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REDUCING POST-HARVEST LOSSES IN THE FOOD PRODUCTION INDUSTRY IN GHANA FOR FOOD SECURITY: PROCESSING LOCALLY PRODUCED TOMATO VARIETIES INTO VALUE ADDED TOMATO-BASED PRODUCTS

TECHNICAL REPORT

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1.0 INTRODUCTION

1.1 Background

Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life (Committee on World Food Security, 2012). Post-harvest losses need to be addressed if food security is to be achieved in Ghana. It is important therefore to make good use of food produced by reducing post-harvest losses in order to increase the proportion of food utilized directly for human consumption.

Available information and direct observation reveals that there are high amounts of food post-harvest food losses in Ghana, which is a constraint to achieving food security in the country. In view of this, a team of researchers from the CSIR – Food Research Institute was constituted to conduct research and identify the drivers of food post-harvest losses, the socio-economic implications of these losses, in order to provide scientific evidence as basis for developing and implementing responsive programmes to address this problem. To achieve this aim, specific food commodities and production areas with high levels of post-harvest losses along food value chains and reasons for the occurrence were identified, with a specific objective to connect food producers with food researchers, processors, traders, consumers and funding agencies to improve activities along value chains.

During the identification of the drivers of food post-harvest losses, priority was given to specific perishable food commodities with a focus on processing and product development. Upon the identification of specific commodity types and locations with high post-harvest losses, the CSIR – Food Research Institute plans to identify and adopt specific food production communities and support them with appropriate food processing technologies and access to markets to reduce their post-harvest losses, diversify their livelihoods, increase income for poverty reduction and other human development outcomes.

Preliminary research was conducted into problems of high post-harvest food losses along specific food commodity value chains such as fish, fruits and vegetables to inform the development of appropriate technologies and interventions to tackle this important national challenge. Results from the preliminary research in the form of data and information gathering and analysis are presented as follows. Conclusions are drawn from the results which are followed by recommendations for further research, policy formulation and advice. Recommendations are intended for use by the Government of Ghana in the formulation of food and agriculture policy, and to provide support for the implementation of the “One District One Factory (1D1F)” initiative which aims to connect food producers with processors and consumers.

1.2 Information on fish post-harvest losses in Ghana

Fish is a major source of animal protein in the diets of Ghanaians, and is consumed in all regions of Ghana, by both the poor and the rich, and in both rural and urban areas. Information gathered from relevant literature suggests that the fishing industry in Ghana has experienced fish production declines in the last couple of decades. Production declines have also been associated with post-harvest losses which occurred as a result of poor processing technologies and improper fish handling. Indigenous fish processing, handling and storage methods were responsible for high fish food losses in the country. Fish post-harvest activities in Ghana predominantly occurred at small-scale level usually at individual homes. Small-scale fish processing methods include smoking, drying, salting, frying and fermenting.

Literature also suggests that small-scale fisheries in Ghana rarely discard fish currently but they lose a sizable amount of the value of their catch before they are eaten. The loss in value happen as a result of high temperatures during catching, landing, processing, storage and marketing. The information gathered shows that fish post-harvest losses are quite low compared to other food commodities such as perishable fruits and vegetables. Losses at landing are minimal particularly when fish caught is not properly kept with ice, which often end up in loss of value in terms of reduced fish price. (Dapaah and Samey, 2015).

Losses occurring at the post-harvest handling and processing stages are difficult to quantify due largely to the inability of fishers, processors and traders to compare losses with input costs. In spite of the difficulty, post-harvest loss is currently not regarded as a major issue in the fishing industry in Ghana. Even if losses are found to occur, they are generally minimal and vary from place to place. Based on these findings, fish was not considered as a suitable commodity for the purpose of this study.

1.3 Information on other commodity post-harvest losses in Ghana

Fruit and vegetable production in Ghana presents an excellent source of income for many people in rural and urban areas. These crops are mainly produced in the rural and peri-urban areas and supplied fresh to cities and urban markets for marketing. As a result of weak organizational capacities of producers, poor road networks, old packaging systems and lack of storage facilities high losses occur along the value chain on these crops. Also hypothesized to immensely contribute to this post-harvest losses is the generally low processing capacities resulting from a dearth in innovative and processing technologies for these agricultural produce. The highest losses are reported to often occur between harvest and storage. These losses result in loss of income to farmers, traders and other value chain actors, and this cascades into a net negative effect on the national economy.

