Human nutrition trials around chicken meat and egg consumed in Ethiopia and Tanzania

ILRI PROJECT REPORT


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Human nutrition trials around chicken meat and egg consumed in Ethiopia and Tanzania

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Executive summary

The African Chicken Genetics Gain (ACGG) Agriculture to Nutrition (ATONU) is striving to improve nutrition outcomes through optimized agricultural investments project, aimed to develop, implement, and evaluate nutrition sensitive interventions (NSIs) within the context of existing agricultural programs with the goal of improving the nutritional status of women of reproductive age and young children, particularly in the first 1,000 days of life. ACGG ATONU implemented a NSI in collaboration with the ACGG program, led by the International Livestock Research Institute (ILRI). ACGG is evaluating the productivity of high producing, tropically adapted and farmer preferred chicken genotypes in Ethiopia, Tanzania and Nigeria. ACGG has provided approximately 25 chickens to each participating chicken producing smallholder households. ACGG ATONU had implemented an additional packages of NSIs among ACGG households using social and behavioural change communication (SBCC) to encourage consumption of chicken products (meat and eggs); recommend water, sanitation and hygiene (WaSH) practices to produce poultry; use income from sale of chicken products to improve nutrition and health; empower women in decision-making around chicken production and sale; and home gardening to produce nutrient dense vegetables to improve dietary diversity within the household.

It is worth mentioning that ACGG's intervention to increase chicken production helped to improve the nutritional status of women and children through increasing access to chicken meat and eggs for household consumption and empowering women by giving them access to income, which could be used to purchase other nutrient dense foods. However, increasing production and income alone may not necessarily translate into improved diets or nutritional outcomes. ACGG ATONU's intervention specifically encouraged the use of chicken products and income to provide nutritious diets for women of reproductive age and young children through extensive nutrition behaviour change communication. Recognizing the unavailability of other nutrient dense foods in local markets helped the project implementers to introduce the home gardening component of ACGG ATONU's intervention that increased the availability of nutrient dense vegetables at the household level. Following the implementation of the NSI's smallholder farmers' consumption pattern, women and children dietary diversity, chicken meat and egg consumption and use, hygiene and sanitation conditions and women empowerment are improved. Field officers have been visiting the homes of smallholder farmers and they witnessed that these farmers are bringing positive changes towards balanced diet consumption, good hygiene and sanitation and lower workload on women. For these results to be recorded, weekly nutrition education sessions, cookery sessions, home to home visits, theatre for nutrition and behavioural change communication, joint financial planning and budgeting and male sensitization were used as approaches.

Introduction

Undernutrition remains a key challenge to global health and development. Data indicate that a quarter (25%) of the world's children under five years are stunted, and this prevalence increases to 38% in sub-Saharan Africa (SSA) (UNICEF 2014). Stunting is a consequence of chronic nutritional deprivation that can begin during and even prior to pregnancy due to maternal malnutrition and other adversities. Child undernutrition is associated with high child mortality and morbidity (Black et al. 2013, (Olofin & McDonald, 2013), poor motor and cognitive development (Sudfeld et al. 2015), and lower educational attainment and economic productivity in adulthood (Victora, Adair, Fall, & Hallal, 2008). Maternal short stature, a long-term consequence of stunting in girls, is further associated with foetal growth restriction, which can lead to neonatal death and stunting in the next generation (Katz et al. 2013). Similarly, maternal and child anaemia has multifactorial causes involving complex interactions with nutrition, with serious consequences for maternal and child survival and health, healthy pregnancies, cognitive development, and work productivity (Balarajan et al. 2011).

Agriculture investments and productivity are increasing in Africa. Despite investments in agriculture and gains in productivity of food staples, the number of children in Africa who are stunted due to malnutrition is climbing (Stevens et al. 2012). To a great extent, achievements in food security have not translated to improved nutrition and health at the household level (IFPRI 2015). The scale of malnutrition across the continent continues to be high, with 58 million children under age of five are too short for their age (stunted), 13.9 million weighs too little for their height (wasted), and 10.3 million are overweight (UNICEF, 2015). An estimated 163.6 million children and women of reproductive age are anaemic (Kumlachew, Tesfahun, Mulugeta, & Tadelle, 2020) while more than 220 million people are estimated to be calorie deficient (FAO, IFAD, WFP 2015).

Adult obesity is on the rise in all 54 African countries, with about 8% of adults over 20 are obese (Kumlachew et al., 2020). Regions leading in agricultural production tend to be the most affected by high rates of child stunting (Tanzania Food and Nutrition Centre 2014). The ripple effects of malnutrition extend beyond the affected individuals to the society and the economy. Agricultural development initiatives have the potential to improve the nutrition of those most vulnerable to malnutrition, such as women of childbearing age and children as well as the general population; however, they must be specifically designed to address nutritional goals (Ruel and Alderman 2013), with rigorous evaluation of impact on nutritional outcomes.

