

Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries

Applying a NutriBusiness Approach to Increase Animal Source Food Consumption in Local Communities¹

Audrey N. Maretzki*² and Edward W. Mills[†]

*Department of Food Science and [†]Department of Dairy and Animal Science, The Pennsylvania State University, University Park, PA 16802

ABSTRACT Animal source foods (ASF) in the diets of schoolchildren are beneficial for supporting optimal physical and cognitive development. Nevertheless, behavioral change and economic development are needed to increase and sustain adequate meat product consumption by schoolchildren in developing countries. A NutriBusiness enterprise may be one way for local communities to promote economic development while increasing the availability of meat for children. This work evaluates the feasibility of a NutriBusiness enterprise involving the production of rabbits and the manufacture of solar dried snack food. Some rabbits would be kept for home use, whereas others would be used in the manufacture of a rabbit-sweet potato dried snack food that could be fed to children or sold for income. The NutriBusiness enterprise would be composed of participants from the community contributing to a cooperative effort for setting up a manufacturing facility and organizing production, manufacturing and marketing functions. A unit operation for rabbit-sweet potato Chiparoos, based on full-capacity operation of a single solar drier would involve up to 110 shareholder families, each producing 240 rabbits/y with 120 used at home and 120 sold for Chiparoos manufacture. Participation in the enterprise would increase the availability to children of iron, zinc and vitamin B-12, and other nutrients, and provide ~\$350/y additional income for the family. *J. Nutr.* 133: 4031S–4035S, 2003.

KEY WORDS: • rabbit • children • Kenya • solar drier • animal source foods

The value of including animal source foods (ASF)³ in the diets of schoolchildren has recently been demonstrated through controlled feeding trials conducted in Kenya (1–3). What has not been established is how to sustain the intake of meat products in the diets of those children in developing countries who could benefit most from an increased consumption of the specific micronutrients provided by meat. However, the success of the Micronutrient and Health Program for Africa (MICAHA), (4) suggests that participatory micronutrient microenterprise activities are a key element in such a strategy. This paper describes how a NutriBusiness approach might be implemented to increase ASF availability in rural and urban areas in developing countries.

Background

To address the situation faced by both subsistence farming households and the urban and periurban poor, sustainable strategies are needed that will result in ASF that are affordable, acceptable and available to children. At the same time, these foods should be culturally inappropriate for consumption by adult males who typically receive preference in the intrahousehold distribution of ASF. For this reason, sustainable local strategies will most likely be based on poultry or small animals that can be confined and raised successfully by women or children, either indoors or within the family compound. Such a strategy, we believe, could also involve the cooperative processing of a portion of the home-produced animals into high value, shelf-stable foods. These processed foods could be marketed to households with disposable incomes sufficient to purchase highly nutritious packaged foods for their young children. Such products might also be sold in bulk to government agencies or philanthropic organizations involved in child feeding or nutritional rehabilitation programs. Selling simultaneously in commercial and institutional markets would increase the demand for ASF products while making them available to children from households that could not afford to buy them. Such an approach has been employed in two sites in rural Kenya where women's cooperatives were formed to produce and market nutritious cereal-based porridge mixes (5). However, to our knowledge, the concept has not

¹ Presented at the conference "Animal Source Foods and Nutrition in Developing Countries" held in Washington, D.C. June 24–26, 2002. The conference was organized by the International Nutrition Program, UC Davis and was sponsored by Global Livestock-CRSP, UC Davis through USAID grant number PCE-G-00-98-00036-00. The supplement publication was supported by Food and Agriculture Organization, Land O'Lakes Inc., Heifer International, Pond Dynamics and Aquaculture-CRSP. The proceedings of this conference are published as a supplement to *The Journal of Nutrition*. Guest editors for this supplement publication were Montague Demment and Lindsay Allen.

² To whom correspondence should be addressed. E-mail: anm1@psu.edu.

³ Abbreviations used: ASF, animal source foods; KIRDI, the Kenya Industrial Research and Development Institute; MICAHA, Micronutrient and Health Program for Africa; NGO, nongovernmental organization.

been adapted to the production and marketing of animal source foods.

