand of approximately 21,000 tonnes (fresh) or 4,200 tonnes dried, which is approximately 3.7% of global imports. This would require 2,300 acres of land under cultivation. Simultaneously, local demand is currently at 1,309 tonnes (dried). Jamaica imports the equivalent of 495 metric tonnes of ginger mostly as split dried and ground ginger from China, Nigeria, USA and Canada (ITC) due to the unavailability of domestic supplies. At current yield of 9.0mt per acre, imports is equivalent to 55 acres of cultivation. The Jamaican Agriculture Ministry has also conservatively estimated present unmet demand for Jamaican ginger in USA, UK and Japan at 1,890mt (about 1.38% of the annual demand of these countries) valued at USD2.6 million, which equates to an opportunity to double the local ginger industry with further cultivation of 210 acres. In addition, with increasing emphasis on the phytochemicals of ginger in the nutraceuticals and functional foods, dietary supplements, beverages and general consumption, Jamaican ginger, with it's verified high concentrations of these compounds, has increasing opportunity for positioning in niche markets of North America and Europe to grow demand beyond the current 1.38% of imports.

The major buyers/users of ginger in Jamaica are mainly teas, seasonings, sauces, beverages and baking manufacturers. For purposes of this report, consultation was done with twelve (12) of these stakeholders to determine their demand/requirement for ginger as well as indication of their preference for any specific variety of ginger (See List of Consultations).

In all cases, the buyers confirmed that local supplies of Jamaican ginger have been woefully inadequate and have consistently not met their annual demand. As such, the shortfall in supplies have been met through imports of mainly split dried, whole peeled and ground ginger from China, Nigeria, India, Thailand and Canada (re-export). Some processors have also utilized imported ginger emulsions and flavours in their formulations. Consultations also indicated that while there is no preference for a specific variety of Jamaican ginger, the processors expressed a unanimous preference for Jamaican ginger varieties, because of the superior pungency and flavour. The imported Chinese and Hawaiian varieties, though larger and cleaner, were found to be far inferior in pungency and flavour but had to be procured because of inadequate supplies of local ginger varieties. The interviewed processors in the seasoning, sauces, beverages, teas and baking industries expressed a combined annual demand for dried ginger of 140mt (700mt fresh/green ginger), which, currently, is imported.

6. Cost of Production for the Cultivation of Ginger Tissue Cultured Plantlets and Rhizomes under Shadehouse Conditions

The successful utilization of disease-free tissue cultured planting materials to increase Jamaica's ginger production and productivity provides a basis for support of an ongoing, structured programme targeted at meeting commercial demand. However, progressive expansion and sustainable development of the local industry hinges on the extent of private sector investments based on demonstrable profitability. The cost of production for commercial production of clean planting materials under shadehouse has been identified as a gap and crucial bottleneck towards this end, and as such, priority focus on this activity is vitally important.

Preliminary estimates for the cultivation of ginger tissue cultured plantlets and rhizomes under shadehouse have been ascertained from the Economic Planning Division of MICAF, based on production in Epsom, St. Mary. Details of these estimates are presented in *Appendix 11 and 12*.

The cost of production for ginger tissue cultured plantlets cultivated in grow bags with coconut coir under 1 acre of shadehouse was estimated at $233.68/kg. This is based on a marketable yield of 14,605kg in year 1 and 38,945kg in years 2 (F1 rhizomes) and 3 (F2 rhizomes), and total production costs of approximately $10.5 million, $5.5 million, and $5.6 million in years 1, 2 and 3, respectively. Production cost items and assumptions are as outlined in the table and notes provided in *Appendix 11*. Additionally, the cost of production for tissue cultured ginger rhizome planting materials (F1 and F2) cultivated in grow bags with coconut coir under similar conditions was estimated at $156.31/kg. This is based on a marketable yield of 38,945kg in years 1 and 2, and total production costs of $6.7 million and $5.5 million in years 1 and 2, respectively. The production cost items and assumptions are as outlined in the table and notes given in *Appendix 12*.