In SSA, smallholder chicken production is an integral component of the livelihoods of poor rural households, and this is likely to continue for the foreseeable future (Kryger et al. 2010). Chicken production is largely a woman's enterprise. In addition to various sociocultural uses, the main outputs from family chicken production are meat or eggs as a source of high value nutrition for home consumption (ideal for the most vulnerable members of the household, such as pregnant women, children and the sick) and income from the sale of birds and eggs. Eggs are an important source of energy and provide 27% of an adult's daily requirements of selenium, 25% of vitamin B12, 23% of chlorine, 15% of riboflavin, 13% of protein, 11% of phosphorus, 9% of vitamin D, 9% of foliate, 8% of vitamin A, 6% of iron, and a small amount of zinc (FAO 2015). With nearly 40% of global chicken exports going to Africa and the Middle East (Mulder and Nelson 2013), there is tremendous opportunity for income growth and increased food security in SSA through improved chicken production (Iannotti et al. 2014). Evidence suggests that increased consumption of animal

foods can improve child growth and development (Marquis et al. 1997). However, limited evidence exists linking increased access to chicken meat and eggs with increased household animal source food consumption and improved nutrition status among women of reproductive age and children (Nielsen et al. 2003; Leroy and Frongillo 2007).

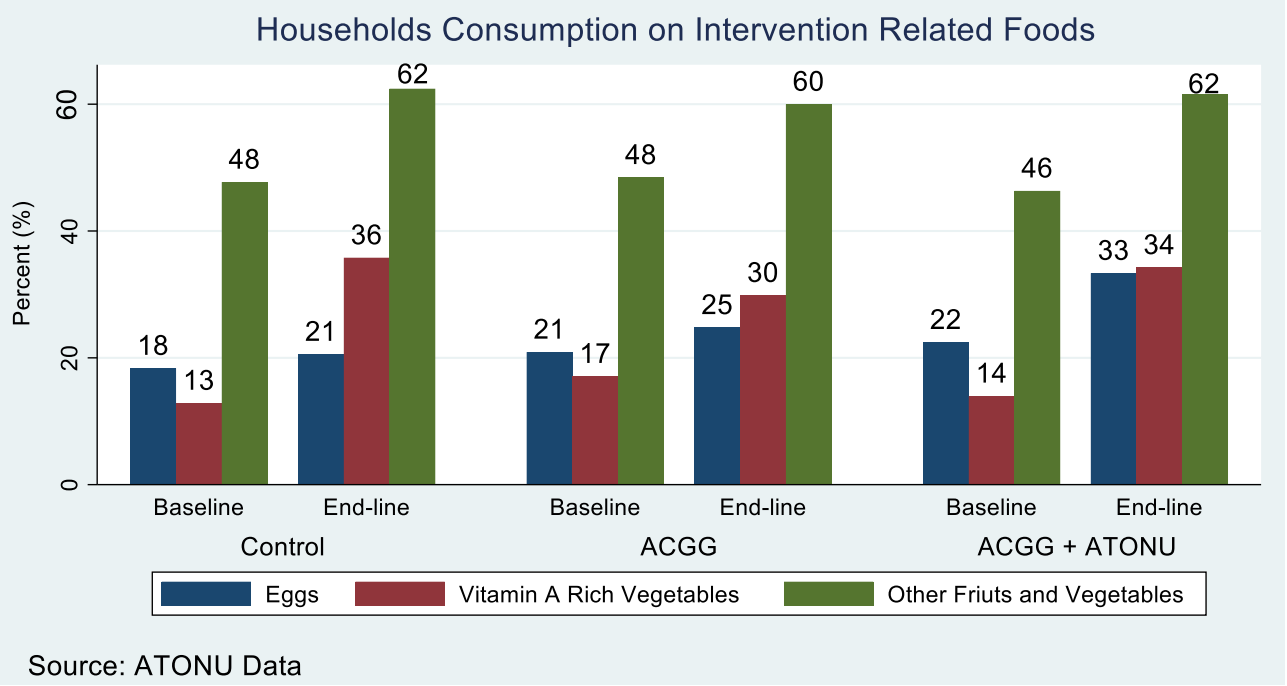
Likewise, evidence for integrating NSIs in agriculture projects for impact on nutrition and health is lacking. This fundamental gap in agricultural development, nutrition and health necessitates an integrated approach towards nutrition sensitive agriculture programs. As this approach evolves in developing countries, ATONU programs become more complex and thus increases the need for novel methods of implementing and measuring the impact. Integrated ATONU interventions cover a broad range of interventions from soil conservation and management to improved germplasm and other inputs, post-harvest processing and value addition, and storage, as well as marketing and food consumption. These processes collectively affect productivity and diversity of the harvest, food safety, and the energy as well as nutrient density of the diet. Specific interventions to integrate along the ATONU continuum may differ from one country to the other depending on national food and nutrition security, available resources, gender and cultural considerations, and hence are also likely to change over time. To successfully implement integrated approaches and ensure appropriate scale up for needed interventions, countries need coordinated efforts and robust evidence to inform decision-making frameworks. This project was designed to assess the impact of integrating NSIs in a targeted chicken production project (ACGG) on maternal and child nutrition and health outcomes.

