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Table of Contents

	Page
Foreword	2
Agriculture and nutrition in the Caribbean: implications for research and development Author - Fitzroy J. Henry, Caribbean Food and Nutrition Institute, Jamaica	3
Growth, feed conversion and carcass traits study in rabbits, Trinidad, West Indies Authors - Ansari Hosein, CARDI, Trinidad and Tobago; and Rajendra Rastogi, University of the West Indies, St. Augustine Campus, Trinidad and Tobago	14
Editorial Guidelines	22
Instructions for Authors	23
Sample Layout	27

Foreword

CARDI is a small institute with a wide geographical spread, approximately 25 agricultural scientists are scattered throughout our 12 member countries. Despite our small numeric strength we have a large mandate and also a long list of required work from our stakeholders.

To overcome this problem of limited resources and a wide mandate CARDI places great emphasis on strategic partnerships and joint work with other institutes in the region and throughout the world.

The two papers in this issue reflect this philosophy. As mentioned in the Foreword to the last issue of CARDI Review we are inviting papers from authors who belong to other Institutes. The first invited paper appears in this issue and is written by the distinguished Dr Fitzroy Henry of the Caribbean Food and Nutrition Institute. Dr Henry is very well known in the Caribbean and is passionate about the diets of the Caribbean people and the relative poor nutritional value of some of these diets. The article in this journal explains some of Dr Henry's views in his usual clear and earnest style.

The second paper describes some work done a few years ago by one of CARDI's young technical assistants, Ansari Hosein, with his supervisor at the University of the West Indies (UWI), Dr Rajendra Rastogi. UWI is a very important collaborator to CARDI and Dr Rastogi is one of the many senior UWI scientists who have collaborated with CARDI for very many years.

I will finish this foreword with a brief preview of an article which will appear in the next CARDI review. This will describe work done by the Ministry of Agriculture, Lands, Forestry and Fisheries in St Lucia (with collaborative inputs from CARDI) to control the coconut pest, Red Palm Mite (*Raoiella indica* Hirst). Thus it can be seen that CARDI collaborates with ministries, universities and sister regional institutes. Our full collaborative list is even wider and we hope to show this in future issues of CARDI Review.

F B Lauckner
Editor, CARDI Review

Agriculture and nutrition in the Caribbean: implications for research & development

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ABSTRACT

Agricultural policy in the Caribbean has been mainly market driven, with primary focus on increasing production and productivity; and competitiveness. However, if food and nutrition security in the Caribbean is to be improved, agricultural policy has to include nutritional considerations.

This paper proposes several lines of action for bridging the gap between nutrition and agriculture that has historically characterised Caribbean agriculture:
1. Policy - establishing nutrition goals as a key determinant for food and agriculture policy decisions
2. Technical - identifying the nutritious foods that will be given priority support in agricultural production, marketing and promotion
3. Technological - ensuring appropriate technological innovations are applied to enhance and preserve the nutritional quality of priority foods
4. Education/training - emphasising education and integrated training among professionals in the various sectors related to the above

Some research issues are identified:
- Examination of the inter-relationship between agriculture, nutrition and health in the Caribbean
- Analysis of our national domestic food production and import policies in relation to health
- Determination of who are food insecure, who are the most vulnerable groups, where they are located and the nature and causes of the food insecurity problem
- Food economics
- To what extent within the WTO agreements can incentives and subsidies for local staples and other foods be used to replace imports with a view to reducing the import bill, and improving health
- Research on pulses and ground provisions should be accelerated to ensure that these crops benefit from new technologies to the same extent as cereals
- Breeding nutritionally superior quality produce from ground provisions
- Biofortification of rice, cassava, peas, yams, plantains
- Food processing / preservation

Keywords: agricultural policies; agricultural research; food security; nutrition; Caribbean

INTRODUCTION

Agriculture is fundamental to achieving nutrition goals through the production of food energy and other nutrients essential for human health and well-being. History has shown, particularly through the Green Revolution, how gains in food production have played a key role in reducing hunger and malnutrition. But these advances have not succeeded in freeing the world of hunger nor have they prevented the emergence of other food-related diseases.

The purpose of this paper is to advocate and advance an interest in agricultural research that is in tandem with the imperatives for improving nutritional status in the Caribbean. In particular, this paper proposes several lines of action for bridging the gap between nutrition and agriculture that has historically characterised Caribbean agriculture. Additionally, an expected outcome of this document is to successfully promote effective dialogues and collaborations between agricultural researchers and technical persons in nutrition, thus making nutritional well-being an attainable and mutual goal.

POLICY FRAMEWORK FOR AGRICULTURE AND NUTRITION

Since the mid-20th century, agricultural policy has been dominated by a paradigm centered on the supply-side to maximise production with active involvement of nation states through subsidies and state sponsored market and research institutions. With increasing involvement of international financial institutions, such as the International Monetary Fund, in the economic affairs of countries in the mid-1970s, there has been an increasing tendency to rely on the market mechanism as a policy option. This is more recently evident in the frameworks created by institutions, such as the General Agreement on Tariffs and Trade (GATT), *cum* World Trade Organization (WTO). Since GATT/WTO, regional and bilateral trade agreements give little or no consideration to food and nutrition but almost exclusively to establishing macroeconomic fundamentals as the main policy driver. Indeed, the "trickle down" dimension of this approach to development assumed that increased production and growth would lead to reduction in malnutrition and better health. Even the negotiations for agreements on agriculture policy give insufficient attention to nutrition and health. Writing about the USA recently a leading scholar there poignantly noted "As a nation, we must understand that farm policy is public health policy" and further "We need to transition from a cheap calorie farm policy to one that nourishes our children's health. It's going to take steps across the health system and at every level of government to not only bend the curve on the obesity epidemic, but to reverse it" (Wallinga 2009).