Fruits and vegetables, aside of their economic potential, form an essential component of Ghanaian diets. The major fruits and vegetables produced in Ghana include oranges, pineapples, mangoes, pawpaw, tomatoes, pepper, etc. Pineapples, mangoes and tomatoes rank among the top five. For these commodities, production has more than doubled over the past decade. However, because of high losses, Ghana imports huge quantities of processed forms of these crops. For instance, about US$57 million worth of tomato paste was imported in 2016 alone, a situation which obviously does not impact positively on the Ghanaian economy. According to Mutungi and Affognon (2013), the following perishable commodities (mango, pineapple, tomato) have the highest estimated post-harvest losses in Ghana. Losses among these crops are estimated to range between 20 and 40%. A summary of production areas and estimated losses for these commodities are presented in Table 1.

Table 1: Perishable commodities/locations with highest estimated post-harvest losses in Ghana

Commodity	Production areas	Estimated post-harvest loss (%)
• **Mango**	• Coastal Ghana • Guinea savannah Ghana	• 20-57 <u>Hotspots for Losses</u> • Sorting (~ 5.4%) • Transportation (~13.4%) • Marketing (~16.2%)
• **Pineapples**	• Central Region • Eastern Region • Greater Accra Region • Volta Region	• 25-32 <u>Hotspots for Losses</u> • Harvesting • Transportation • Marketing
• **Tomato**	• Brong Ahafo - Akumadan (Offinso North), Derma (Tano South), Tuobodom (Techiman North), Wenchi • Upper East - Bolgatanga (Bolgatanga), Pwalugu (Talensi) • Volta - Adidome (Central Tongu) • Ashanti - Agogo (Asante Akim) • Greater Accra - Ada	• 37.5 <u>Hotspots for Losses</u> • Harvesting (~4%) • Sorting (~13.8%) • Transportation (~14.4%) • Marketing

Even though domestic processing of these commodities remains low, it presents one of the tangible approaches to help curb the post-harvest loss plaguing the agro-food sector of Ghana. Indeed food processing has been suggested to have the potential of transforming Ghana's economy. Its prospects include creating new opportunities for value creation, contribution to diversifying product markets, reducing import of processed fruit and vegetable products, driving processing towards a net exporter of processed food. Furthermore it may promote job creation and contribute to improved nutrition and attaining national food security.

Products that could be developed from these food commodities include mango puree, mango juice concentrate, tomato puree, tomato juice, canned tomato slices, pineapple juice, pineapple concentrates, crushed pineapple, pineapple puree, dried mango, pineapple or tomato slices and tomato powder. Proposed approach and related technologies for processing include setting up a raw material processing facility within selected communities for primary processing and sending the product to the CSIR-FRI for final processing and marketing, stationing a mobile processing van within the selected communities to process ready-to-eat fruit drinks and puree. Partly processed crops may be transported to CSIR-FRI for finishing which will help in reducing losses due to handling, transportation and marketing, and providing good refrigeration or simple dehydration facilities for extending shelf life of commodities.

After careful analysis and considerations, tomato processing was selected as a pilot project to assess the feasibility of product development by the CSIR-FRI using tomato produced in some selected communities in the country. This necessitated further information gathering on tomato production and utilization in Ghana and to conduct laboratory research and analysis of product development. The study was aimed at contributing to reducing postharvest loss of tomatoes by exploring the processing of locally grown tomato varieties into other value added forms such as tomato puree, tomato sauce, tomato pulp, and tomato juice. The findings from the study are presented as follows.

1.4 Information on tomato production and utilization

Tomato is one of the most important vegetables known to man. Globally, it is an indispensable ingredient in the diets of many people. It is, by far, the most widely cultivated vegetable grown in Ghana, with an estimated production quantity of 371,811 tonnes in 2017 alone (FAOSTAT, 2019). Although production is largely seasonal and rain-fed in Ghana (Robinson and Kolavalli, 2010) tomato is also considered a cash crop. It generates huge sums of income and is therefore a source of livelihood for farmers in many growing areas and other value chain actors alike. Tomato production is fairly evenly distributed among the major ecological zones but the main production hubs remain Greater Accra, Brong Ahafo and the Upper East Region. Due to the seasonal nature of availability, there is always a cycle of glut-low price followed by shortage and rise in prices of fresh tomatoes during the dry season. According to Melomey *et al.* (2019), several varieties of tomatoes (as shown in Table 2) are grown depending on geographical area.