It is recommended that these estimates, as well as estimates for work conducted at the Bodles, Orange River and Montpelier Research Stations (which were not completed up to the time of finalization of this Report), should be utilized to conclude on cost of production analysis to compile the necessary investment profiles for private sector engagement.

7. Considerations towards Development of Geographic Indicators for Jamaican Ginger

Geographical Indicators (GIs) are valuable tools to protect and take advantage of the distinctive characteristics and reputation of agricultural products which are derived from a particular geographical area. According to the Protection of Geographical Indications Act, 2004 (Jamaica), a geographical indication is "an indication which identifies a good as originating in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its

geographical origin." A GI offers protection to producers and manufacturers of certain goods based on where they are produced and/or the method of production used. It creates a link between the standard of quality and the place of origin of the product, and essentially ensures that the acquired reputation is protected and maintained. Development of standards and quality requirements and standardization of minimum criteria to be met by all producers are essential prerequisites for development of GIs.

In order to leverage the goodwill of Brand Jamaica and protect the reputation that distinctive Jamaican products enjoy locally and internationally, the Jamaica Intellectual Property Office (JIPO) has encouraged the development of GIs for Jamaica through consultation with stakeholders, including ginger. The Office has also developed a Geographical Indications Manual to provide information and guide the process of registration. Accordingly, considerations and steps towards obtaining a GI for Jamaican ginger, based on information provided in the manual (JIPO, 2015), include the following:

- Identification of a link between the quality of Jamaican ginger and the geographical area in which it is produced;
- Determination of how the geographical area assists in creating a unique and superior ginger product, including the influence of climate, soils, altitude, specialized local knowledge etc. The uniqueness of the product should be discerned visually (size, shape, colour), by taste, smell or symbolically etc.,
- Determination of the viability of pursuing GI status for ginger by determining the level of interest of the main stakeholders in participating in the process and market and basic analysis to determine possible costs;
- Formation of a Ginger Producers' Association (comprising representatives from the government and various persons involved directly in production) should be done to organize production, manage the GI process and develop a long-term strategic plan that will oversee all pre- and post registration actions relating to the GI;
- An essential element of the long-term strategic plan relating to GI for ginger would include the development of a Code of Practice with relevant information setting out the criteria for the product to qualify for GI status, which should be based on the

link between the unique characteristics of ginger and the geographical location within which it is produced, and a Control Manual, which outline the steps required for ginger produced under the GI to be inspected for standards compliance and quality assurance;

- Control measures to ensure that the described quality is maintained will need to be established including a mechanism of control at the level of producers (to ensure that what is being produced meets the required standards). At the level of the Ginger Producers' Association, a monitoring and inspection system of control should be established to ensure that the product name is not compromised and all requirements are met;
- It is recommended that an external body should also be involved to ensure that ginger in the local and international market complies with requirements and meets international standards. The external body and the Producers' Association will need to work together to develop controls such as how many producers will be controlled, how often the control mechanisms will be implemented on an annual basis, testing of products etc.;
- Penalties stipulated by the Act range from 12 months imprisonment and/or a fine of up to J$1 million in the lower courts, to 5 years imprisonment and/or a fine to be determined by the Supreme Court. Pecuniary damages may be awarded for improper usage of the GI.

The general acceptance of the superior quality of Jamaican ginger globally, substantiates the formulation of a hypothesis or research question to investigate geographic indications (GIs) or origin-linked characteristics for Jamaican ginger. As outlined in the Geographical Indications Manual, the critical first step in the process towards developing GIs for Jamaican ginger lies in the establishment of the link between its quality and geographical location and determination of how the geographical area assists in creating a unique and superior ginger product, including the possible influence of climatic conditions, soil characteristics, altitude etc. Visual, taste, smell and other distinct uniqueness of the product would also need to be established.

The preliminary work on chemical characterization of local varieties which was conducted by the SRC, with samples collected from the parish of Clarendon, is an important first step in the process towards development and registration of GIs for Jamaican ginger. However, there is need for further, more comprehensive and systematic research on representative samples collected across the island to link the pungency and other chemical characteristics of Jamaican ginger to geographic location or microclimatic conditions. This should also be coupled with simultaneous multidisciplinary work, possibly involving the SRC, UWI and the R&D Division of MICAF, to include molecular and morphological characterization for more conclusive validation.