We use the term “NutriBusiness” to define the engagement of women or other community residents in a cooperative business venture to process and market nutritious, shelf-stable foods made from locally grown crops and/or locally raised animals. If a NutriBusiness is to be sustainable, a reliable source of product ingredients must be available, the processing technology must produce a product of consistently high quality, and a market must be available when the product is priced to allow the cooperative’s shareholders to make a reasonable profit. Because of the fixed costs associated with the venture, a profitable NutriBusiness operation would not be achievable if the business is viewed as a village-level enterprise. To be economically viable, a NutriBusiness cooperative would need to market its products regionally or nationally while effectively involving rural women as shareholders and decision makers.

Lessons learned through the Kenya NutriBusiness project indicate that a NutriBusiness strategy should be undertaken only when certain preexisting conditions prevail. In addition to an agroecology capable of supporting the proposed operation, a sustainable NutriBusiness requires a physical infrastructure that includes a reliable source of potable water, all-weather roads and access to the fuel and energy sources needed for a food-processing operation. These conditions, however, must be supplemented by a social-institutional infrastructure that includes: 1) women who are skilled, able and culturally motivated to access basic financial services and function cooperatively as entrepreneurial decision makers; 2) the presence of a government agency or nongovernmental organization (NGO) to provide appropriate technical and organizational training, facilitate the business planning process and regularly monitor the activities of the cooperative; 3) a local university, a private sector organization or a government laboratory that can provide timely technical assistance and accurately perform basic analytical services as required; and 4) accessible urban or periurban markets that serve consumers who are financially able to purchase value-added food products.

Clearly, these conditions do not always coexist in a developing country, but where they do, a NutriBusiness strategy might be implemented that would encourage a large number of low income households to produce, for example, rabbits or chickens. Some of these animals could be slaughtered for home consumption, with the remainder being transported to a central processing facility that is owned cooperatively by local shareholders. A cooperative member would receive immediate payment for healthy animals delivered to the processing facility. These would be processed into shelf-stable products and transported to urban and periurban markets for sale. There, the products would be purchased in appropriately sized units by market women who would repackage the product for retail sale in smaller units that individual, moderate-income consumers could afford to buy. The products could also be packaged in bulk for sale to health centers, schools and other institutions that operate feeding or nutritional rehabilitation programs.

The ASF processing facility would create low skilled employment for individuals living in the vicinity of the operation. Revenue generated from the sale of the primary products as well as by the processing and sale of by-products such as skins, offal and feathers would be used to operate the processing facility. At the end of the year, shareholders in the cooperative would receive a share of any profit that was not reinvested in the operation. Because the ASF product to be marketed might include nonanimal ingredients, the possibility exists for member households to sell both crops and animals to

the cooperative, or for households that do not raise animals to also be involved in the NutriBusiness cooperative.

A meat and potato product for a NutriBusiness venture

An effort has been made by our research group to develop some of the preliminary information required for initiating a NutriBusiness cooperative to process and market value-added animal source foods (6). The specific purpose of this effort was to develop a food product containing rabbit or chicken meat that could be fed to children for the primary purpose of optimizing their physical and cognitive development. The product, called a “Chiparoo,” is a crispy shelf-stable meat and potato item that is suitable for use as a meal component or as a snack food. It can also be crumbled into porridge for older infants and very young children. The Chiparoo product was dried in our laboratory under conditions that simulated those achieved in a solar drier fabricated for the Kenya NutriBusiness Project by KIRDI, the Kenya Industrial Research and Development Institute in Nairobi. The finished product was packaged in plastic to prevent rehydration.

A Chiparoo NutriBusiness operation would involve the raising of rabbits, chickens or other small animals by a number of households in the vicinity of the processing facility. Animal-rearing practices might vary from free-range conditions to hand feeding of animals raised in pens. The later system, involving more planning and labor, would likely lead to greater animal productivity. Animals would be transported to the processing facility by their owners, who might walk or use public transportation. On-site animal housing facilities at the processing plant would be needed to maintain animals until they are slaughtered. Such facilities should provide for the continuing welfare of the animals by supplying water, protection from excessive heat and adequate space. Species-appropriate feed should be provided if animals must remain at the facility for >1 d. Slaughtering and processing would be scheduled according to availability of the drier and an adequate number of animals to produce a batch of Chiparoos. Nonmeat ingredients must also be available in a timely fashion. It may be beneficial to dry these ingredients earlier and store them on site until the animals are available for processing. Following manufacture, the packaged Chiparoos could be purchased by the cooperative members themselves, sold in the local community or transported to urban markets to be sold at wholesale to local retailers or in bulk to institutional markets. Many other NutriBusiness scenarios could be envisioned, but the Chiparoo is an example of a product that is specifically designed to provide the advantages of ASF to young children in developing countries.

