Going Green: An Inside Look at Kesho Congo's Use of Cowpea Leaf Protein Concentrate to Combat Malnutrition

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Courtesy of Kesho Congo & E.Obu

Food Science in Action:

- ✓ Food Processing
- ✓ Food Fortification
- ✓ Sustainable Food Systems
- ✓ Nutrition

Figure 1. Cowpea leaf protein concentrate (LPC) fortified biscuit[a] sandwiches. Figure subset depicts powdered cowpea LPC ingredient

Kesho Congo is a non-profit organization that produces leaf protein concentrate (LPC) from locally grown cowpea in the Democratic Republic of Congo. This protein concentrate is used to fortify the filling of biscuit[a] sandwiches which are consumed by acutely malnourished children. Protein, beta-carotene (provitamin A), folate (vitamin B9) and iron have been analytically measured in cowpea LPC which was found to substantially increase the nutritional value of biscuits. LPC presents a green opportunity for ready-to-use supplementary food (RUSF) formulations. *Kesho* is Swahili for tomorrow, which symbolizes the future of locally empowered and sustainable food relief systems in Congo and the rest of sub-Saharan Africa.

Introduction

The Democratic Republic of Congo (DRC), also known as Congo Kinshasa, is the second largest African nation with a population of roughly 87 million.[1] The country is emerging from nearly 3 decades of wars and rebellions that decimated 6 million people mostly in the eastern region, according to the Mapping Report of the United Nations.[2] A mélange of circumstances, not limited to a recent history of political instability, has rendered 43% of Congolese children under 5 years old chronically malnourished.[3,4]

This issue extends to the South Kivu community, which is nestled in the east of the DRC, where Dr. Adolphe Nyakasane, current head of the pediatrics department at Ciriri General Hospital, founded Kesho Congo in November 2015.

Kesho Congo takes on an integrated approach in fighting the malnutrition of children under 10 years of age with a focus on those under 5. They educate the population of Bukavu, DRC about nutrition and health; promote peace and democracy through cultural activities; empower women in rural areas through agricultural cooperatives and fortify food using leaf protein concentrates (LPCs).[5]

[a] "Biscuits" are synonymous with "cookies"

Available as an import from France, LPCs are an ingredient the Kesho Congo team has taken the initiative to produce themselves thus encouraging local Congolese productivity and sustainable, plant-based food relief systems (Figure 2). Proteins of high quality and quantity are associated with animal sources, though there is growing evidence to support that this plant-based protein is of comparable caliber (Table 1).[6]

In the DRC, leaf protein concentrates are locally sourced from cowpea (*Vigna unguiculata*) leaves and are internationally procured from alfalfa[b] (*Medicago sativa*) leaves. A secondary product of bean production, cowpea leaves are traditionally consumed in the DRC as a leafy vegetable for subsistence. Their very high postharvest perishability deters growers from maximizing leaf harvest. LPC is a value-added product; it enables the ambient storage of foliage through shelf-life extension from a couple days in its fresh state to more than 6 months as a nutritionally dense concentrate.[7] Cohort studies and randomized control trials (RCTs) show that LPCs offer a versatile approach to increase micronutrient (such as iron) intake and decrease nutrient deficiency related diseases and disorders (such as anemia).[6,8] Anthropometric measurements such as height or weight and biological markers such as hemoglobin have been used to evaluate control and treatment groups for anemia, vitamin A status or growth; internationally, groups which consumed LPC had significant improvements compared to those that did not.[6]

LPC can be formulated into traditional meals, flours, snacks and drinks.[6,7,9] It contains notable amounts of beta-carotene (provitamin A) and iron, a couple of the most prominent global nutrient deficiencies.[6,10,11] The COVID-19 pandemic emphasized the importance of strengthening domestic food relief solutions. Research and development on the LPC intervention is important to Kesho Congo's push for national progress towards alignment with the United Nations Sustainable Development Goals (SDGs); particularly, LPCs support Goal 2 to achieve zero hunger and Goal 3 to achieve good health and well-being. During a visit to Kesho Congo's operating sites in 2021, the United States Ambassador to the DRC, Mike Hammer, recognized their positive community impact.

Figure 2. Kesho Congo provides work opportunities to rural women via harvesting activities

Courtesy of Kesho Congo

Table 1. Dried alfalfa leaf concentrate: essential amino acid composition and comparison with other foods[6]