Tomatoes play a key role in human nutrition. Its nutritional significance stems from the fact that it contains good amounts of vitamins, minerals and phytochemicals such as lycopene (Beecher, 1998) which is a potent antioxidant with possible anticarcinogenic properties (Singh and Goyal, 2008). According to Tambo and Gbemu (2010), tomatoes evidently is an essential ingredient in many foods consumed in many Ghanaian households. Unfortunately heavy post-harvest losses occur along the tomato value chain. Robinson and Kolavalli (2010) estimated up to 20% loss for tomatoes, 5 days after harvest. Aidoo *et al.* (2014) maintain that nearly 40% of the crop is lost annually in production hubs such as the Offinso North District. Some important determinants of postharvest losses cited include rough handling during harvesting, inappropriate storage facilities, long distance from farms to market places (Adarkwa, 2011; Babalola *et al*., 2010). Johnson *et al*., (2001) also noted that both mechanical and pathological damages account for losses at the fresh market end of the tomato value chain.

Table 2: Tomato varieties produced in Ghana

Commodity	Varieties produced in Ghana	Possible product
Tomatoes	Roma VFN, Power, Laurano, Power Rano, Pectomech VF, Tropimech, Rio Grande, Woso woso, Jaguar, Lindo, Titao Derma, Ada Cocoa	Paste, Puree, Slices, Tomatoes in brine, Tomato Juice

Robinson and Kolavalli (2010) attribute tomato post-harvest losses to irregular raw material supply, limited varieties ideal for processing and lack of adequate skilled labor. In Ghana, many varieties such as Pectomech, Tropimech, Roma VF, Power, Techiman, Italy, Rasta, etc. are cultivated (MoFA, 2008; Clottey *et al*., 2009; Robinson and Kolavalli, 2010; Ellis *et al*., 1998). However, apart from Power Rano and Pectomech, many of these varieties are not ideal for industrial processing into tomato paste because they contain low dry matter, have poor colour, low brix, high pH or too many seeds. That notwithstanding, there ought to be a clear strategy to develop other value added products out of these varieties.

1.5 Aim and objectives of the study

The aim of the study was to enhance the utilization of locally grown tomatoes through processing into value added products to reduce post-harvest losses that occur in selected tomato growing areas in Ghana. Specific objectives were to process selected varieties of locally grown tomatoes into tomato juice and pulp, determine the physical and chemical qualities of the products and evaluate the keeping qualities of the products. Targeted beneficiaries to benefit from results of the study include tomato farmers, processors and traders on one hand and the government of Ghana on the other for policy formulation and advice.

2.0 MATERIALS AND METHODS

2.1 Raw tomato varieties

To conduct laboratory analysis on fresh tomatoes for product development, raw tomatoes were purchased from the Madina market in Accra. With the assistance of the vendor, the tomatoes were classified into five different groups based on varieties identified according to the vendor's terminology as "Rasta", "Navrongo", "Rano", "Pectomech" and "Local". There were clear physiological differences among the different varieties even though their authenticity was not scientifically verified (Figure 1).

Figure 1: Tomato varieties used in the study

2.2 Processing

The tomatoes were sorted and prepared for processing by breaking off the stalk before cleaning and washing thoroughly in potable water. These were then processed into pulp or tomato puree using the hot-break method. The tomatoes were rapidly heated to 90°C before crushing and pureeing whiles still hot. The fruits were pureed using a laboratory blender and strained with a sieve to obtain a puree of uniform consistency. Salt and citric acid were added to the puree. The puree (290 mL) was manually dispensed into 320 mL glass jars and canned in a hot water bath at 90°C for 20 min. Canned tomato puree (as shown in Figure 2) were cooled and stored at room temperature

Figure 2: Tomato puree prepared from different tomato varieties

2.3 Analytical determinations

Physicochemical analyses were conducted on the raw tomatoes before processing. Similarly, these analyses were conducted on the tomato puree, after processing and while in storage on monthly basis. Color, pH and brix of fresh tomatoes and canned tomato pulp were determined by standard methods, using a color meter, pH meter and a refractometer respectively.

3.0 RESULTS AND DISCUSSION

Some physicochemical indices of the fresh tomato are summarized in Table 3. As shown, the "pectomech" was the darkest and the most reddish among the group. "Rano" was the least reddish, with an a*-value of 11.5. The brix, which represents the soluble solids content of the tomatoes ranged between 4.9 to 8.7 for Local and "Pectomech". Rasta and "Pectomech" recorded the lowest pH of 3.87, while "Navrongo" had the highest pH of 4.1.