Product quality considerations

Meat preservation in developing countries often involves dehydration where reliable refrigeration is not available. However, the resulting dried meat products (similar to beef jerky) are not commonly considered children’s food and are far too chewy for very small children. In the current effort, the Chiparoo product was formulated with a significant portion (~50%) of sweet or white potato. Other starchy ingredients such as cereal grains or tubers could also be used. In addition to improving product texture, the inclusion of nonmeat ingredients reduces cost and may improve the nutrient balance of the product by providing energy as well as key nutrients, such as β -carotene in the case of sweet potatoes. After drying, the Chiparoo product is crunchier than traditional dried-meat

products and can be readily crumbled into porridge for feeding to infants and young children. Because Chiparoos are a novel food item that could be made from rabbit, chicken or meat from other small animals, it is expected that they will be considered a culturally appropriate food for children, but possibly not for adults.

Sensory evaluation of Chiparoos

The quality of food products is a combination of their functional properties, including safety, convenience, shelf stability, nutritional content and palatability. Sensory properties of new food products are commonly evaluated by the intended audience. The sensory acceptability of Chiparoos was assessed in two rural Kenyan communities with mothers and children as respondents. Rabbit or chicken and sweet or white potatoes were used to manufacture four types of Chiparoos for sensory evaluation. Simple paired comparison tests were conducted with the help of leaders from the community who were trained to assist the respondents. The rabbit and white potato combination was slightly preferred by the Kenyan tasters, although all four products received favorable evaluations (6).

Food safety and sanitation

Animal products represent a significant source of human pathogens. In the U.S., meat, milk and eggs directly and indirectly account for ~23% of food-borne illnesses for which the vehicle of transmission is known (7). Comparable data are not available for developing countries, but clearly the microbial safety of a new meat-containing product such as Chiparoos needs to be considered. The drying process used for Chiparoos (9 h at 55°) was demonstrated in our laboratory to achieve at least a five-log reduction of selected pathogens including *Salmonella typhimurium*, *Escherichia coli* O157:H7, *Staphylococcus aureus* and *Listeria monocytogenes* for the four meat and potato combinations when the batters were slightly acidified with lime juice (8). Other drying protocols or product formulations should be similarly validated before being used for commercial production.

A fundamental challenge for all food manufacture is maintenance of consistent product safety. This is an even greater issue for NutriBusiness projects where various environmental and workforce problems may lead to a loss of process control. A food-borne pathogen outbreak would place the owners and their customers at a health risk and could effectively destroy the NutriBusiness cooperative through adverse publicity. In rural areas in developing countries, the available workers would generally be unskilled and are likely to have little knowledge of the sanitation practices appropriate for commercial food processing. Concepts such as "Good Manufacturing Practice" or "Critical Control Points" are not part of the culture. The cooperative structure of the NutriBusiness project provides a clear benefit in this regard because some workers may also be owners of the business. As owners they are likely to take a personal interest in performing the process correctly every time.

Controlling the ambient environment is even more problematic than successfully managing workers. Solar drying depends on consistent sunlight, temperature and relative humidity. These ambient conditions are especially important considerations in assuring the safety of dried-meat products. For reliability in a solar drying situation, an active solar drier, equipped for heat storage and accelerated air flow, such as the model constructed by KIRDI, should be employed. Regardless of the drying system employed, however, the process must achieve the validated time/temperature combination to assure safety of the finished product. Facility operators must be willing

to discard product that does not meet safe processing standards and must have access to technicians able to reliably and rapidly service the drying unit if mechanical or electrical problems arise.