ACGG was identified as a project that integrates and assesses the impact of selected NSIs to provide evidence for agricultural potential to deliver positive nutritional outcomes. In designing and implementing the NSIs, ILRI partnered with two country implementing partners namely: the Ethiopian Institute of Agricultural Research and the Tanzania Livestock Research Institute. The Harvard School of Public Health and its local Ethiopian partner, Addis Continental University, were responsible for the designing and conducting of the impact evaluation for the NSIs in Ethiopia, while Sokoine University of Agriculture was responsible for the impact evaluation in Tanzania. ACGG ATONU project was built on ACGG project that works with partners and beneficiaries to design and evaluate effective agriculture tailored nutrition interventions, and advocate for them. ACGG ATONU's primary beneficiaries were smallholder farm families in four regional states; Amhara, Tigray, Oromia and Southern Nations Nationalities and Peoples' Region in Ethiopia and in three agricultural zones; central, southern highlands and eastern zones in Tanzania. The project targets were women of childbearing age and young children in the first 1,000 days of life in rural households, where high nutritional demands of pregnancy, development and early childhood must largely be met through food grown, or income earned, on family farms in both Ethiopia and Tanzania. The project benefited 1,600 households in both countries.

Chicken products consumed at baseline and endline, Ethiopia

One of the major focuses of ATONU intervention is enhancing poultry and vegetable product consumption through improved production and management practices. Households in the intervention areas were provided chicken to improve own consumption and sale of eggs and live birds and encouraged to produce vegetables for the same purpose. During the baseline and endline assessment data were generated on the production and consumption of these commodities. Figure 1 presents a summary of index of child eggs and vegetable consumption in the previous seven days. In general, compared to the baseline, consumption of both food items has increased at the endline in all treatment arms. However, the increase in consumption of eggs looks significantly higher in the ACGG+ATONU treatment arm than both control and ACGG treatment arms. Compared to the control and ACGG treatment arms, a higher proportion of children in the ACGG+ATONU arm households consumed eggs that could be attributed to the NSI.

Figure 1. Chicken, eggs, vitamin A rich vegetables, and other vegetables and fruit consumed in Ethiopia.



Descriptive summary of household dietary diversity, Ethiopia

Household dietary diversity index (HDD) is one of the most important indicators used to assess the food security status of households. It helps to measure the number of different types of food and food groups household consume and shows the diversity of food groups the household consume. It can be measured either at households or individual level such as women or children. Even though there are no standard cut off points that would indicate the adequacy of measured values, some institutions like IFPRI have their cut off points to assess the adequacy level. Table 1 presents a summary of household dietary diversity indicators by intervention period using 12 food groups approach at the household level and 9 food groups approach for women level and 7 food groups approach for child level. The household level dietary diversity is measured using 30 days food consumption recall information and usually, it does not only indicate the food security status of households, but also the wealth of households. As a result, it includes more food groups that are not included at individual level measurements. The overall average household dietary diversity score was about 4.13 during baseline and increased to 4.64 at the endline. The test for the presence of a difference between the mean values at different periods shows the presence of a statistically significant difference during the three periods.

Table 1. Summary of household dietary diversity, Ethiopia

Food security indicator	Baseline		Midline		Endline		Total		Chi-squared
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
HHDD_30DY	4.13	1.76	4.41	1.76	4.64	1.85	4.39	1.80	76.7***
WDD_7NEW	3.70	1.56	4.14	1.61	4.27	1.67	4.03	1.63	152.4***
WDD_YNEW	2.72	1.06	2.93	1.16	3.14	1.20	2.93	1.15	132.2***
CHDD_7NEW	2.14	1.71	2.39	1.69	2.68	1.85	2.42	1.77	22.05***
CHDD_YNEW	1.79	1.45	2.05	1.44	2.22	1.54	2.03	1.49	22.5***

**Inference: *** p< 0.01; ** p< 0.05;*p< 0.1.

Women's dietary diversity was measured using 7 days and 24 hours of food consumption information. The 7 days consumption dietary diversity shows women's dietary diversity grew from 3.7 food groups at baseline to 4.27 food groups at the endline. The average difference at baseline and endline seems statistically significant. Likewise, the 24 hours food consumption recall also indicates women's food consumption diversity has increased from 2.72 to 3.14 food groups, with a statistically significant difference between the baseline and endline. Children's dietary diversity was also measured using the 7 days and 24 hours of food consumption recall. On average the seven days consumption of child dietary diversity grew from 2.14 during baseline to 2.68 during the endline. Similarly, the 24 hours recall consumption also grew from 1.79 food groups to 2.22 food groups. The test for difference in the average values suggests the presence of a statistically significant difference between baseline and endline.

Minimum dietary diversity is also the other binary food security indicator that indicates the food security status of households, women, and children. This indicator is constructed using certain cut off points, where individuals above the cut-off point are considered as a food secure and below the cut-off point as otherwise. Table 2 presents

a summary of women and child level indicators measured in 7 days and 24 hours recall. Based on the 7 days recall measure, the proportion of women that fulfil the minimum dietary diversity increased from 27.9 to 43.0%, which seems very significant. Similarly, based on the 24 hours recall measure, the proportion of women considered as an inadequate dietary diversity increased from 4.9 to 11.8%. The test for the presence of an association between minimum dietary diversity and period of observation is statistically significant at 1%, suggesting the presence of a strong association between periods of observation and level of minimum dietary diversity. Like the women minimum dietary diversity indicator, the proportion of children who were considered inadequate dietary diversity increased from 22.2 to 35.5%. There is also a statistically significant association between children's minimum dietary diversity and period of observation. In general, the minimum dietary diversity indicator of women and children suggests the presence of significant improvement during the endline than the baseline, which could be associated with the project interventions or other changes outside the project intervention.