The newly established Jamaica Agricultural Commodities Regulatory Authority (JACRA) which is mandated under the JACRA Act (2016) for development, regulation and standardization of the agricultural commodities industry, including ginger, should take a lead role in and pilot the development of GIs for Jamaican ginger. A national Ginger Producers' Association should seek to bring together farmer groups within ginger producing areas across the island and RADA should assume responsibility for organizing production and facilitating the Association in collaboration with JACRA. Partnership with external organizations such as JIPO and the BSJ will be key for support on the legal framework for the protection of the GI and to ensure that quality standards and ultimately, reputation are maintained.

8. Policy Recommendations (with Reference to the Draft National Seed Policy)

As part of the resuscitation and expansion programme for Jamaican ginger to address the drastic decline in production caused by outbreak of the ginger rhizome rot disease, priority attention has been given to the provision of clean, disease-free ginger planting material using tissue culture. Towards this end, the Christiana Potato Growers' Cooperative Association (CPGCA), Scientific Research Council (SRC), Biotechnology Centre of the University of the West Indies and the R&D Division of the Ministry of Industry, Commerce, Agriculture and Fisheries (MICAF) have been involved in multiplying clean ginger planting

materials which have been distributed to farmers. In addition, the SRC in collaboration with MICAF has been working to develop irradiated tissue culture ginger plants that are resistant to ginger rhizome rot through a project funded by the International Atomic Energy Agency (IAEA). However, while irradiation holds potential for the intended purpose, it is important for such intervention to take into consideration the import requirements of Japan (the largest potential and recent historic export market) on irradiation treatment and the general positioning of Jamaican ginger in global specialty (health foods) markets.

The development of tissue culture facilities/infrastructure for the provision of clean ginger planting material is addressed under the recently developed Draft National Seed Policy which provides a framework for development of a seed or planting material system to ensure availability of high quality planting materials to support agricultural production and productivity. The policy addresses areas for research, plant breeding, varietal evaluation, seed multiplication, processing, storage, quality control, marketing, promotion and protection of plant genetic resources for food and agriculture. It also provides a framework for implementation of appropriate institutional arrangements, building of technical and institutional capacity, promulgation of seed legislation, financing strategy and a communications programme.

Recommendations for policy imperatives with reference to the Draft National Seed Policy include the following:

- The Draft National Seed Policy should be examined in order to definitively define a way forward for the development of the Jamaican ginger varieties;
- The Draft National Seed Policy should mandate the certification of tissue culture producing facilities (labs, greenhouses, shade-houses) under validated processes, and verification of pathogen-free planting materials prior to distribution for commercial production. This is critical to the development of a reputable seed/planting material industry;
- Specialized extension services, as was available during 2009 to 2014, should be re-introduced to the ginger industry to build technical capacity, conduct field

experiments and guide commercial operations to minimize diseases, select varieties and improve yield and output.

- Private/public partnerships should be promoted for the evaluation, characterization and multiplication of local varieties of ginger using tissue culture. This should also include private sector involvement in operation of grow-out facilities and contract arrangements with ginger farmers;
- Consideration should be given to provision of appropriate tax and other incentives to the private sector for the operation of private sector tissue culture laboratories and grow-out facilities to support the required commercial expansion of the industry;
- Collaboration between local, regional and international organizations should be strengthened to maximize utilization of limited resources;
- Support should be given for capacity building and training of adequate numbers of research personnel and technicians to support the national seed/planting material programme and the foreseeable expansion to the private sector;
- Support should be provided for expansion of *in vitro* germplasm conservation of local ginger planting materials using tissue culture;
- The strategic development of appropriate legislative framework towards intellectual property rights protection and geographic indications for Jamaican ginger (supported by the required data to link chemical profiling of Jamaican ginger to geographic and microclimatic conditions) should be supported and implemented;
- To ensure successful and sustainable implementation, it is imperative that adequate funding support be provided to include financing from government, private sector investment, donor funding and technical cooperation.