The spectre of agricultural growth in the absence of nutritional considerations continues to stare at the Caribbean people. The picture is frightening and costly because with the significant increase in food availability over the last few decades the people of this Region have concomitantly experienced a massive increase in obesity and co-morbidities, the consequences of which overwhelm our health budgets and more importantly undermine our economic growth. The need to link agriculture and nutrition represents a multi-disciplinary challenge of no small magnitude and therefore requires a multi-disciplinary approach to find a solution. So what can agriculture and nutrition contribute collectively towards this solution? And how can these fields intersect with others to benefit the Caribbean society?

These questions beg for a conceptualisation of agriculture policy that combines food access and availability with nutritional and health considerations, and for forging links among agriculture, health and nutrition, trade and other sectors. These multi-sectoral interactions remain to be fully appreciated and exploited by regional policy makers. This is an urgent task in light of the globalisation process that is expected to take deeper root after the current economic downturn is reversed.

INTEGRATING AGRICULTURE AND NUTRITION

Bridging the gap between nutrition needs and agriculture policy will be approached in this paper through the following four lines of action:

1. Policy issues - establishing nutrition goals as a key determinant for food and agriculture policy decisions
2. Technical issues - identifying the nutritious foods that will be given priority support in agriculture production, marketing and promotion
3. Technological issues - ensuring appropriate technological innovations are applied to enhance and preserve the nutritional quality of priority foods.
4. Education/training issues - emphasising education and integrated training among professionals in the various sectors related to the above.

Within each of these lines of action several research issues arise. Advancing a culture of research on these areas will help address the third Key Binding Constraint of the Jagdeo Initiative "Inadequate Research and Development".

Policy issues

Policy makers on agriculture in the Caribbean continue to focus primarily on increasing production and productivity. This is understandable. The Jagdeo Initiative is a framework for enabling regional competitiveness in agriculture towards attaining sustainable economic, social and environmental development. This initiative lists ten key Binding Constraints to the development of agriculture in this Region. The litany of other constraints to production and distribution that farmers face in the region at times appears to be insurmountable. Additionally, the uncertainty of food commodities from foreign sources and the massive food price inflation culminating in 2008 has strengthened the call for reducing food import dependency, reducing the food deficit, increasing food production and improving competitiveness and quality of produce.

While it is understandable that we steadfastly attempt to address the supply side (production and productivity) of the agriculture policy, new concerns in the Region have emerged that make it imperative for our policy makers to reassess the role of agriculture and its relationship with other sectors in the economy. Nutrition-related non-communicable diseases, such as diabetes, heart disease, hypertension and cancer have emerged as the major causes of death in the Region. These diseases emerge largely from the consumption of nutritionally unbalanced diets. The association between food/nutrition and diabetes, hypertension and heart disease are well known but Figure 1 shows the strong correlation ($r = .86$) between fat and cancer in the Caribbean in 2002. Conversely, the negative correlation with plant foods for all cancers ($r = .82$) also demonstrate a clear trend (Figure 2). Even though ecological analyses of risk are not definitive, the strong correlations shown are compelling (Henry 2002).

This nutritional transition is characterised by a shift away from diets based on locally grown indigenous staples (grains, starchy roots), locally grown fruits, vegetables, legumes, and limited foods from animal origin, to diets that are more varied and energy-dense, consisting of foods that are more processed (including processed beverages), more of animal origin, more added sugars and fats, and often more alcohol. These nutritional and epidemiological transitions provide strong arguments for an indispensible link between agriculture and nutrition.

Much more emphasis now needs to be placed on the demand side to improve access to, and distribution of adequate and healthful food through efficient marketing channels and through availability of income. The current disproportionate focus by regional policy makers on the supply side of the food security equation must be corrected not only in light of the prevalence and negative impact of nutrition-related chronic diseases but also in terms of quality of life and loss of labour productivity in the Region.

The close interaction between agriculture policy (supply and demand) and nutritional status remains to be fully appreciated and exploited through research. The burgeoning nutrition-related health problems mentioned above compel urgency in analysing our national domestic food production and import policies in relation to health. This research is particularly urgent for small island developing states in our Region in light of the globalisation process that is currently transforming world economic relationships and which makes nations and regions an integral part of a common unifying global system.

This research will allow CARICOM countries to establish key nutritional goals so that national agriculture and food systems can deliver adequate and nutritionally appropriate quantities of food, especially to low-income and vulnerable groups. Implicit in establishing these nutrition goals is the need to identify research priorities that will advance the process to meet the targets.