These results suggest that the most suitable variety for processing tomato puree or paste may be Pectomech, since it was the most reddish, with the highest sweetness level and lowest pH. However, for the purpose of the study, all the varieties were processed into puree and evaluated during storage.

pH of tomato puree made from the various varieties was stable over three month storage period (Figure 3). Stability in pH is an indication that there was no spoilage activities caused by microbial action. Over the period of study pH of the purees remained below 4, and this, is appropriate for long-term storage of the product. When adequately processed, proliferation of microbes in tomato puree at this pH is markedly halted.

Table 3: Physicochemical properties of fresh tomato varieties

	Color		**Brix**	**pH**
	L*	**a***		
Local	43.15±0.06[a]	13.85±0.72[b]	4.90±0.01[d]	3.93±0.01[c]
Rasta	41.55±0.40[b]	14.12±0.55[b]	7.00±0.07[b]	3.87±0.01[d]
Navrongo	41.64±0.25[b]	12.39±0.87[bc]	6.80±0.02[b]	4.13±0.01[a]
Rano	41.12±0.10[b]	11.51±0.50[c]	5.95±0.07[c]	4.07±0.01[b]
Pecto	40.61±0.10[c]	18.96±0.38[a]	8.70±0.01[a]	3.87±0.01[d]

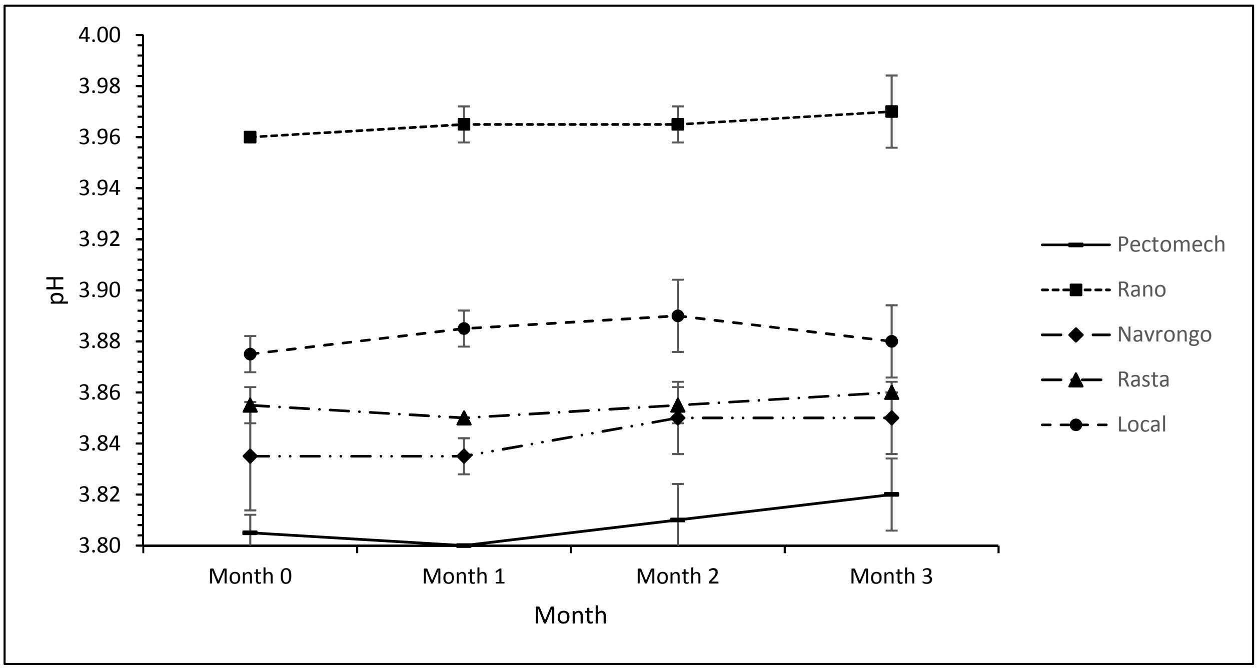

Figure 3: Variation in pH of puree from 5 tomato varieties over 3 months of storage