9. Process to Transfer Information to the Producers of Ginger Tissue Culture Plants by MICAF

The supply of clean ginger planting materials of the different local varieies to farmers is a critically important strategy to combat the spread of ginger rhizome rot

disease which has been plaguing the Jamaican ginger industry. Work is already underway in this regard under the ginger resuscitation and expansion and Value Chain development programmes, in which priority attention has been given to the provision of clean, disease-free planting material using tissue culture. Over the years, the Christiana Potato Growers' Cooperative Association (CPGCA), SRC, Biotechnology Centre of the University of the West Indies and the R&D Division of MICAF are the main laboratories which have been involved in the multiplication of tissue culture plantlets for distribution to farmers. The Export Division of MICAF has been the main driver of this effort in providing funding support and facilitating distribution of planting material in collaboration with RADA.

A National Tissue Culture Technical Working Group (NTCTWG) has been formed under the auspices of MICAF to develop an improved governance and management structure for the propagation of clean and certified planting material for crops of economic importance, including ginger. The R&D Division of MICAF serves as the Chair and host of the NTCTWG, which is comprised of the three (3) main tissue culture laboratories, namely R&D Division, SRC and Northern Caribbean University (NCU), as well as the Jamaica Citrus Protection Agency (JCPA) of the Plant Quarantine Division and RADA, which will play a role in certification of nurseries and field operations, respectively. It is also envisaged that with development of infrastructure and capacity, the College of Agriculture, Science and Education (CASE) will also be brought on board as a participating laboratory. Under the Draft Terms of Reference for the NTCTWG (2017-2019), the Working Group is expected to coordinate activities in the propagation and production of required quantities of tissue cultured planting material, with a view to sharing among laboratories and greenhouse/shadehouse facilities (NTCTWG, 2017). Based on discussions with the Chair of the Working Group, targets have already been set for ginger, with allocations made for each laboratory.

MICAF has also recently constituted a Ginger Value Chain Coordination Committee comprised of public sector, private sector and academia partners, which is mandated to coordinate development of Jamaican ginger industry along the value chain. It is envisaged that activities will include clean-up and distribution of clean planting materials over a 4 - 5 year period, nursery operation and certification and private sector operation of planting material grow-out facilities linked to contract arrangements with ginger farmers.

It is proposed that the concluded information from this Report be made available to producers of ginger tissue culture plants through the Ginger Value Chain Coordination Committee and the NTCTWG of MICAF. It is also recommended that the Terms of Reference of the Value Chain Coordination Committee and the NTCTWG be examined towards finding sync with a road map for development of local ginger varietals in particular. The findings of this Report will also specifically support activities identified under the research component of the Draft Implementation Action Plan of the Working Group in providing information on variety characterization and location which will guide future research and production (NTCTWG, 2017). Samples of different varieties from specified locations should assist in boosting the process. The gaps identified in research related to agronomic evaluation, morphological, chemical and molecular characterization should be useful in setting the agenda for prioritization of future collaborative, multidisciplinary research and development work among the R&D institutions. The report will also guide collection of material for tissue culture propagation and the much needed replication and expansion of chemical, molecular and agronomic evaluation of samples from across the island, which will concretize the basis for sustainable production of commercial quantities of tissue culture plantlets to meet market demand.

10. Recommendations towards a Roadmap for Developing the Jamaican Ginger Varieties

Strategic development of the Jamaican ginger industry generally is being addressed through implementation of several initiatives including the Ginger Resuscitation and Expansion Programme and launch of the NTCTWG by MICAF, FAO Value Chain Development Project, JBF Ginger Industry Supply Chain Project, among others. The findings of this report are of fundamental importance in highlighting critical follow-up activities which should be implemented towards development of Jamaican ginger varieties, in particular. It is recommended that ***a roadmap*** specifically for developing the Jamaican ginger varieties be done to include the following:

- ***Identification, Characterization and Mapping of the Location of Ginger Varieties*** **-** Conclusive research to *simultaneously* include work on the morphological, chemical and molecular characterization needs to be done to specifically distinguish the Jamaican ginger varieties, and conclude on nomenclature. In this regard, a comprehensive, island-wide study should be undertaken as part of a collaborative research project involving the R&D institutions including the R&D Division of MICAF, SRC, UWI Biotechnology Centre, UWI Mona Institute of Applied Sciences (MIAS), Northern Caribbean University (NCU), the College of Agriculture, Science and Education (CASE) and RADA.
- ***Agronomic evaluation of Ginger Varieties*** - It is recommended that the work done on agronomic evaluation of ginger varieties be repeated to provide conclusive data on variety/planting material yields;
- ***Research on Ginger Rhizome Rot resistant/tolerant varieties*** - It is important that, in addition to irradiation work currently being carried out, further collaborative/interdisciplinary research work be conducted on disease tolerant/resistant varieties of ginger by the relevant R&D institutions;
- ***Support to NTCTWG*** - Support should be provided to the NTCTWG towards a national production programme for clean, tissue cultured ginger planting material to meet commercial demand. This should also include development support for

appropriate governance and management structure for the propagation of clean, certified planting material. It is also recommended that the Terms of Reference of the NTCTWG be examined towards finding sync with a road map specifically for the development of local ginger varietals;

- ***Expansion of Ginger Resuscitation and Expansion/Value Chain Programme with Priority Focus on Jamaican Ginger Varieties*** - Continued priority support should be given to the Ginger Resuscitation and Expansion and Value Chain Programmes to facilitate rapid expansion of ginger production, with special reference to Jamaican ginger varieties. Particular focus should be given to outputs from the NTCTWC relating to production targets for clean tissue cultured planting material linked to the capacity of laboratories and mapped distribution of specific varieties;
- ***Establishment of Geographic Indications for Jamaican Ginger*** - With implementation of the comprehensive, island-wide collaborative project referenced above, data supporting the link between quality of *Jamaican ginger varieties*, *in particula*r and geographical location should be utilized in developing GIs for the ginger varieties. Prior to conclusion of the study, it may also be useful to initiate discussions with JIPO to chart the way forward;
- **Private Sector Engagement and Investment** - Using existing market information, a specific, time-bound production/investment programme should be developed to systematically supply high quality Jamaican ginger varieties to processors and manufacturers to meet current demand, starting with the 2018/2019 ginger crop. It is proposed that this initiative be led by JACRA in collaboration with RADA.

  To boost investment interest from the private sector, it is imperative that available cost of production estimates, including those documented in this Report as well as analyses for shadehouse/greenhouse production conducted at the Bodles, Orange River and Montpelier Research Stations (which were not completed up to the time of finalization of this Report), be utilized to conclude on cost of production analysis to facilitate compilation of the necessary investment profiles for private sector engagement. Public/private partnerships should also be explored

towards operation of planting material grow-out facilities, linked to contract arrangements with ginger farmers.

- **Policy Support** - Leveraging existing policy imperatives as outlined in the Draft Seed Policy and other relevant agricultural policies, Intellectual Property Rights policies and regulations, Science and Technology Policy and relevant industrial and investment policies are critical to acquiring the necessary funding support for the development of the Jamaican ginger varieties. Steps should therefore be taken to forge and strengthen an inter-ministerial approach to the development programme for Jamaican ginger.

List of References

Bailey-Shaw, Y.A., Williams, L.A.D., Junor, G., Green, C, Hibbert, L., Salmon, C. and Smith A., 2008. *Characterization of cultivars of Jamaican ginger ((Zingiber officinale Roscoe) by HPTLC and HPLCJ. Agric. Food Chem. 2008, 56, 5564–5571.*

Food and Agriculture Organization, 2017. *Support for the development of the Ginger Value Chain in Jamaica Project: Value Chain and Market Analysis of Ginger in Jamaica. Cordia Thompson, National Consultant.*

Jamaica Agricultural Commodities Regulatory Authority Act 2016.