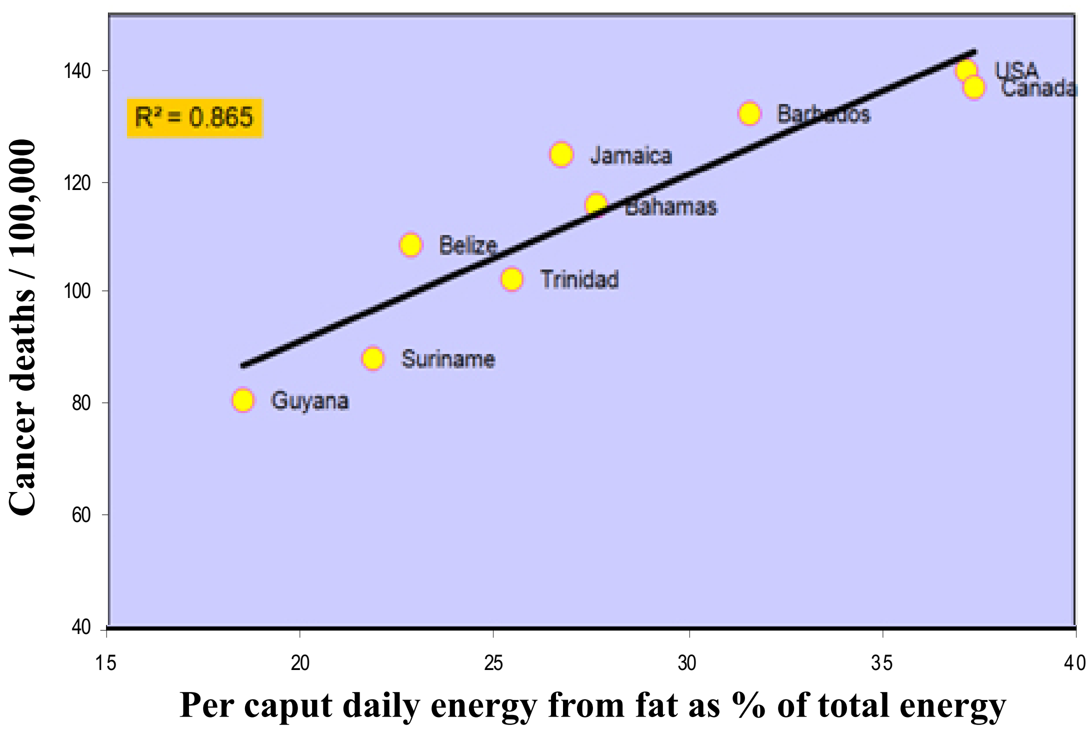

Figure 1 Relationship between cancer death rate and fat consumption in selected countries

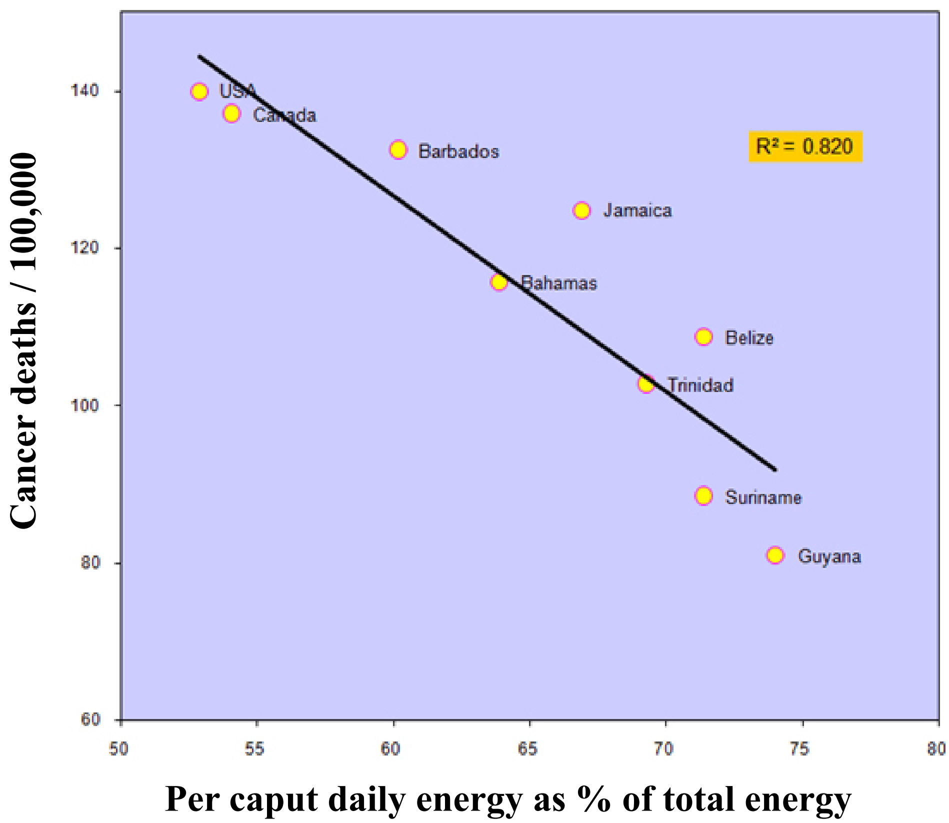

Figure 2 Relationship between death rates and plant food consumption in selected countries

How can these national nutrition goals be established? Nutritionists recommend that 55-65% of dietary energy should come from complex carbohydrates (food from plant origin except sugar and oil), and sugar be limited to less than 10% of energy, protein about 10% and fat less than 25% (Sinha 1995; Henry et al. 1997). At the aggregate level, food balance sheet data show that for the Caribbean region, energy from fats and sugars has exceeded the recommended population goals from as early as the 1960s and has increased consistently up to the 1980s. The data also show that imports of both fats and sugar have been increasing over the years. While the contribution of fruits and vegetables has been increasing since the 1960s, consumption remains well below the recommended population goals. In addition, the contribution of imports continues to outstrip that of local production. This pattern of consumption of fats, sugars, fruits and vegetables, with very slight variations, hold for most of the individual countries in the Caribbean (FAO 2002).

These regional trend data clearly demonstrate a major element of food insecurity in the Region, namely the failure of the food system to meet the nutritional and health requirements of the population. It is for this reason that national nutritional goals must be established so that the agricultural and food systems can serve the population, especially the poor and marginalised groups. In this regard, Caribbean countries can learn from the experiences of the now developed countries, such as, USA where ironically food and nutrition programmes - which are an integral part of their agriculture policy – are needed to fix problems that other aspects of the US Agriculture policy have created (Wallinga et al. 2009).

Another area of research should focus on targeting. The achievement of food security is not an automatic process but depends on conscious, deliberate and focused national policies designed specifically to the task. The information needs to conduct this kind of intervention are not trivial and entail knowing who are food insecure, who are the most vulnerable groups, where they are located and the nature and causes of the food insecurity problem.

At the household level, income inequality and poverty are major factors that impact negatively on food security. Although substantial advances have been made in economic and social development in the Region over the years, poverty is still pervasive in several countries. This has been made worse in recent years following economic reforms and globalisation.

Food balance sheets for the Caribbean from the Food and Agriculture Organization (FAO 2002) indicate that food availability meets and even surpasses recommended levels. However, this is not a cause for complacency; instead it should point to research topics to be explored, such as, how household food insecurity can exist side by side with ample availability of food. Second, scholars who have compared actual household and individual food intake data with food balance sheet data, estimate that the latter over-estimate food availability by 20-27% over actual consumption levels (Popkin et al. 2001). Third, food balance sheet data do not measure food distribution across geographic regions, communities or even among members of the same households. Finally, trade liberalisation and its attendant reduction of trade barriers, accent on competitiveness, removal of preferential quotas - all with possible negative impacts on Caribbean agriculture - poses major concern to policy makers throughout the Region. As these events and changes unfold, productivity, efficiency and prices will become increasingly important issues likely to impact on food security. So although national food insecurity has declined, the threat of its resurgence is still lurking in the background and may erupt as a serious problem under these fragile economic systems. In this sense, the Region is insecure for food and other consumables as well.