Table 2. Summary of minimum dietary diversity for women and children, Ethiopia

Minimum dietary diversity		Baseline	Midline	Endline	Total	Pearson chi^2
HMDD	Yes	21.6	26.4	32.8	26.9	
	No	78.4	73.6	67.2	73.1	66.6***
WMDD7	Yes	27.9	37.4	43.0	36.0	
	No	72.1	62.6	57.0	64.0	105.5***
WMDDY	Yes	4.9	9.1	11.8	8.6	
	No	95.1	90.9	88.2	91.4	64.2***
CMDD7	Yes	22.2	26.2	35.5	28.2	
	No	77.8	73.8	64.5	71.8	45.9***
CMDDY	Yes	12.3	15.4	20.7	16.3	
	No	87.7	84.6	79.3	83.7	26.5***

**Inference: *** p< 0.01; ** p<0.05;*p<0.1.

Impact of intervention on household dietary diversity (HDD), Ethiopia

The impact of the project intervention on household food security indicators was measured using the most commonly used difference-in-difference (D–I–D) approaches. Table 3 presents estimated results on the HDD indicators for the three treatment arms (Control vs ACGG+ATONU; Control vs ACGG; ACGG vs ACGG+ATONU). The impact of ACGG+ATONU interventions on HDD seems statistically significant at 1%. Compared to households in the control arms, households in the ACGG+ATONU had higher HDD, which could be attributed to the project intervention. Compared to the control arm, there was also a positive change in the ACGG treatment arm though the difference is not statistically significant. Furthermore, considering ACGG as the control group, the impact of ACGG+ATONU intervention on HDD seems positive despite the absence of a statistically significant difference between the two groups. This shows that in addition to the chicken-based intervention the NSI in the ATONU villages brought some change in HDD.

Table 3. D–I–D result for HDD, Ethiopia

Treatment arms	Before				After				D–I–D (T–C)	
	CT	TR	Diff (T–C)	T	CT	TR	Diff (T–C)	T	Diff (T–C)	T
Control vs ACGG+ATONU	0.253	0.232	–0.021	–0.88	0.295	0.375	0.08	3.27***	0.101	2.96***
Control vs ACGG	0.238	0.218	–0.019	–0.82	0.3	0.325	0.025	1.05	0.045	1.33
ACGG vs ACGG+ATONU	0.224	0.232	0.007	0.3	0.332	0.375	0.043	1.76*	0.036	1.05

**Inference: *** p< 0.01; ** p<0.05;*p<0.1.

Where CT=Control, TR=Treatment, T–C=Treatment minus Control, T=Treatment

Impact of intervention on household members dietary diversity, Ethiopia

In addition to household level aggregated data, intra household level indicators can also give us a good picture of the nutritional status of the selected household members who are vulnerable to food insecurity. Using the D–I–D approaches, the impact of the two interventions on women and children's dietary diversity is presented in Table 4. The estimated result suggests the impact of ACGG+ATONU intervention on women's dietary diversity measured at seven days recall seem statistically significant. Compared to women in the control arm, women in the ACGG+ATONU arms had higher dietary diversity at the endline than at the baseline. This could be attributed to the NSIs in the ATONU treatment arm. The D–I–D test between the ACGG and ACGG+ATONU intervention also shows the presence of a positive change in the ACGG+ATONU arms than the ACGG arms. However, this difference is not statistically significant. The positive difference in the values of these two intervention arms is expected due to the impact of other nutrition-based interventions in addition to the chicken related intervention.

Table 4. D–I–D results for woman and child dietary diversity, Ethiopia

Indicator	Treatment arms	Before				After				D–I–D (T–C)	
		CT	TR	Diff (T–C)	T	CT	TR	Diff (T–C)	T	Diff (T–C)	T
Woman dietary diversity –7D	Control vs ACGG+ATONU	3.694	3.825	0.131	1.56	4.134	4.513	0.38	4.43***	0.249	2.08***
	Control vs ACGG	3.665	3.758	0.093	1.12	4.116	4.299	0.183	2. 14***	0.09	0.75
	ACGG vs ACGG+ATONU	3.786	3.825	0.039	0.44	4.332	4.513	0.181	2.03***	0.143	1.14
Child dietary diversity–7D	Control vs ACGG+ATONU	0.305	0.229	–0.076	–2.02***	0.362	0.432	0.07	1.92**	0.146	2.97***
	Control vs ACGG	0.246	0.229	–0.016	–0.43	0.322	0.432	0.11	3.0***	0.126	2.4***
	ACGG vs ACGG+ATONU	0.338	0.245	–0.094	–2.54***	0.311	0.313	0.002	0.05	0.095	1.86*