Jamaica Intellectual Property Office, 2015. *Geographical Indication Manual. April 2015*

Ministry of Agriculture and Fisheries, Research and Development Division. *Compilation of Ginger Work. 2010-2011.*

Ministry of Agriculture and Fisheries, 2014. *Ginger. A Production Guide for Jamaica.*

Ministry of Agriculture and Fisheries, Research and Development Division, 2015. *Compilation of Ginger Research of the Crop Research Unit 2011-2015. 22pp.*

Ministry of Industry, Commerce, Agriculture and Fisheries, 2016. *Draft National Seed Policy.*

National Tissue Culture Technical Working Group, MICAF, 2017. *Draft Terms of Reference.*

National Tissue Culture Technical Working Group, MICAF, 2017. *Draft Implementation Plan.*

Protection of Geographical Indications Act, 2004 (Jamaica).

Research and Development Division, 2014. *Annual Report, 2013-2014.*

Research and Development Division, 2015. *Annual Report, 2014-2015.*

Research and Development Division, 2016. *Annual Report, 2015-2016.*

Rural Agricultural Development Authority, 1999. *Growing Ginger in Jamaica.*

Scientific Research Council, 2014. *International Atomic Energy Agency (IAEA) Project Report.*

Internet Sources

http://www.japarliament.gov.jm/attachments/article/339/The%20Jamaica%20Agricultural%20Commodities%20Regulatory%20Authority%20Act,%202016-hor.pdf

http://www.worldstopexports.com/ginger-exporters/

https://www.alibaba.com/showroom/jamaica-market-prices-for-ginger.html

http://www.src.gov.jm/src-key-to-nutraceutical-industry/

APPENDICES

Appendix 1. List of Consultations

Institution	Contact
Jamaica Business Fund	Ms. Cordia Thompson
Ministry of Industry, Commerce, Agriculture and Fisheries, Research and Development Division	Mrs. Carla Douglas Dr. Lisa Myers-Morgan Mrs. Michelle Sherwood Dr. Peta Gaye Chang Mr. Sheldon Elliot
Ministry of Industry, Commerce, Agriculture and Fisheries, Export Division	Mr. Byron Henry
Ministry of Industry, Commerce, Agriculture and Fisheries, Marketing and Economic Planning	Mr. Carlton Wedderburn Mr. Patrick Forrest Mr. Kevin Condappa
Scientific Research Council	Mr. Ryan Francis
Rural Agricultural Development Authority Clarendon Hanover Manchester/Clarendon Portland St. Andrew St. Ann St. Catherine St. Elizabeth St. James St. Mary St. Thomas Trelawny Westmoreland	 Mr. Kervin Riley Mr. Dale Hartley Mr. Winston Baines Mr. Kedon Manning Mr. Andrey Rodgers Mr. Delroy Luke Ms. Tamara Coleman Mr. Allison Wedderburn Ms. Kerisha Sinclair Mr. Leighton Brown Mr. Sheldon Scott Mr. Carlton Douglas Mr. Dwayne Joseph
Jamaica Intellectual Property Office	Dr. Marcus Goffe
Farmer	Mr. Maxim Waite, St. Elizabeth
Farmer	Mr. Timothy Watson, Manchester
Farmer	Mr. Delroy Armstrong, Manchester
Farmer	Mr. Michael Williams, Manchester
Farmer/Exporter	Ms. Joycelyn Smith, Clarendon
Perishables Jamaica Ltd.	Mr. Norman Wright
Jamaica Teas	Mr. Norman Russell
Musson Jamaica Ltd - ACME Spices	Mrs. Claudette Kidd
Island Spice	Mr. Christopher Johnson
SALADA Foods Jamaica Ltd.	Mrs. Dianna Blake-Bennett
King Pepper Products Ltd.	Mrs. Christine Wong
Ashman Food Products Ltd.	Mrs. Winsome Ashman
National Baking Company Ltd.	Mr. Terry Clacken
Spur Tree Spices	Mr. D. Hawkins
Walkers Wood (Associated Manufacturers Ltd.)	Mr. Rohan Clarke
Baronhall Farms (Jamaica Standard Products Ltd)	Mr. Wilfred Greenland
J. Wray and Nephew Ja. Ltd.	Ms. Natalee Facey
Trade Winds Citrus Ltd.	Mr. Miguel Francis

Appendix 2. Yields of Jamaica Yellow, Jamaica Blue and Jamaica Native evaluated under greenhouse conditions at the Bodles Research Station