Essential amino acid (g/100 g food)	Leaf concentrate	Eggs	Whole milk	Beef (steak)	Chicken	Cooked rice
Valine	3.1	0.8	0.2	1.6	1.3	0.2
Leucine	4.7	1.1	0.3	2.6	2.0	0.2
Isoleucine	2.6	0.7	0.2	1.5	1.4	0.1
Methionine	1.0	0.4	0.1	0.8	0.7	0.1
Cysteine	0.5	0.6	0.0	0.8	0.7	0.1
Tryptophan	1.2	0.2	0.1	0.2	0.3	0.0
Threonine	2.4	0.6	0.1	1.3	1.1	0.1
Lysine	3.1	0.9	0.1	2.7	2.3	0.1
Histidine	1.2	0.3	0.1	1.0	0.8	0.1
Phenylalanine	3.0	0.7	0.1	1.3	1.1	0.1
Tyrosine	2.2	0.5	0.2	1.0	0.9	0.1
Methionine + cysteine	1.5	0.7	0.1	1.3	1.1	0.1
Phenylalanine + tyrosine	5.2	1.2	0.3	2.3	2.0	0.2
Total essential amino acid content	25.0	6.8	1.5	14.8	12.6	1.2
% Moisture	8.0	74.0	88.0	56.0	65.0	23.0

[b] Alfalfa leaves are commonly used in the animal feed industry. Extraction of leaf protein concentrate yields a digestible ingredient for human consumption.

Courtesy of Kesho Congo

Figure 3. Mid-upper arm circumference (MUAC) measurement taken by Dr. Julien Migabo (left) and recorded by Dr. Lydia Zigabe (right). MUAC is used to monitor malnourishment status

Response With support from *L'Association pour la Promotion des Extraits Foliaires en Nutrition* (APEF), the King Baudouin Foundation and friends from Syracuse, NY, USA, Kesho Congo leveraged food processing to extract protein concentrate from cowpea leaves. The product is used to fortify biscuit filling and *masoso* (maize, sorghum and soy) porridge as a sustainable nutrition relief intervention for children. Doctors and nutritionists at Kesho Congo's Center for Nutrition and Health Education monitor the progress of malnourished children who receive LPC (Figure 3). Packets of unfortified biscuits are sold to support Kesho Congo's operations while LPC fortified biscuit sandwiches are easily distributed to school-age children in need. Cowpea LPC offers a local, plant-based alternative to imported ingredients for nutrient fortification. Agronomists work to select cowpea cultivars for maximal foliage yield as well as monitor and evaluate crop growth. After leaf harvesting, a production team heats its fresh pressed "green" juice to 85-90 degrees Celsius for 10-20 minutes (Figure 4). The coagulum is the protein concentrate that is filtered and dried using solar or wood heat to create an ambient temperature stable product. At the time of need, it is ground and sieved to a powder consistency for use as an ingredient in the filling of biscuit sandwiches. LPC is an ingredient which imparts a strong flavor and green color; the sweetness of the biscuit filling helps to mask the flavor.[8]

Currently, locally sourced honey is the sweetener of choice. In the filling formulation, honey is functionally used to incorporate (without additional heat) a child's 5g daily serving of LPC and to bind two biscuits together. From a sensory standpoint, honey helps with the taste, though flavor profile does not drive the formulation.

Sowing, leaf harvesting, LPC manufacturing and biscuit production have been done by Kesho Congo since 2016. There is an ongoing project (2020-2023) to upgrade production equipment and processes for increased LPC yield. Agricultural activities integrate the rural community by offering avenues for employment. Manufacturing of Kesho Congo's production equipment occurs locally when feasible, which encourages community business in lieu of outsourcing.

In the context of malnourished children, fiber (found in the press cake byproduct) is considered an antinutrient which is significantly reduced (to <2g/ 100g DM) during the processing of alfalfa leaf to LPC.[7,8] To date, no compounds have been reported to be deleteriously present nor concentrated in alfalfa and cowpea LPCs. So far, alfalfa LPC is authorized for use as a novel food ingredient in the European Union.[13] It also has a history of application in product development.[6,14]

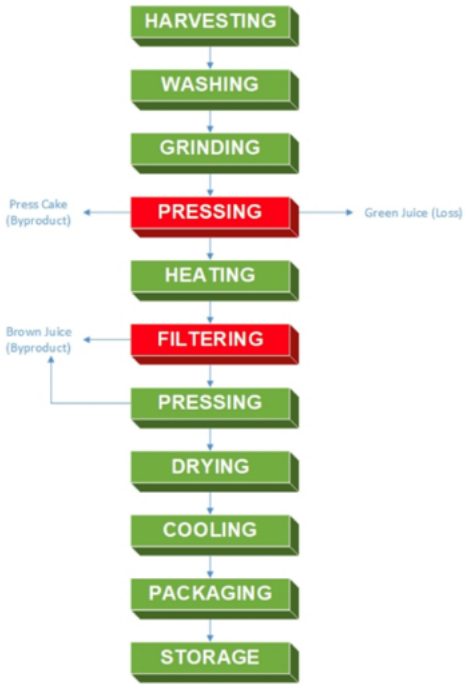

Figure 4. Small scale leaf protein concentrate process flow diagram. Red blocks indicate key material separation process steps[12]

Table 2. Biscuit fortification with 5g cowpea leaf protein concentrate (LPC)[12]