**Inference: *** p<0.01; ** p<0.05;*p<0.1.

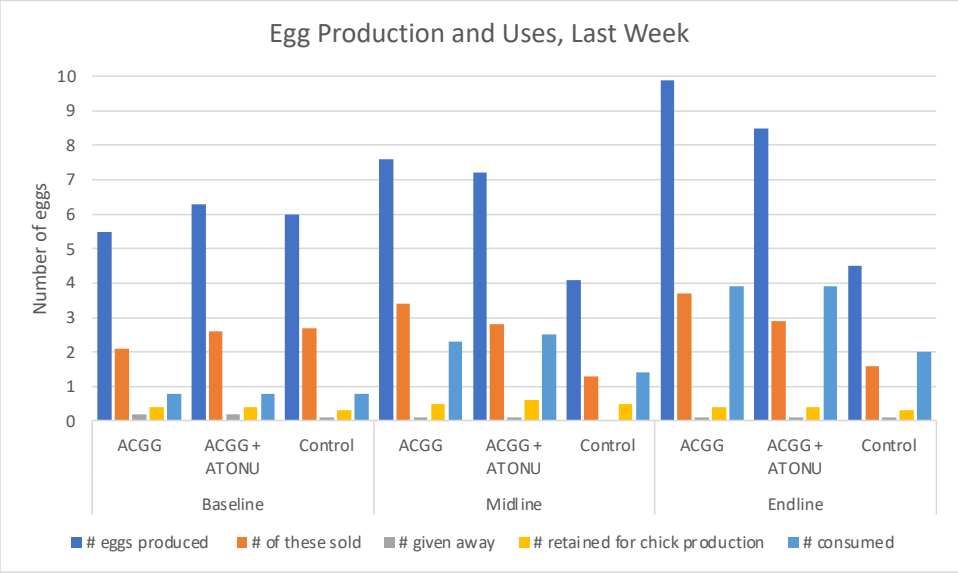
Where CT=Control, TR=Treatment, T–C=Treatment minus Control, T=Treatment

Like women's dietary diversity, the NSIs have brought significant change in the diversity of children's diets. Compared to the control arms, both ACGG and ACGG+ATONU interventions have brought statistically significant changes in child dietary diversity. Furthermore, the test for the relative difference between ACGG and ACGG+ATONU suggests the presence of statistical difference (10%) in dietary diversity between the two intervention areas. The above findings show if properly implemented NSIs could potentially bring positive change in food and nutrition security of rural households.

Chicken meat and egg consumed and used in Ethiopia

To assess the pathway between chicken production and consumption, women were specifically asked about egg consumption and cooking methods. Figure 2 describes eggs produced, consumed, sold, given away and retained for chick production. The survey questions on which this section is based ask specifically about the previous seven days. Looking at endline data, we see that the ACGG and ACGG+ATONU arms are producing approximately twice as many eggs at endline as the control arm, and more eggs than at baseline. At endline, the average number of eggs produced in the last week was 9.9, 8.5 and 4.5 for ACGG, ACGG+ATONU and control arms, respectively. We also see that in each arm, similar numbers of eggs are consumed at home as are sold.

Figure 2. Egg production and uses, last week, Ethiopia.



Overall, while household consumption of eggs produced on-farm was low and not different among arms at baseline ($p>0.05$), the ACGG and ACGG+ATONU arms had higher household egg consumption (approximately 4 eggs/week) than the control arm (approximately 2 eggs/week) at endline ($p<0.05$).

Table 5 also shows the most common egg preparation methods. On average, the ACGG+ATONU group prepared the greatest number of eggs at endline during the last preparation (6.9), which had increased from the baseline amount by about one egg (from 5.6); the ACGG arm consumed about 6.6 eggs during the last preparation, which also increased from 5.6 at baseline. The control arm prepared about 5.8 eggs during the last preparation, which also saw an increase from about 5.1 at baseline. The most common cooking method was frying and scrambling for all treatment arms. There seemed to be a slight decrease in boiling eggs, and a slight increase in preparation by cooking in a stew or meat dish compared to baseline for all treatment arms.

Table 5. Eggs prepared during past week, Ethiopia

	Baseline			Midline			Endline		
	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Prepared egg(s) in past week	27%	32%	27%	37%	41%	28%	46%	51%	28%
No. of eggs prepared	5.6	5.8	5.1	6.5	6.7	5.6	6.6	6.9	5.8
How were they prepared? %									
Boiled and combined in a meat dish	2%	4%	2%	6%	9%	5%	12%	7%	7%
Boiled (not combined in a meat dish)	20%	18%	13%	14%	12%	16%	11%	12%	8%
Fried, scrambled	56%	50%	43%	44%	42%	33%	53%	51%	46%
Fried, whole	11%	11%	15%	14%	12%	16%	7%	11%	13%
Cooked in stew	12%	18%	25%	21%	23%	29%	16%	20%	27%

Table 6 is based on the section of the survey that first asks about whether eggs were consumed in the past week, and if they were, how many were consumed by the following groups: the woman of reproductive age, the index child, the oldest child, other household members, the household head and non-household members. The average number of eggs consumed at each meal for the woman of reproductive age and the index child is relatively consistent from baseline to endline and across groups. However, as shown in Table 5 above, there was a much higher percentage of households that prepared eggs in the past week in the ACGG+ATONU (51%) and ACGG (46%) arms compared to the control arm (28%), meaning a greater number of children and women of reproductive age actually ate eggs in these groups, and that a greater number of eggs was consumed by these intervention groups relative to the control.

Table 6. Who consumed eggs prepared during last week, Ethiopia?