Variety /Media Type	**Jamaica Yellow**		**Jamaica Blue**		**Jamaica Native**	
	Perlite	**Coir**	**Perlite**	**Coir**	**Perlite**	**Coir**
Average Rhizome Yield/(g)	226.21	638.27	349.93	722.95	194.68	631.96

Appendix 3. Mean yield of ginger on coir versus perlite media

Medium	**Yield (g/plot)**
Coir	4,596
Perlite	4,364

Standard Error of the Difference (Sed) = 1,192)

Appendix 4. Average yield of Jamaica Blue, Jamaica Native and Jamaica Yellow varieties

Variety	**Yield (g/plot) Yield (g/plot)**
Jamaica Blue	5,095
Jamaica Native	3,997
Jamaica Yellow	4,170

(avg. sed = 1,829 Least Significant Difference lsd = 3,841)

Appendix 5. Harvest data on the overall yield of tissue culture and F1 rhizome planting materials.

Variety	**Tissue Culture Yield /(kg)**	**F1 Rhizome Yield /(kg)**	**Total Yield (kg)**
Jamaica Blue	103.2	134.5	237.7
Jamaica Yellow	96.5	124.8	221.3
Total Yield (kg)	199.7	259.3	459

Appendix 6. Mean yield per plot of Jamaica Blue and Jamaica Yellow varieties

Variety	Jamaica Blue	Jamaica Yellow
Mean Yield/Plot (kg)	19.65	18.61

(l.s.d. = 3.845)

Appendix 7. Mean yield of tissue culture plantlets and F1 rhizome planting material

Planting Material	F1 Rhizome	Tissue Culture Plantlets
Mean Yield/Plot (kg)	20.18	18.08

(l.s.d. = 3.748)

Appendix 8. Average recorded yield of tissue culture and F1 rhizome planting material of Jamaica Yellow and Jamaica Blue

Variety/Planting Material	Jamaica Blue		Jamaica Yellow	
	Tissue Culture Plantlets	F1 Rhizome	Tissue Culture Plantlets	F1 Rhizome
Mean Yield/Plot (kg)	18.62	20.70	17.52	19.68

(l.s.d. = 5.579)

Appendix 9. Yield from tissue culture and F1 rhizome planting material of Jamaica Yellow and Jamaica Blue grown on imported and local coir media.

	Jamaica Yellow		Jamaica Blue	
	Tissue Culture	F1 Rhizome	Tissue Culture	F1 Rhizome
Av. Wt/bag (lbs)				
Imported Coir	0.70	0.88	1.85	1.76
Local Coir	1.24	0.97	1.41	1.39

Appendix 10. Pungent principles in Jamaican ginger varieties and Hawaiian ginger.

Variety	6-Gingerol	8-Gingerol	10-Gingerol	6-Shogaol
Hawaiian Ginger	0.527	0.162	0.176	0.172
Bulbous Blue Ginger	0.797	0.223	0.294	0.278
Frog Blue Ginger	0.758	0.224	0.253	0.216
Yellow Tambric Ginger	0.811	0.160	0.281	0.163

Appendix 11. Cost of Production - Ginger Tissue Cultured Plantlets under Shadehouse (1 acre/ Epsom, St. Mary) (2016)

Cost	Year 1 J$	Year 2 J$	Year 3 J$
Variable Cost			
Labour	600,000	600,000	600,000
Materials			
Planting Material	4,883,760		
Coconut Coir	3,213,000	3,213,000	3,213,000
Grow Bag	963,900	963,900	963,900
Fertilizer	300,000	300,000	300,000.00
Pesticide	20,000	20,000	20,000.00
Water	80,000	80,000	80,000.00
Fixed Cost			
Benches*	150,000		150,000.00
Shade House*	120,000	120,000	120,000.00
Irrigation System*	180,000	180,000	180,000.00
Total Cost	10,510,660	5,476,900.00	5,626,900.00
Yield (kg)	14,605	38,945	38,945
Cost of Production ($/kg)	**$233.68**		