A Chiparoo unit operation

In the NutriBusiness Unit Operation Plan shown in the Appendix, we outline a Chiparoo unit operation that involves 110 women, each of whom would invest \$116 (in U.S. dollars) to acquire breeding stock and construct and equip a co-operatively owned and managed processing facility capable of producing 4812 kg of Chiparoos/y. Under the assumptions we have made for this unit operation, the 110 shareholders in the cooperative would each be producing 120 rabbits/y for home consumption and selling a similar number to the cooperative. They would also be producing and selling the potatoes used in the product. The production and sale of the rabbits and potatoes would provide a gross additional household income of \$487/y and would also result in the availability of two rabbits per wk for household consumption. We did not factor into our calculations the possible need to purchase food for the rabbits, pay for household labor, purchase materials for constructing rabbit pens or pay to transport animals to the processing facility. If we assume that participation in a NutriBusiness enterprise would add, on average, \$350 to the net annual income of a family of eight persons currently living at the level of \$1/person/d, the annual income of that household would increase by ~12% without the need to cultivate significantly larger amounts of land.

At an estimated wholesale price of \$20/kg, Chiparoos would need to be repackaged and sold in small units to be affordable to most consumers. Our calculations suggest that a 14-g portion of Chiparoos could be profitably sold for ~\$0.35. The amount of rabbit meat contained in that portion would provide ~35%, 5%, 12% and 180%, respectively, of the recommended intake of protein, iron, zinc and Vitamin B-12 for a child 12–36 mo of age (9–11).

Social and institutional considerations

The assumptions highlighted in the Chiparoo unit operation serve to illustrate the technical issues that should be considered well in advance of a decision to initiate a NutriBusiness enterprise. However, rural women are unlikely to take on the added responsibility of raising animals simply to improve the growth and cognitive development of their children unless there is an economic incentive for them to do so. Certainly, they will not borrow or invest savings to amass the resources needed to collectively construct and equip a food-processing facility unless they are convinced that the investment will yield a short-term return as well as a longer-term profit on their investment. The importance of engaging a nongovernmental organization with animal husbandry expertise, such as Heifer International, in the support of a NutriBusiness project that involves commercial production of animals, even on a small scale, cannot be overemphasized. In the case of a cooperative food-processing venture it is also important to involve both an institution or organization with technical competence in food processing and an organization that can address the many social and organizational issues associated with the establishment and management of the cooperative. Effective participatory decision-making is difficult to achieve even when those making the decisions are well known to each other. In an organization large enough to successfully undertake a NutriBusiness venture, this interpersonal knowledge would not exist and

the possibility that a few dominant individuals may control decisions affecting the resources of the entire group should be addressed. Leadership development in a NutriBusiness cooperative is extremely important if the business is to achieve long-term sustainability.

Donor funding to assist with the capitalization of a NutriBusiness enterprise could be considered. However, it is important to ensure from the outset that the activity does not take on a project mentality in which the shareholders in the cooperative become dependent upon external financial and logistical support and fail to develop the ability to deal with the risks inherent in the operation of their own business enterprise.

Product marketing

The marketing of locally processed value-added ASF in developing countries is not well understood at present. The strategy of selling a high value meat-based food product to urban market women, who would repackage it in units that they could sell at a profit to moderate-income consumers in urban areas has, to our knowledge, not been tried. However, the concept has been used successfully in the marketing of other consumer items such as cigarettes, candy and chewing gum. A government-sponsored social marketing campaign that positions meat as a healthful addition to children's diets would be advantageous to such a strategy, but it would not result in sales unless the women who are actually selling the product are able to communicate to their potential customers that such products are a convenient form of meat that is affordable and good for children. Because mothers with limited incomes would be unlikely to buy an expensive meat food as a snack for their children, it seems reasonable to market Chiparoos as a snack food primarily in relatively affluent neighborhoods where the product could be attractively packaged to appeal to families with a relatively high disposable income. In less affluent areas, Chiparoos might be marketed as a child's alternative to the meat consumed by adults in the household. In this case, Chiparoos could be served to children as a nutritious addition to the family meal.