Food economics is another critical area of research that can forge greater understanding and interventions in agriculture and nutrition. The global economic recession which started in 2008 has particular importance for small CARICOM states with particular regard to food and nutrition. As real incomes fall and relatively cheaper imported foods, that are high in fats and calories but low in complex carbohydrates, become more available, traditional diets (high in complex carbohydrates) are likely to be supplanted by diets that are high in fats, sugars and red meats, predisposing consumers in the Region to further increases in obesity and its related diseases. This hypothesis motivates the need for comprehensive studies on productivity and competitiveness since ultimately the rational consumer demands products whose prices compare well with close substitutes, whether domestic or imported. In other words, people consume less-healthy foods because of cost and availability (i.e. they make economically rational, but nutritionally detrimental decisions to consume foods). Hence, poor diet is as much a food economics issue as it is a health-education one.

Since 1971, the Caribbean region has been a net food importer, and currently spends well over US$4 billion annually on food imports to close the gap between food consumption and domestic food production. Some countries import over 70% of dietary energy and almost 60 % of protein. Since the late 1980s, with the trends towards trade liberalisation, the food import indices for most regional economies have increased significantly (FAO 2002). The pros and cons of the WTO agreements in relation to food have been published some time ago (FAO 2001). Caribbean countries, while expressing concerns about being constrained by WHO rules, have not fully explored to what extent within the WTO agreements can incentives and subsidies for local staples and other foods be used to replace imports with a view to reducing the import bill, improving health and enhancing culinary delights and tastes. This is another area for research.

Technical issues

In the Caribbean the quality of food consumed is as much a public health concern as the quantity of food consumed. Many people are consuming too many calories, without meeting the recommended goals for intake of some nutrients. This vital issue must unquestionably be addressed at the upstream locus of action relating to food availability – i.e. that of local production, imports and competitiveness – as well as at the downstream locus of action which will attempt dietary behaviour change and hence "swimming against the tide." The rapid rise in food-related problems should impel regional agriculture and food experts to ensure the availability and accessibility of those foods that satisfy the nutrition and health goals of Caribbean populations (Henry 2007). It is feared that in the face of limited availability of and accessibility (especially due to limited financial resources) to appropriate foods, the region may experience a regression in its current nutrition and health status – which has seen significant improvements, especially in micronutrient sufficiency and maternal and child nutrition and health.

The Council for Trade and Economic Development (COTED) of CARICOM has agreed on a set of priority commodities that best satisfy the factors related to the Jagdeo Initiative framework. Factors used in selecting these commodities include - the commonality of the food items, production potential, market niche and competitiveness. The glaring gap among those criteria relates to nutritional considerations. Prioritisation of food commodities to be supported for national food security must include nutritional criteria. Research is needed to produce a ranked list of prioritised commodities that can genuinely enhance food and nutrition security within the Caribbean region and at the national level.

Table 1 details the criteria that can be used to assess how well food commodities satisfy nutrition and health requirements. Recommendations are based on proven and probable associations between the nutrients and diseases of major public health concern. Commodities that satisfy these criteria are considered favourable to nutrient intake and health goals.

Technological issues

With foods being used more frequently for biofuels the danger exits that more remunerative crops, such as cereals, will replace less remunerative crops, such as pulses and ground provisions. Research on the latter commodities should be accelerated to ensure that these crops benefit from new technologies to the same extent as cereals. Sweet potato, for example, is a prized food item for the Caribbean and the Caribbean Agricultural Research and Development Institute (CARDI) has commendably assessed the performance of sweet potato in various ecological settings; the shelf life of different varieties; and their ability to resist insect pests. But more funding will assist our agriculture research institutions to have the capacity to join the global agriculture research programmes which seek to breed nutritionally superior quality produce from ground provisions and other foods. In addition, answers to the following questions need to be sought.

Can our varieties respond to cheaper fertiliser inputs and maintain high yields and desirable nutrition quality? What are the key factors in commonly consumed Caribbean foods that can lead to better nutrient content - is it the genetic make up, the soil, the use of fertiliser, weather conditions, maturity at harvest, packing, storing or which combination will produce the optimal nutritional product? The performance assessment of our corn hybrids and the germplasm research conducted by CARDI are critical steps forward. But can the amino acid content of our cereals be improved without adversely affecting yields, and taste?

Table 1 Nutritional criteria for ranking food commodities

Criteria for grading	**Associations with major diseases in the Caribbean**
High in complex carbohydrates	• Greater glycaemic control due to lower glycaemic index, reducing risk of impaired glucose tolerance (precursor to diabetes) • More satiety with fewer calories, allowing for better weight management
High in dietary fibre	• Reduces plasma total and low density lipoprotein (LDL) cholesterol levels, reducing risk of cardiovascular disease. • Reduces transit time through gut, possibly lowering absorption of carcinogens
High in protein	• Provides a balance in the daily diet • Reduces the risk of protein-energy malnutrition in HIV/AIDS • Facilitates optimal metabolisation of key dietary nutrients
Low in saturated fats	• Reduces risk of elevated total and LDL cholesterol levels • Reduces risk of fat-induced impaired glucose tolerance and insulin sensitivity • Reduces risk of obesity and co-morbidities
Low in trans fats	• Reduces risk of elevated LDL and lowered high density lipoprotein (HDL) cholesterol levels
High in monounsaturated fats	• Reduces risk of elevated total and LDL cholesterol • Reduces risk of impaired glucose tolerance
High in iron	• Reduces risk of iron-deficiency anaemia • Reduces the risk of impaired cognitive function
Low in sodium	• Reduces risk of elevated blood pressure and CHD
High in potassium	• Reduces risk of elevated blood pressure and CHD
High in calcium	• Reduces risk of osteopenia and osteoporosis
High in vitamin A	• Reduces the risk of blindness and ocular injury • Facilitates iron utilisation • Reduces the risk of impaired growth and development and of impaired immunocompetence
High in vitamin C	• Facilitates iron absorption • Possibly lowers risk of cancer and CVDs
High in thiamine	• Reduces the risk of neurodegeneration
High in niacin	• Possibly reduces risk of impaired glucose tolerance