Crop	Ginger
Crop Maturity	9 months
# of Rows of Benches	21
Area of one Bench	400' x 3'
# of Bags per Row	1,020
Plant Population (2 clusters/bag)	42,840
Method of Irrigation	Fertigation
Area of Shadehouse	400' x 108'
Reaping Period	3 weeks
Man-Day Charge (incdg. lunch)	$2,000

Notes to Table:

1. **Cost of Tissue culture plantlets**: $114/cluster; cluster is divided into 3 sub-plantlets;
2. **# of Clusters per Grow Bag** - 2 clusters;
3. **Cost of Grow Bags**: $45 each;
4. **Cost of Coconut Coir** - $300/bag (1/2 bag of coir per grow bag).
5. **Labour Cost** includes: planting; applying fertilizer; applying pesticide; filling grow bags with coir and harvesting;
6. **Cost of Establishing Irrigation System** - approximately $1.8 million;
7. **Irrigation system** has a **useful life** of 7 years and **depreciates** by 10 percent each year;
8. **Cost of Establishing Shadehouse** - approximately $1.2 million;
9. **Shadehouse Structure** - round wood and shade cloth;
10. **Shadehouse** has a **useful life** of 15 years and **depreciates** by 10 percent each year;
11. **Benches** made up of round wood and bamboo and last for 2 crop cycles. Repair cost is $150,000;
12. *** Denotes depreciation**;
13. **Yield per bag in Year 1** (Generation 0) = 1.5lbs; **Yield per bag in Year 2** (1st generation) and **Year 3** (2nd generation) = 4 lbs.
14. Rhizomes not used beyond 2nd generations because of significant decline in yield.

***Data Sourced From: Economic Planning Division, MICAF**

Appendix 12. Cost of Production - Tissue Cultured Ginger Rhizomes under Shadehouse (1acre/Epsom, St. Mary) (2016)

Cost	Year 1 J$	Year 2 J$	-
Variable Cost			
Labour	600,000	600,000	-
Materials			
Planting Material	1,071,000	-	
Coconut Coir	3,213,000	3,213,000	-
Grow Bag	963,900	963,900	-
Fertilizer	300,000	300,000	-
Pesticide	20,000	20,000	-
Water	80,000	80,000	-
Fixed Cost			
Benches*	150,000	-	
Shade House*	120,000	120,000	-
Irrigation System*	180,000	180,000	-
Total Cost	6,697,900	5,476,900.00	-
Yield (kg)	38,945	38,945	-
Cost of Production ($/kg)	**$156.31**		

Crop	Ginger
Crop Maturity	9 months
# of Rows of Benches	21
Area of one Bench	400' x 3'
# of Bags per Row	1,020
Plant Population (2 clusters/bag)	42,840
Method of Irrigation	Fertigation
Area of Shadehouse	400' x 108'
Reaping Period	3 weeks
Man-Day Charge (incdg. lunch)	$2,000

Notes to Table:

1. **Cost of Ginger Rhizomes**: $200/lb; 8 plants may be obtained from 1lb. of rhizomes. i.e. (1plant/2oz.);
3. **Cost of Grow Bags**: $45 each;
4. **Cost of Coconut Coir** - $300/bag (1/2 bag of coir per grow bag).
5. **Labour Cost** includes: planting; applying fertilizer; applying pesticide; filling grow bags with coir and harvesting;
6. **Cost of Establishing Irrigation System** - approximately $1.8 million;
7. **Irrigation system** has a **useful life** of 7 years and **depreciates** by 10 percent each year;
8. **Cost of Establishing Shadehouse** - approximately $1.2 million;
9. **Shadehouse Structure** - round wood and shade cloth;
10. **Shadehouse** has a **useful life** of 15 years and **depreciates** by 10 percent each year;
11. **Benches** made up of round wood and bamboo and last for 2 crop cycles. Repair cost is $150,000;
12. *** Denotes depreciation**;
13. **Yield per bag in Year 1** (1st Generation) and **Yield per bag in Year 2** (2nd Generation) = 4 lbs.
14. Rhizomes not used beyond 2nd generations because of significant decline in yield.

***Data Sourced From: Economic Planning Division, MICAF**