	1 Serving		
Nutrient	Unfortified Biscuits (20g)	LPC Fortified Biscuits with Honey Filling (27.6g)	LPC Fortified Biscuits with Banana Avocado Jam Filling (35g)
Protein (g)	1.409	4.167	4.265
Vitamin B9 (µg)	5.597	57.701	57.985
Vitamin A (µg RAE)	20.506	74.256	74.608
Iron (mg)	0.144	1.448	1.465

RAE: Retinol Activity Equivalents

Results

From 2020-2021, the impact of cowpea LPC fortification on Kesho Congo's biscuit nutrient composition was assessed using laboratory and computational analyses at Ghent University's VEG-i-TEC lab in Belgium. A recipe of 2 biscuits sandwiched together with honey and 5g cowpea leaf protein concentrate resulted in the following increases from a single serving of 2 biscuits alone (Table 2): 195% protein, 909% iron, 931% vitamin B9 and 262% RAE (retinol activity equivalents). An experimental recipe of 2 biscuits sandwiched together with a banana avocado jam and 5g cowpea leaf protein concentrate resulted in the following increases: 203% protein, 921% iron, 936% vitamin B9 and 264% RAE.[12]

Both alfalfa and cowpea LPC offer an average of 55% protein per 100g dry weight.[12,13] Since 2016, 6,480 children at Kesho Congo's Center for Nutrition and Health Education have been liberated from moderate acute malnutrition using LPC fortified food. Since 2016, nearly 75,000 children have received either cowpea or alfalfa leaf protein concentrates in biscuits or porridge at feeding centers collaborating with Kesho Congo.

- In 2020, Kesho Congo upgraded its production space to operate at an increased capacity.
- Children are welcomed to Kesho Congo's Center of Nutrition and Health Education on Mondays, Wednesdays and Fridays to receive LPC fortified foods.
- To meet needs on days where the center is not open, children are sent home with *masoso* (maize, sorghum and soy) flour mix and LPC to consume porridge with supervision.
- Since 2018, Kesho Congo hosts an annual leaf extract training seminar ("SIFEF"). It congregates local and international stakeholders as well as interested participants to share and discuss findings, progress and opportunities to address malnutrition with leaf protein concentrate.

Courtesy of Kesho Congo

Figure 5. Kesho Congo employee handling solar dried cowpea leaf protein extract

Courtesy of Kesho Congo

Figure 6. Kesho Congo team assembling leaf protein concentrate fortified biscuit sandwiches

Lessons Learned

- Cowpea LPC has the potential to be formulated into widely distributed ready-to-use supplementary foods (RUSF) for moderate acute malnutrition.
- A nutrition intervention using LPC has been and can be replicated in contexts outside of the DRC and malnutrition. LPC is valued in the EU and USA health food markets and leveraged as a nutrition intervention or food ingredient in countries such as Mexico, India and Ghana.[6,9,15]
- Scaling up cowpea LPC production to meet the demand is a present challenge. There is a growing network of local Congolese stakeholders, namely other community feeding centers, who would like access to cowpea LPC. An exchange of more efficient technologies available would be a resource that facilitates LPC production in the DRC.
- "Press cake" is the fibrous residue that remains a sizeable byproduct of LPC production. Strategic reintegration of this output along with "brown juice", the liquid byproduct, into the food system by avenues such as animal feed, fertilizer or further product development would increase byproduct utilization.
- Individually sandwiching biscuits together with a fortified filling is labor intensive and time consuming. Leveraging technologies which increase the efficiency of this process would help the Kesho Congo team.
- Children tend to open biscuit sandwiches. Further research and development on alternative techniques for incorporating LPC may be utilized to circumvent this.

Next Steps

- Future scientific research may include the optimization of the protein extraction process to increase LPC yield. In collaboration with Kesho Congo, researchers in Australia are currently exploring factors which control this. The Australian Institute of Food Science and Technology, *Fondation Coromandel*, the Humanitarian Food Science and Technology (HFST) and the King Baudouin Foundation are partners who support this development.
- Hunger relief and health care organizations can delve into a greener alternative to fortifying foods with LPC. LPC advocacy and education can be increased. Continued research on cowpea LPC may include an assessment of its amino acid profile.
- Food and nutrition policy makers may enable LPC as a local approach to food fortification which empowers its denizens and addresses plaguing nutrition related health issues.
- There is an opportunity for continued investment in food safety studies of LPC. Expanding clinical trials to the local target population and cowpea product would provide further evidence for key stakeholders to decide for or against LPC integration into government nutrition programs. Concurrently, development of a quality control plan is essential for ensuring product safety and effectiveness.
- Extending either cowpea or alfalfa leaf protein concentrates to 140,000 children in the DRC is Kesho Congo's 2023 target.

Courtesy of Kesho Congo

Figure 7. Dr. Adolphe Nyakasane (left) distributing leaf protein fortified biscuits to children at Kesho Congo's Center for Nutrition and Health Education in the Democratic Republic of Congo

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