			No. of eggs WRA consumed	No. of eggs index child consumed	No. of eggs oldest child consumed	No. of eggs other household (hh) members consumed	No. of eggs hh head consumed	No. of eggs non hh members consumed
Baseline	ACGG	Mean	1.8	2.0	1.6	3.2	2.2	0.6
		SD	1.1	1.4	0.9	2.5	1.2	1.0
	ACGG+ ATONU	Mean	2.1	2.4	2.1	3.0	2.1	0.8
		SD	2.1	2.2	2.4	2.1	1.5	1.4
	Control	Mean	2.0	2.3	2.1	3.1	2.3	0.7
		SD	1.9	2.6	2.3	2.8	1.9	1.3
Midline	ACGG	Mean	1.8	1.9	2.1	3.4	2.0	0.4
		SD	1.1	1.5	2.1	2.3	1.2	1.0
	ACGG+ ATONU	Mean	1.8	2.0	2.0	3.5	2.1	0.7
		SD	1.5	2.0	2.2	2.9	2.1	1.3
	Control	Mean	1.7	2.1	1.6	3.1	2.0	0.4
		SD	1.2	1.6	1.0	2.4	1.2	0.6
Endline	ACGG	Mean	1.8	1.8	1.8	3.3	2.0	2.8
		SD	1.3	1.2	1.6	2.9	1.6	1.9
	ACGG+ ATONU	Mean	1.8	1.7	1.6	3.9	2.0	3.4
		SD	1.6	1.5	1.6	2.9	1.3	3.0
	Control	Mean	1.8	1.7	1.6	2.8	1.8	2.3
		SD	1.4	1.6	2.0	2.2	1.2	1.6

WRA=Women of Reproductive Age

Children's consumption of chicken remained low across all arms, while egg consumption by children increased across time for all arms. Results from the 24-hour recall indicate that chicken consumed by children was low throughout the study with <1% of children consuming chicken in the previous 24 hours (Table 7). In the 7-day food frequency questionnaire, chicken consumption increased marginally to 2.7% at endline from 1% at baseline. Egg consumption by children was more frequent, with 15.4% of the children consuming eggs in the previous 24 hours at endline compared to 12% at baseline. In the previous 7 days, 27.5% of children had consumed eggs at endline compared to 24.2% at baseline. Eggs consumed appeared to be greater for the ACGG+ATONU arm at endline compared to other arms (Table 8).

Table 7. Children's consumption of chicken and eggs in the previous 7 days and 24 hours, Ethiopia

	Chicken consumption						Egg consumption					
	7-day FFQ•			24 hr recall			7-day FFQ			24 hr recall		
	Baseline	Midline	Endline	Baseline	Midline	Endline	Baseline	Midline	Endline	Baseline	Midline	Endline
No.	7	11	27	4	1	4	177	207	272	88	110	152
%	1.0	1.2	2.7	0.6	0.1	0.4	24.21	23.05	27.5	12.04	12.25	15.37
No.	731	898	989	731	898	989	731	898	989	731	898	989

•FFQ=Food Frequency Questionnaire.

Table 8. Children's consumption of chicken in the previous 7 days and 24 hours by treatment arm, Ethiopia

	Chicken consumption 7-day FFQ•									Chicken consumption 24-hour recall								
	Baseline			Midline			Endline			Baseline			Midline			Endline		
	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control
No.	4	1	2	4	5	2	7	8	12	0	0	4	0	0	1	0	3	1
%	1.7	0.5	0.8	1.4	1.8	0.6	2.3	2.6	3.2	0.0	0.0	1.5	0.0	0.0	0.3	0.0	1.0	0.3
No.	243	222	266	286	278	334	305	307	377	243	222	266	286	278	334	305	307	377

•FFQ=Food Frequency Questionnaire.

Based on the FFQ table, eggs consumed in the ACGG+ATONU arm for the last 7 days was improved from 27% at baseline to 35.8% at endline among children. This improvement is registered as a significant change resulted from the ATONU packages (Table 9). Taking the 24-hour recall method into account, egg consumption among indexed children of the ACGG+ATONU treatment arm showed a significant increase from 15.4% at baseline to 21.8% at endline (Table 9).

Table 9. Children's consumption of eggs in the previous 7 days and 24 hours by treatment arm, Ethiopia

	Egg consumption 7-day FFQ•									Egg consumption 24-hr recall								
	Baseline			Midline			Endline			Baseline			Midline			Endline		
	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control
No.	58	60	59	76	73	58	82	110	80	26	31	31	44	39	27	47	67	38
%	23.9	27.0	22.2	26.6	26.3	17.4	26.9	35.8	21.2	10.7	14.0	11.7	15.4	14.0	8.1	15.4	21.8	10.1
No.	243	222	266	286	278	334	305	307	377	243	222	266	286	278	334	305	307	377

•FFQ=Food Frequency Questionnaire.

On average, 11.5% of women reported consuming eggs in the 24-hour dietary recall at endline, compared to 6.9% at midline and 4.6% at baseline. Comparatively, 32.8% of the women reported consuming eggs on at least one occasion in the past 7 days, compared to 25.4% at midline and 19.4% at baseline. At endline, 1% of women reported consuming chicken in the previous 24 hours compared to 0.5% at baseline; 5.4% ate chicken on at least one occasion in the past week compared to 2.2% at baseline (Table 10). Chicken consumption remained very low throughout the study, while egg consumption showed marginal increases in all arms. Eggs consumed appeared to be greater for the ACGG and ACGG+ATONU arms at endline compared to the control arm (Table12).