The whole area of biofortification should be pursued by our regional agriculture institutions possibly in collaboration with the International Center for Tropical Agriculture (CIAT). Biofortification seeks to bridge the agricultural and nutrition services to address the perennial problem of micronutrient deficiency (Graham et al. 2001). This can be conducted on a wide range of Caribbean food crops including rice, cassava, peas, yams and plantains (Bouis 2000).

It is often forgotten that very few agricultural commodities become food without processing of some sort. Processing is mainly intended to extend product lines and variety but do our methods in the Region compromise nutritional quality? For example, it is known that heat causes the proteins in fish to coagulate. During salting, water is drawn out from the muscle and some protein and amino acids are lost in the brine. Water soluble vitamins are also lost during salting, while fat and fat soluble vitamins are conserved. Sun drying causes rancidity in fish causing fat to become unavailable. Sun drying of fruits and vegetables affects both macro and micro nutrients. Hot water blanching causes loss of vitamin C and B. Also, loss of carotene and ascorbic acid can be considerable through oxidation. This type of research information is vital to optimise the nutritional quality of our processed products.

The Trinidad and Tobago Agribusiness Association has significantly advanced the efforts to preserve Caribbean foods. They have successfully frozen and dried cassava, sweet potato, plantains, pawpaw, fruits, vegetables and rabbit meat, among others. The Rural Agriculture Development Authority and the Scientific Research Council in Jamaica and UWI, among others, have sporadically developed preserved food items. But much more expansion and consistency are required for this type of research and product development of our commonly consumed Caribbean foods.

Research questions should centre around - which processing techniques using heat, oxygen, pH or light adversely affect the nutrient content of specific Caribbean foods? And which combination is synergistic or antagonistic to each other? While food processing techniques mainly extend shelf-life, the preservation techniques need much more research so that nutritious foods can be made available and affordable year-round across all locations.

Will we be able to move towards cassava replacing wheat in our baked products in the Caribbean? Are baking and taste factors major barriers to this? Not enough research is done on the cooking quality of food and the keeping quality of the cooked products of cereals, particularly roti. Complaints are often heard about the lower palatability of some of the new products – is this based on prejudice or reality?

Constant interaction among breeders, post harvest technologists, nutritionists, and extension specialists is necessary to integrate the developments in various disciplines and evolve a system approach that will result in raised production levels and optimum utilisation without sacrifice of nutritional or sensory qualities. Coordination among the areas of agriculture, food technology and nutrition needs to be reflected in practice not just in policy. Such interaction has a very crucial role to play in the food system.

Education / training issues

The previous sections emphasise that central to the link between agriculture and health is nutrition. But there are other important factors that must be researched, understood and applied. For example, households' accessibility to nutritious food is a function of many factors including income, prices, marketing and distribution. Second, good nutrition depends on the quality of diets, food preparation practices, education levels and other factors. Little research has been done to allow for intervention-related understanding of the inter-relationship between agriculture, nutrition and health in the Caribbean.

Consequently, training the cadres of workers along this chain has been vertical which further fragments the integrated policy formulation and programme implementation in these sectors. Research efforts with a nutrition focus are needed to disentangle these inter-linkages so that specific recommendations can be applied individually for national food-health policies. In so doing, appropriate capacity building programmes can be developed for the various cadres of professionals involved in the sub-sectors. In redressing this imbalance between food availability and good nutrition, the education component must not be neglected. There is need to impart education at various levels and it is equally important to realise that the kind of communication media used and the content of what is to be taught to each target group will be different. Thus, there is a great and urgent need to carry out research on education methodology and to evolve and develop appropriate material for mass communication.

The formulation and implementation of integrated education programmes require the participation of scientists in various disciplines, including nutrition, agriculture, home science and food technology. Our Caribbean universities and agriculture research institutions should aim to direct the attention of students and faculty on these issues.

CONCLUSION

The Regional Transformation Program on Agriculture and the follow up, Jagdeo Initiative, are important documents that provide a framework for action to advance the supply side of the food equation. The Caribbean Ministers of Agriculture have recently declared the need and commitment to forge links between agriculture and health (CFNI 2007).

The long-term solution to food and nutrition problems in the Caribbean requires a sound understanding of the interface aspects, in which agriculture science, food technologists, nutritionists and others concerned would constantly interact with each other to ensure a multi-disciplinary attack and work as an interdisciplinary team in a concerted manner. Such research information should transcend the policies in agriculture and in so doing improve health and enhance economic development in this region.

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Growth, feed conversion and carcass traits study in rabbits, Trinidad, West Indies