Application of the NutriBusiness model to ASF production and preservation offers the prospect of improving child nutrition and enhancing rural household food security. The success of the cooperative requires that the owner/operators apply sound business and food-safety principles. Sustainability of the NutriBusiness model hinges on a set of critical factors existing in the community. Community leaders, nongovernmental organizations, universities or others wishing to promote the development of NutriBusiness projects should carefully investigate the local situation before launching their efforts.

APPENDIX: NUTRIBUSINESS UNIT OPERATION PLAN FOR RABBIT AND SWEET POTATO CHIPAROOS

Technical assumptions

Rabbits for household consumption. Average of 6 children per household and 28 g raw meat/child/d.

Six children would need 1176 g raw meat/wk ($28 \text{ g} \times 6 \text{ children} \times 7 \text{ d}$).

Two rabbits (1.96) per wk would supply six children, ages 1–10 y, with one-fifth to one-third of their recommended daily protein intake, 4.5% of their iron, 4.5–9.1% of their zinc and 59–226% of their vitamin B-12 (9–12) if the rabbit meat was consumed solely by the children.

Rabbit production. 2 kg slaughter weight (live); 30% raw meat yield from live weight; 0.6 kg meat/rabbit; 5 litters/doe/y (31-d gestation); 8 kits/litter; 9-wk growth time to 2-kg live weight; 5–7 kg feed required (more if only forage is used).

Commercial processing. Chiparoo formulation: rabbit meat 3 kg (45.2%); boiled sweet potato 3.3 kg (49.7%); salt 45.4 g; lime juice 280 mL; curing salt* 11.4 g; *(93.75% sodium chloride, 6.25% sodium nitrite); Calculations assume that only muscle meat is processed. However, the liver and heart as well as the rabbit blood would be nutritionally desirable additions to the Chiparoo batter; Solar drier capacity 100 kg wet weight; Drying cycle (~9 h each) 5 cycles/wk during sunny season; 35 wk operation/y; Drying yield 27.5% from raw batter weight.

Estimates based on assumptions

Dryer capacity. 500 kg raw batter/wk of operation; 226 kg raw rabbit meat/wk of operation; 377 rabbits/wk of operation; 13,195 rabbits/y (35 wk of operation).

Operational unit. In the basic structure a family would raise 240 rabbits (offspring from six does) along with 79 kg of sweet potatoes/y. Sweet potato tops could be consumed by the household or used as feed for the rabbits. This production would provide, on average, 28 g of unprocessed rabbit meat/d for each child (two rabbits/wk). In addition, the household would deliver 24 rabbits to the processing facility every 9–10 wk ($5 \times /y$). In this structure, 110 households (hh) would be needed to keep the solar drier operating at full capacity for 35 wk/y.

Economic assumptions (all prices in U.S. dollars)

Initial costs. Processing facility construction and equipping. Solar drier - \$5,000; Building construction/renovation to meet health standards - \$4,000; Small processing equipment - \$2,000; Total cost = \$11,000; Breeding stock (6 does/hh @ \$2.50 \times 110 hh + 1 buck/3hh @ \$2.00 = \$1,724); Initial cost per cooperative member household = \$116 (excluding cost of constructing pens for the rabbits).

Ingredient costs. Raw materials for 4,812 kg of Chiparoos/y (assumed drier capacity); Rabbits (13,200 @ \$2.50 = \$33,000); Sweet potatoes (8,690 kg @ \$.50 = \$4345); Limes, salt and curing salt = est. \$2655; Total = \$40,000.

Total operating costs. Total annual operating costs including ingredients, salaries (a manager and three technicians), packaging materials, transportation, maintenance and repair of equipment and facilities, insurance, etc. (not including initial costs): \$80,000/y.

Sales and revenue. Break-even price of Chiparoos = \$16.62/kg. Wholesale selling price of Chiparoos = \$20.00/kg; Profit to cooperative from sale of Chiparoos = \$3.38/kg or \$16,264/yr; Additional revenue for the cooperative could be generated through: Sale of rabbit pelts; Composting/pulverizing of bones for sale as fertilizer; Passive drying of the animal waste material for sale to cooperative members to improve nutritional and caloric density of rabbits' forage-based diet. This additional revenue is not incorporated into the economic analysis. Annual projected income for each cooperative member (110 members); Sale of 120 rabbits = \$300.00; Sale of 79 kg sweet potatoes = \$39.50; Share of profit from sale of Chiparoos = \$147.85; Total annual income to cooperative household = \$487.35.