Table 10. Women's consumption of chicken and eggs in the previous 7 days and 24-hour recall, Ethiopia

	Consumed chicken						Consumed eggs					
	7-day FFQ•			24-hr recall			7-day FFQ			24-hr recall		
	Baseline	Midline	Endline	Baseline	Midline	Endline	Baseline	Midline	Endline	Baseline	Midline	Endline
No.	46	87	110	11	10	20	410	518	664	98	141	233
%	2.2	4.3	5.4	0.5	0.5	1.0	19.4	25.4	32.8	4.63	6.91	11.49
No.	2,117	2,041	2,027	2,117	2,041	2,027	2,117	2,041	2,027	2,117	2,041	2,027

•FFQ=Food Frequency Questionnaire.

Based on the FFQ table chicken meat consumed in the ACGG+ATONU arm for the last 7 days was improved from 1.8% at baseline to 5.1% at endline among women. This improvement is registered as a significant change resulted from the ATONU packages (Table 11). Taking the 24-hour recall method into account, chicken meat consumed among women of reproductive age of the ACGG+ATONU treatment arm also showed a slight increase from 0.4% at baseline to 0.7% at endline (Table 11).

Table 11. Women's consumption of chicken in the previous 7 days and 24 hours by treatment arm, Ethiopia

	Consumed chicken in 7-day FFQ•									Consumed chicken in 24-hour recall								
	Baseline			Midline			Endline			Baseline			Midline			Endline		
	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control
No,	20	13	13	34	35	18	41	43	26	5	3	3	2	7	1	8	5	7
%	2.8	1.8	1.9	5.0	5.1	2.7	6.1	6.3	3.9	0.7	0.4	0.4	0.3	1.0	0.2	1.2	0.7	1.0
No,	710	709	698	684	687	670	673	681	673	710	709	698	684	687	670	673	681	673

Table 12. Women's consumption of eggs in the previous 7 days and 24 hours by treatment arm, Ethiopia

	Consumed egg in 7-day FFQ•									Consumed egg in 24-hour recall								
	Baseline			Midline			Endline			Baseline			Midline			Endline		
	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control	ACGG	ACGG+ ATONU	Control
No,	122	160	128	184	211	123	238	278	148	23	44	31	46	66	29	83	98	52
%	17.2	22.6	18.3	26.9	30.7	18.4	35.4	40.8	22.0	3.2	6.2	4.4	6.7	9.6	4.3	12.3	14.4	7.7
No,	710	709	698	684	687	670	673	681	673	710	709	698	684	687	670	673	681	673

•FFQ=Food Frequency Questionnaire.

Chicken meat and egg consumed in Tanzania

The Agriculture to Nutrition (ATONU) is trying to improve nutrition outcomes through optimized agricultural investments project sought to break the intergenerational cycle of undernutrition and answer the question of what agriculture can do to deliver positive nutrition outcomes through tailored NSIs targeting women of childbearing age and children in the first 1,000 days of life, that is, from conception to two years. ATONU has developed frameworks to select and provide technical support to agricultural projects for integrating NSIs, identifying, selecting, and implementing NSIs and evaluating their impact. The project's approach was to work with existing agriculture development projects to select and implement tailor made interventions, evaluate their impact, and provide evidence of what agriculture can do to deliver positive nutrition outcomes. ATONU selected the ACGG project, which was implemented by ILRI in several African countries, including Ethiopia and Tanzania. The ACGG project's aim was to improve the production and productivity of chickens kept by smallholder households by introducing and testing the performance of improved and tropically adapted genotypes. Although ACGG was implemented in five zones, ATONU interventions were implemented in three zones of Tanzania, namely eastern, central and southern highlands. The following interventions were selected and overlaid onto the ACGG project and delivered as a package to participating households:

- Social and behavioural changes communication (SBCC) on nutrition education and hygiene to increase eggs and chicken meat consumed.
- SBCC to increase expenditure on nutritious food through income generated from sale of eggs and chicken.
- SBCC to empower women to influence changes in women's time use and participation in decision-making within the household.
- Promoting home gardens to increase vegetable production for improving dietary diversity.

This study hypothesized that both ACGG and ATONU can improve women's and children's diets via the following three pathways: food production for own consumption, increased income expenditure on additional nutrient dense foods, and women's empowerment, all working in concert. Specifically, ACGG could increase chicken meat and eggs produced, which would increase access to these products for household consumption. These products could also be marketed, providing a source of income that could be used in part for improving diets. ACGG's efforts to target women could also lead to greater engagement and participation by women in household decision-making on chicken production and marketing, which could, in turn, empower them and improve their status within the household. The SBCC on nutrition education and hygiene could encourage household consumption of chicken products and other nutrient dense foods, especially by women and children. SBCC on household budgeting could encourage use of income from chicken production, specifically for the purchase of other foods that could not be produced by the household but provide nutrients that would be missing in the household diet.

Interventions addressing gender dynamics within the household could further empower women in chicken production and other aspects of household life. Household members' adoption of appropriate WaSH behaviours could decrease harmful exposure to poultry droppings, thereby decreasing morbidity among children and improving

food and nutrient use. Given that chicken products provide a good source of animal protein and essential amino acids and micronutrients, it was expected that infants and young children would have better growth, women would be less likely to be underweight, and both women and children would have a reduced risk of anaemia.