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ABSTRACT

A total of 71 New Zealand White rabbits of both sexes were reared from birth to slaughter ages of 12 (n=24), 14 (n=24) and 16 (n=23) weeks. After weaning at four weeks of age, weaners were housed in individual cages and fed a 50/50 mixture of chicken broiler finisher (min. 18.5 % crude protein) and pig grower (min. 16 % crude protein) pellets. Available type of grass and dried whole coconut fibre were provided *ad libitum*. During the fattening period, each rabbit was weighed on a weekly basis before feeding. Rabbits were fasted for 24 hours before slaughter. Post-weaning ADG for rabbits grown to 12, 14 and 16 weeks was 24.6, 22.8, and 25.4 g, respectively. There was no significant effect (P>0.05) of the length of growing period on ADG. However, average daily feed intake and the feed conversion ratio (FCR) significantly (P<0.001) increased as the slaughter age increased from 12-16 weeks. FCR was 2.03, 2.35 and 2.77 at 12, 14 and 16 weeks respectively. Every carcass trait measured was found to have significantly (P<0.001) increased between 12 and 16 weeks old with the exception of the kidney fat and gall bladder, which showed no significant (P>0.05) variation. Fat deposition seems to have shifted from the kidneys to the pelvic area after the 14th week of life. The average dressing percentage was 51.1, 51.2 and 53.2% for rabbits slaughtered at 12, 14 and 16 weeks, respectively. The increase in live weight between 12 and 16 weeks was 51.7%. The increases in the weights of kidney (35.9%), gastrointestinal tract (30.2%) and distal part of the four feet (31.1%) were lower than increases in the weights of the skin (85.8%), hind legs (57.3%), liver (56.9%), pelvic fat (152.7%), kidney fat (75.9%) and reproductive tract (160.8%). Considering only the cost of feed pellets for the doe during gestation and lactation plus that for the fattener, the cost of producing 1 kg edible carcass, inclusive of the kidneys, heart, liver and lungs, was found to be the lowest (TT$8.88) at 14 weeks old compared to rabbits slaughtered at 12 (TT$8.99) or 16 (TT$9.85) weeks old. The income above the feed pellet cost was calculated to be TT$19.90, TT$20.01 and TT$19.04 for rabbits grown to 12, 14 and 16 weeks of age, respectively. Based on the cost of production and good carcass composition, it was concluded that rabbits should be slaughtered at 14 weeks (2.1 kg live weight) of age.

Keywords: New Zealand White, rabbits, growth performance, dressing percentage, carcass traits

INTRODUCTION

The global and inter-sectoral competition for food grains is on the rise especially with the utilisation of corn for the production of biofuel. In Trinidad, where most livestock feed ingredients are imported the effect is a regular increase in the price of commercial concentrate feeds. Feed costs on average account for approximately 70% of the total cost of raising livestock. While feeding forages of the highest nutritional quality to rabbits *ad libitum* can reduce this cost, it cannot be eliminated, due to the poor quality of tropical forages (Raharjo et al. 1986), some concentrate feed must be offered. Weaned rabbits need concentrate feed for rapid post weaning weight gain to ensure achievement of the slaughter weight in the shortest possible time. Thereafter, if rabbits are to be placed in the replacement herd, a limited quantity of concentrates should be fed to prevent fat deposition and obesity problems in the mature rabbit.

This study attempts:

- To study the growth performance of rabbits reared under tropical conditions from birth to 12, 14 and 16 weeks.
- To document and detect any significant differences in selected carcass traits of rabbits reared under tropical conditions and slaughtered at 12, 14, and 16 weeks old.
- To determine the most economical and optimal age at slaughter to produce a rabbit carcass which will be acceptable to the consumer.

MATERIALS AND METHODS

The rabbitry is located at the University Field Station (UFS), Trinidad (10.30^o N latitude and 61.50^o W longitude). Locally adapted high-grade New Zealand White rabbits were weaned at 28 days, placed in individual cages of dimensions 60 cm x 38 cm x 40 cm and randomly assigned to one of three groups, S12 (slaughtered at 12 weeks old, n = 24), S14 (slaughtered at 14 weeks old, n = 24) and S16 (slaughtered at 16 weeks old, n = 23).

Rabbits were fed feed pellets as well as wilted forage. A 50/50 mixture of Chicken Broiler Finisher (Min. 18.5 % Crude Protein, Min. 4.0% Crude Fat, Max. Crude Fibre, 5.0 %) and Pig Grower (Min. 16 % Crude Protein, Min. 2.5% Crude Fat, Max. 7.0% Crude Fibre) was used.

During the fattening period, each rabbit was weighed on a weekly basis before feeding. Fatteners were offered a measured quantity of concentrate feed daily. The refusal was weighed to determine apparent intake. Available forage of varying quality was mechanically harvested and wilted for 24 hours before being fed *ad libitum* to all the rabbits. Also, dried whole coconut fibre was provided as a source of indigestible fibre.

Rabbits were fasted for 24 hours before slaughter. Pre- and post-fasting live weights as well as weights of the skin, blood, hind legs, head, feet, gastrointestinal tract, reproductive tract, liver, kidney, lungs, heart, pelvic fat, kidney fat and gall bladder were recorded. The hind legs were de-boned and the weight of the muscle and bone were recorded separately to obtain a ratio of muscle to bone in the hind legs. The carcass, after the removal of the head, feet, tail and the emptying of the abdominal and chest cavity, was also weighed.

Average daily gain (ADG), average daily feed intake (ADFI), the cost of feed pellets per unit weight gained over the fattening period, feed conversion ratio (FCR), dressing percentage and the income over feed cost were calculated.

The effect of age at slaughter on growth and carcass parameters was tested using a one-way analysis of variance (ANOVA). Data analysis was done using MINITAB Release 13.1.

RESULTS AND DISCUSSION

Age effects on feed conversion efficiency and growth

Weaning weights for rabbits grown to 12, 14 and 16 weeks old were 352, 458, and 455 g, respectively, and were significantly ($P<0.001$) different. The overall post-weaning ADG was not significantly ($P>0.05$) different among treatment groups (Table 1). Overall post-weaning ADG were 24.6, 22.8, and 25.4 g for rabbits slaughtered at 12, 14 and 16 weeks of age, respectively. FCR increased at an increasing rate between 12 and 16 weeks of age. This may be due, in part, to a larger proportion of feed nutrients being utilised by the rabbit for maintenance of body weight rather than for weight gain. FCR in the S16 group was 2.8 compared with 2.4 and 2.0 in the S14 and S12 groups, respectively. The statistically non-significant increase ($P>0.05$) in ADG compounded with the significant ($P<0.001$) increase in ADFI resulting in an increase in FCR ($P<0.001$) serve as a deterrent to increasing the slaughter age of rabbits from 12 to 16 weeks of age.