Economics of retail marketing of Chiparoos in urban and periurban areas

Wholesale price of 1 kg of Chiparoos (bulk pack) = \$20.00

1 kg = 72 market units weighing 14 g.

Wholesale cost = (\$.28/unit)

Retail selling price = \$.35/unit

Profit to retailer after repackaging = ~\$5/kg.

Nutrients delivered by Chiparoos

28 g of Chiparoo provides the nutrient equivalent of 46 g of raw rabbit meat

The amount of rabbit meat in a 14-g retail portion of Chiparoo would provide 4.55 g of protein, 0.356 mg of iron, 0.356 mg of zinc and 1.626 mcg of vitamin B-12 (12).

For a child between 12 and 36 mo, this portion would provide ~35% of the Recommended Dietary Allowance for protein, 5% for iron, 12% for zinc and 180% for vitamin B-12 (9–11).

LITERATURE CITED

1. Reid, E. D., Neumann, C. G., Siekmann, J. H., Bwibo, N. O., Murphy, S. P. & Allen, L. H. (2002) Supplementation with beef or milk markedly improves vitamin B₁₂ status of Kenya schoolers. *Global Livestock CRSP. Research Brief 02-04-CNP*. University of California, Davis, CA.
2. Whaley, S. E., Sigman, M., Neumann, C. G., Bwibo, N., Guthrie, D., Weiss, R. E., Murphy, S. & Alber, S. (2002) The impact of dietary intervention on the cognitive development of Kenyan school children. *Global Livestock CRSP. Research Brief 02-01-CNP*. University of California, Davis, CA.
3. Neumann, C. G., Harris, D. M. & Rogers, L. M. (2002) Contribution of animal source foods in improving diet quality and function in children in the developing world. *Nutr. Res.* 22: 193–220.
4. World Vision. (2002) MICAH Phase I Results 1995–2001. 1 World Drive, Mississauga, Ontario, Canada.
5. Muroki, N. M., Maritim, G. K., Karuri, E. G., Tolong, H. K., Imungi, J. K., Kogi-Makau, W., Maman, S., Carter, E. & Maretzki, A.N. (1997) Involving rural women in the development of nutritionally improved weaning foods: nutribusiness strategy. *JNE* 29: 335–342.
6. Kieras, S. J. (1999) Safety Assessment and Sensory Analysis of Meat-Based Dried Snack Food for Children in Sub Saharan Africa. Masters thesis. Department of Food Science, The Pennsylvania State University, University Park, PA.
7. Olsen, S. J., MacKinnon, L. C., Goulding, J. S., Bean, N. H. & Slutsker, L. (2000) Surveillance for Foodborne Disease Outbreaks—United States, 1993–1997. *National Center for Infectious Diseases. Surveillance Summaries.* 49: 1–51.
8. Kieras, S. J., Mills, E. W. & Knabel, S. J. & Maretzki, A.N. (2003) Validation of pathogen destruction during manufacture of a meat-based potato snack (Chiparoo). *J. Food Proc. Preserv.* 26: 385–399.
9. Dietary Reference Intakes for Energy. Carbohydrates, Fiber, Fat, Protein and Amino Acids. Food and Nutrition Board, Institute of Medicine, National Academy Press, Washington, DC. <http://books.nap.edu/books/0309085373/html/496.html> (accessed Sept. 29, 2002).
10. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. Food and Nutrition Board, Institute of Medicine, National Academy Press, Washington, DC. <http://books.nap.edu/books/0309072794/html/468.html> (accessed Sept. 29, 2002).
11. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline. Food and Nutrition Board, Institute of Medicine. National Academy Press, Washington, DC. <http://books.nap.edu/books/0309065542/html/326.html> (accessed Sept. 29, 2002).
12. USDA Nutrient Database of Standard Reference. Release 14. United States Department of Agriculture, National Agricultural Library, Washington, DC. http://www.nal.usda.gov/fnic/cgi-bin/lista_nut.pl (accessed July 10, 2002).