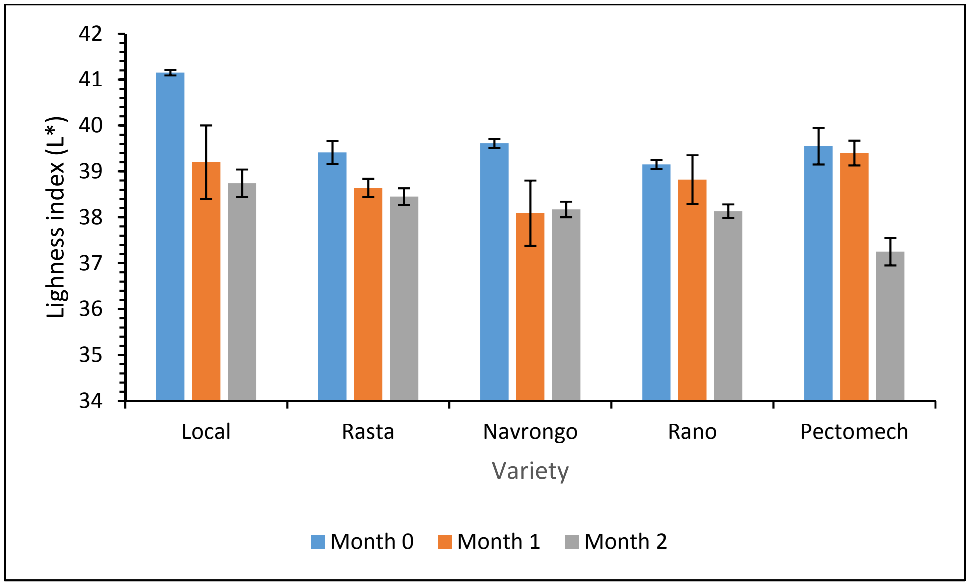

Figure 4: Lightness/darkness index (L*) of tomato puree from 5 tomato varieties over 3 months of storage

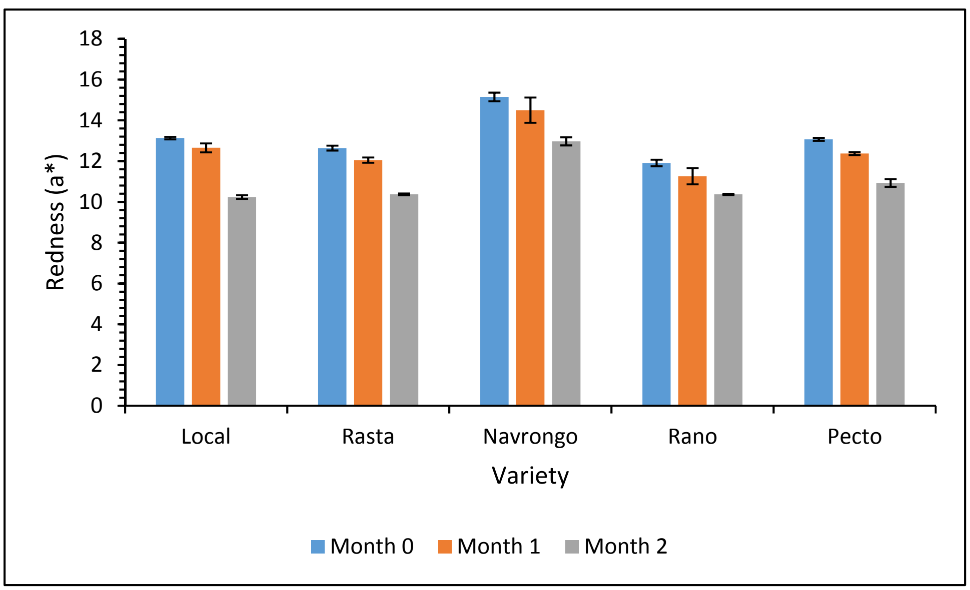

Figure 5: Redness index (a*) of tomato puree from 5 tomato varieties over 3 months of storage

Color is an important index and drives the appeal of many food products, and tomato puree is no exception. Changes in the lightness/darkness and redness of the purees in storage are presented in Figures 4 and 5. The purees became darker in storage and this is shown by significant reduction in the L* value of purees from all the varieties over the storage period. Generally a remarkable darkening is noticed between month 0 and month 1 and a marginal decrease after month 1 for all the varieties apart from Pectomech. For this variety a reverse of this trend was observed in which a marginal reduction in lightness rather occurred during the first month of storage. The reduction in lightness index may be attributed to browning reactions occurring as a result of exposure of the puree to light, through the transparent glass bottle. As indicated in Figure 5, loss of redness was also observed after processing and during storage. This has been ascribed to the isomerization of lycopene, from the trans- to the cis- form during processing. Also, the stability of lycopene is reduced during thermal processing, because of the inactivation of enzymes that prevents the isomerization or oxidation of the compound.

4.0 CONCLUSIONS

Over the storage period, the pH of tomato purees made from the different varieties of tomatoes showed remarkable stability, and this rules out spoilage of the product by microbial action. Color, however, changed during storage, and this was shown in the reduction of lightness index and redness, L* and a* respectively.

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