Table 1 Mean ± SEM average daily gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR) and feed pellet cost over the fattening period

Age at slaughter (weeks) **Fattening period (weeks)**	**12** **4-12**	**14** **4-14**	**16** **4-16**	
Length of fattening period (days)	56	70	84	
Number of rabbits	24	17	24	
Overall ADG (g)	24.6 ± 0.49	22.8 ± 1.25	25.4 ± 0.54	NS
ADFI (g)	49.9 ± 1.02	53.0 ± 2.61	69.9 ± 1.23	***
Feed conversion ratio	2.0 ± 0.03	2.4 ± 0.08	2.8 ± 0.05	***
Cost of feed pellets consumed during fattening ($TT[1])	5.06 ± 0.10	6.71 ± 0.33	10.63 ± 0.19	***

NS: non significant ($P>0.05$), ***$P<0.001$, SEM = Standard Error of Mean
[1]US $1 = TT $6.30

As expected, as a result of the increase in FCR, significant differences ($P<0.001$) also occurred for the cost of feed per unit weight gained over the varying fattening periods. The continued growth of the digestive tract during the period from 12 to 16 weeks of age, hence the increased capacity of the rabbit for feed intake, will contribute to this increase in feed pellet cost. It should be noted that these figures do not include the weight of forage fed to the rabbits, although the nutrient intake from forages was insignificant. The results exceed those obtained by Omole (1982) in Nigeria, and Rastogi (1986) in Trinidad. The higher average fat

(3.25 %) and crude fibre (6%) content could be a major contributor to the lower feed intake observed in this study. Another possible reason for the superior results obtained in this study is the rearing of fatteners in individual cages as opposed to the group rearing practiced by Omole (1982) and Rastogi (1986). In the case of the latter, results were based on feed offered and not on actual feed intake. This could have resulted in a higher FCR.

With regard to final weight, significant differences ($P<0.001$) were observed with rabbits weighing 1710, 2050 and 2590 g at S12, S14 and S16 groups respectively. Predictably, there was also an accompanying increase ($P<0.001$) in post-weaning feed consumption.

Age effects on selected carcass traits

Weight averages for each body part are summarized in Table 2. Mean body weights after fasting for S12, S14 and S16 were 1664, 1944 and 2524 g with significantly different ($P<0.01$) dressing percentages of 51.1, 52.0 and 53.2, respectively. Dressing percentages were lower than those obtained by Cobos et al. (1995) and Hulot et al. (1994). These authors reported an average dressing percentage for crosses of New Zealand White (NZW) and California rabbits of 58% and for NZW of 60% for 2 kg and 2.5 kg live weight, respectively. The higher body weight achieved in the S16 group (2.52 kg) failed to produce a higher dressing percentage than that obtained by the aforementioned authors. It can therefore be inferred that dressing percentage is not limited to the effect of body weight but is a result of an interaction of factors inclusive of body weight. Higher body weight may result in higher dressing percentage only when rabbits are subjected to similar environmental and management conditions. The difference in mean live-weight after fasting between S12 and S16 was approximately 51.7%, with 16.8 % occurring between S12 and S14 and 29.9% occurring between S14 and S16. Compared to these increases, some body parts showed a growth rate below average, average, and above average.

The gastrointestinal tract for S16 increased by 30.2% over S12. However, the ratio of the gastrointestinal tract to live weight before slaughter decreased by 2.8% from a slaughter age of 12 to 16 weeks, with the tract still constituting 16.8% of the live weight after fasting at 16 weeks. The declining proportion of the digestive tract to the live body weight after fasting will favorably affect the final dressing percentage. A definite decrease was also described by Rao et al. (1978), Petersen et al. (1988), Szendrö (1989) and Parigi-Bini et al. (1992).

Skin weight increased significantly ($P<0.001$) between 12 to 16 weeks of age (+85.8%). Although body organs such as the liver, lungs and the heart showed no significant increases ($P>0.05$) in proportion to live weight before slaughter as age increased from 12 to 16 weeks old, there were significant differences ($P<0.001$) in weight of each of these organs. This suggests that these organs may have been developing whilst maintaining their proportion to the body weight as age increased. There was a significant difference in kidney weight ($P<0.01$) as well as the weight of the kidney in proportion to the live weight after fast ($P<0.05$) between S12 and S16.

In fact, all the other carcass traits studied, with the exception of the gall bladder and weight of kidney fat, increased significantly ($P<0.001$) as the slaughter age increased from 12 to 16 weeks. In the case of the kidney fat, most is deposited by the 14th week of life after which fat deposition shifts towards the pelvic area. Results suggest that not only the heart of the rabbit, but also most other organs in the body of the rabbit at 12 weeks of age are still growing and therefore not fully developed. Weight of individual body parts did not increase in proportion to the difference in live body weight at the different slaughter ages.

Table 2 The effect of age at slaughter on carcass traits of New Zealand White rabbits (Mean ± SEM)