Chicken meat consumed in Tanzanian ACGG+ATONU project

Chicken meat consumed was higher at baseline than at endline (Table 13). At baseline, the mean number of chickens consumed per year ranged from 20 to 22 chickens in all treatment arms and zones. At endline, the mean number of chickens consumed was 18 (95% CI, 15.00–20.98) for ACGG+ATONU treatment arm; 20 (95% CI, 15.58–23.96) for ACGG; and 13 (95% CI, 9.69–16.78) for the control treatment arm. The extent of reduction of the number of chickens consumed per year was 7, 3 and 4 in the control, ACGG and ACGG+ATONU treatment arms, respectively. Similarly, the reduction was 6, 4 and 2 for the central, southern highlands and eastern zones, respectively.

Table 13. Household consumed chicken per annum at baseline and endline, Tanzania

	Baseline				Endline			
Treatment/zone	No,	Mean	SE	95% CI	No,	Mean	SE	95% CI
Control	458	20.04	1.31	17.43–22.65	386	13.23	1.77	9.69–16.78
ACGG	453	22.48	1.77	18.94–26.02	446	19.77	2.09	15.58–23.96
ACGG+ATONU	481	21.9	2.09	17.70–26.08	512	17.99	1.49	15.00–20.98
Zone								
Central	564	20.04	1.55	16.94–23.13	562	14.44	0.68	13.09–15.79
Eastern	287	20.15	1.33	17.49–22.80	240	18.45	2.42	13.61–23.30
Southern highlands	541	23.68	1.88	19.92–27.44	542	19.54	2.22	15.10–23.98

D–I–D analysis of consumed chicken, Tanzania

To assess the effect of the treatment arms on change in household chicken consumption from baseline to endline, D–I–D analysis was performed using linear mixed model. Results of the fitted model are presented in Table 14 (local chickens) and Table 15 (improved chickens). The analysis was adjusted for zone and endline household wealth index. For local chickens, the results revealed that consumption increased from baseline to endline. The magnitude of the D–I–D coefficient for ACGG+ATONU vs control treatment arms was 1.1929, with p-value of 0.0473. This means that the change in local chicken consumption from baseline to endline was significantly higher in ACGG+ATONU than in the control treatment arm. However, no significant difference was observed for ACGG only compared to control treatment arm (β=1.1489, p=0.0595) and ACGG+ATONU as compared to ACGG only (β=0.04400, p=0.9407).

Table 14. Parameter estimates of the adjusted linear mixed model for D–I–D analysis of local chicken consumption, Tanzania

Effect	Estimate	Standard error	P-value
Intercept	2.5215	0.3924	< 0.0001
Time			
Endline	0.5741	0.4379	0.19
Baseline	Reference		
Treatment			
ACGG	–0.4452	0.4129	0.2811
ACGG+ATONU	–0.5047	0.4065	0.2145
Control	Reference		
Time*treatment			0.0853
Time*ACGG	1.1489	0.6093	0.0595
Time*ACGG+ATONU	1.1929	0.6011	0.0473
Agro-ecological zone			0.0028
Central	0.5157	0.2741	0.06
Eastern	1.1553	0.3395	0.0007
Southern highlands	Reference		
Endline wealth index			<0.0001
Lowest	Reference		
Second	0.5326	0.3928	0.1753
Middle	0.7423	0.3972	0.0618
Fourth	1.2249	0.3997	0.0022
Highest	2.2261	0.4001	<0.0001
D–I–D coefficients			
Effect	Estimate	Standard error	P-value
ACGG vs control	1.1489	0.6093	0.0595
ACGG+ATONU vs control	1.1929	0.6011	0.0473
ACGG+ATONU vs ACGG	0.04400	0.5911	0.9407

Table 15. Parameter estimates of the adjusted linear mixed model for D–I–D analysis of improved chickens' consumption, Tanzania

Effect	Estimate	Standard error	P-value
Intercept	0.02877	0.2023	0.8874
Time			
Endline	3.5778	0.3932	<0.0001
Baseline	Reference		
Treatment			
ACGG	0.004499	0.1945	0.9815
ACGG+ATONU	0.02961	0.1915	0.8771
Control	Reference		
Time*treatment			0.0225
Time*ACGG	0.9125	0.4702	0.0525
Time*ACGG+ATONU	1.2863	0.4663	0.0059
Agro-ecological zone			0.0718
Central	–0.1402	0.1578	0.3743
Eastern	0.2854	0.1894	0.132
Southern highlands	Reference		
Endline wealth index			0.0329
Lowest	Reference		
Second	0.006073	0.2214	0.9781
Middle	0.2681	0.2203	0.2238
Fourth	0.2817	0.2208	0.2021
Highest	0.5942	0.2186	0.0066
D–I–D coefficients			
Effect	Estimate	Standard error	P value
ACGG vs control	0.9125	0.4702	0.0525
ACGG+ATONU vs control	1.2863	0.4663	0.0059
ACGG+ATONU vs ACGG	0.3738	0.3612	0.3008

For improved chicken, the results of the adjusted linear mixed model presented in Table 15 showed that the number of improved chickens consumed was also higher in endline as compared to baseline. In addition, the change for improved chicken consumption was significantly higher among subjects in ACGG+ATONU (β=1.2863, p=0.0059) and ACGG only (β=0.9125, p=0.0525) in comparison to subjects in control arms. But no significant difference in change for improved chicken consumption was observed between ACGG+ATONU and ACGG only (β=0.3738, p=0.3008).

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