Age at slaughter weeks	12	14	16	Effect of age
Number of rabbits	24	24	23	
Live weight (after 24h fasting) (g)	1664 ± 32.2	1944 ±76.1	2524 ± 51.3	***
Blood (g)	51.2 ± 2.50	61.0 ± 3.15	73.4 ± 2.94	***
Skin (g)	151.2 ± 4.06	185.6 ± 10.3	280.9 ± 7.23	***
Hind legs (g)	227.3 ± 5.52	270.7 ± 11.10	358.0 ± 10.3	***
Hot carcass (without head and edible parts) (g)	792.5 ± 18.5	951.3 ± 41.90	1254.0 ± 26.7	***
Head weight (g)	162.1 ± 2.73	187.1 ± 6.83	232.1 ± 4.18	***
Feet (distal portion) (g)	63.2 ± 1.22	70.6 ± 2.55	82.9 ± 3.69	***
Complete gastrointestinal tract (g)	324.7 ± 11.7	353.1 ± 11.5	422.7 ± 14.0	***
Reproductive tract (g)	4.9 ± 0.36	6.6 ± 0.59	12.7 ± 0.75	***
Liver (g)	35.7 ± 0.92	39.0 ± 2.01	56.0 ± 3.31	***
Kidney (g)	9.4 ± 0.39	10.0 ± 0.45	12.7 ± 0.39	***
Lung (g)	8.4 ± 0.40	9.0 ± 0.47	12.2 ± 1.05	***
Heart (g)	5.2 ± 0.21	5.4 ± 0.28	7.6 ± 0.44	***
Pelvic fat (g)	23.5 ± 1.79	24.6 ± 3.26	59.4 ± 4.84	***
Kidney fat (g)	2.2 ± 0.18	6.0 ± 1.93	3.9 ± 0.49	NS
Gall bladder (g)	1.7 ± 0.20	1.6 ± 0.16	1.5 ± 0.21	NS
Meat to bone ratio in hind legs	5.7 ± 0.17	6.4 ± 0.17	7.8 ± 0.21	***
Carcass wt.(g)+liver wt. (g)+giblets wt. (g)	851.2 ± 19.00	1014.8 ± 44.3	1342.5 ± 28.90	***
Dressing percentage [carcass wt. (g)+liver wt. (g)+giblets[1] wt. (g)] / lv. wt. after fast x 100	51.1 ± 0.49	52.0 ± 0.42	53.2 ± 0.41	**

NS: non significant (P>0.05), *P<0.05, **P<0.01, ***P<0.001, SEM- Standard Error of Mean
[1]Giblets – lungs, heart, kidney

Age effects on cost of meat production

Averages for specific growth and carcass parameters in Tables 2 and 3 were used to calculate the cost of meat production for rabbits grown to 12, 14 and 16 weeks old (Table 4).

Table 3 Mean ± SEM for growth parameters and feed pellet intake for rabbits slaughtered at 12, 14 and 16 weeks old

Age at slaughter (weeks)	12	14	16
Number of rabbits (g)	35	17	24
Total feed intake (post-weaning) (g)	2681 ± 63.9	3707 ± 182.0	5873 ± 103.0
Weight at slaughter (g)	1712 ± 43.4	2052 ± 101.0	2588 ± 52.7
Average total post-weaning weight gain (g)	1327 ± 35.6	1594 ± 87.3	2133 ± 45.0
Post weaning feed conversion ratio	2.03 ± 0.03	2.35 ± 0.08	2.77 ± 0.05

SEM - Standard Error of Mean

Despite the reduction in the efficiency of feed conversion from 12 to 14 weeks, the feed pellet cost of producing a 1 kg edible carcass at 14 weeks was slightly lower (TT$8.88) than that at 12 weeks (TT$8.99), primarily due to the higher dressing percentage. However, the cost of producing a 1 kg edible carcass at 16 weeks increased by approximately 10.92% compared to that at 14 weeks because the increase in the dressing percentage could not compensate for the even greater increase in the feed conversion ratio.

The overall costs of production for a 1 kg edible carcass (considering the cost of feed pellet only for doe during gestation and lactation plus feed cost for the fattener) at 12, 14 and 16 weeks of age were found to be TT$8.99, TT$8.88 and TT$9.85, respectively. The retail price for rabbit meat in Trinidad is approximately TT$28.89 per kg (2003 prices). Therefore, the income over feed cost per 1 kg edible carcass is calculated to be TT$19.90, TT$20.01 and TT$19.04 for rabbits grown to 12, 14 and 16 weeks of age, respectively.

Table 4 Feed conversion efficiency and cost of meat production for rabbits grown to 12, 14 and 16 weeks of age

Age at slaughter (weeks)	**12**	**14**	**16**
Number of rabbits	35	17	24
Average live wt. at slaughter (kg)	1.7	2.1	2.6
Feed pellet[1] offered to each doe			
i. First 23 days of gestation @ 80 g/day (kg)	1.84	1.84	1.84
ii. Last 8 days of gestation @ 100 g/day (kg)	0.8	0.8	0.8
iii. Kindling to weaning at 28 days (100 g + 10 g/kit)/day (assuming 4 kits weaned per litter)	3.92	3.92	3.92
• Total up to weaning for doe + 4 kits (kg)	6.56	6.56	6.56
• Total up to weaning for doe + 1 kit (kg)	1.64	1.64	1.64
Average feed pellet intake of each fattener post-weaning up to slaughter age (kg)	2.68	3.71	5.87
Total feed pellet offered to doe and fattener (up to slaughter) (kg)	4.32	5.35	7.51
Average total post-weaning gain (kg)	1.33	1.59	2.13
Post-weaning feed pellet/gain (kg)	2.03	2.35	2.77
Feed pellet cost of production (TT$[3]) at $1.81/kg (2003 prices)			
i. For a fattener with a live weight of:			
• 1.70 kg @ 12 weeks	7.82		
• 2.10 kg @ 14 weeks	9.68		
• 2.60 kg @ 16 weeks	13.59		
ii. For 1 kg edible carcass inclusive of kidney, heart, liver and lungs:			
• With a dressing % of 51.1 % at 12 weeks	8.99		
• With a dressing % of 51.2 % at 14 weeks	8.88		
• With a dressing % of 53.2 % at 16 weeks	9.85		
Income[2] over feed cost			
• Slaughtering at 12 weeks old for 1 kg edible carcass	19.90		
• Slaughtering at 14 weeks old for 1 kg edible carcass	20.01		
• Slaughtering at 16 weeks old for 1 kg edible carcass	19.04		

[1] Rabbits were fed a 50-50 mixture of chicken broiler finisher (min. 18.5 % crude protein) and pig fattener (min. 16% crude protein) feed pellets and mixed grass *ad lib*.
[2] Income through sale of edible parts only @ TT $28.89/kg
[3] US$1 = TT$6.30

CONCLUSIONS

Concentrate feed costs are similar (as is income) in growing rabbits to 12, 14, and 16 weeks old. Therefore, the decision as to the age at slaughter must consider weight and an acceptable carcass composition. This, among other factors, favours growing rabbits to 14 weeks of age.

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