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Assessing the Impact of Post- Production Infrastructure on Women's Economic Empowerment and Access to Nutritious Diet Among Female Groundnut Growers and Processors in Northern Ghana

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About the report

ICED has approved the final version of the report titled “Impact of Road Infrastructure on Household Nutrition, Women’s Empowerment and Gender Equality in Rural Nigeria,” as part of the Grant Agreement INV-035360 (Prime Agreement) awarded to the International Centre for Evaluation and Development (ICED) to support the project “Infrastructure’s Impacts on Nutritious Diet, Women’s Empowerment, and Gender Equality (IINDWEGE).” The report is deemed technically sound, and ICED will publicly release this final version of the report in its received form, with no further modifications made.

Assessing the Impact of Post-Production Infrastructure on Women's Economic Empowerment and Access to Nutritious Diet Among Female Groundnut Growers and Processors in Northern Ghana

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Summary

There remains insufficient knowledge about the contribution of processing infrastructure (post-production infrastructure) on women's nutritional and empowerment outcomes. This study aims to fill this dearth in the literature by focusing on the impact of processing infrastructure on women's access to and consumption of nutritious diets, and to their economic empowerment.

The study employed a concurrent mixed-method design involving the collection and analysis of both quantitative and qualitative data. Quantitative data were collected from a random sample of 850 women (and 801 men) across the Northern, North-East, Upper West, and Savannah Regions of Ghana. Women's empowerment was measured using the project level women empowerment in agriculture index (pro-WEAI) tool. Qualitative data were gathered from purposively selected participants using key informant interviews, focus group discussions and in-depth interviews. The doubly robust inverse probability weighting regression adjustment was applied to estimate the average treatment effects using Stata. A thematic analysis approach was used in analyzing the qualitative data with the aid of NVivo.

Findings indicate that access to improved groundnut processing infrastructure remains low. The pro-WEAI results show that less than half (48.5%) of the women were empowered relative to the men in their households. The overall Gender Parity Index (GPI) was 0.92. In households where gender parity was not present, the average empowerment gap between women and men was 19%. The qualitative evidence points to the perceived impact of processing infrastructure on women's economic empowerment in several domains including the ability to earn an income, save, invest in children's education, asset acquisition, free mobility, social recognition, group membership and general economic wellbeing. The average dietary diversity score for women (aged 15-49 years) was 4.5 and that of households was 5.9. Only 45.2% of the women achieved the minimum dietary diversity for micronutrient adequacy. The treatment effects show that women who specialize in the processing of groundnuts are more likely to be empowered relative to primary producers. Groundnut processing is found to significantly improve access to, and intake of diverse diets at individual and household levels. Among the processing facilities considered, access to groundnut shelling and grinding machines was found to have significant potential in promoting women's economic empowerment. While the quantitative results show no significant direct effects of processing infrastructure on dietary outcomes, the qualitative results show both direct and indirect impacts of processing infrastructure on access to and consumption of nutritious diets.

These findings have several implications for policy and programming. Access to processing infrastructure for women groundnut processors is both a means of household food security and a poverty reduction strategy. Thus, agricultural, and rural development policies that support both groundnut production and processing must be ...to optimize women's economic empowerment outcomes. Such policies should recognize that groundnut processing and related micro-enterprises have an important role in increasing income from processing activities and strengthening their capabilities to become economically independent.

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Abbreviations and Acronyms

AEAs	Agriculture Extension Agents
AFPP	Artisanal Fish Processing and Applied Research Project
AGM	Active Group Membership
ATE	Average Treatment Effect
ATET	Average Treatment Effects on the Treated
CEDAW	Convention on the Elimination of All Forms of Discrimination against Women
CI	Conditional Independence
COVID-19	Corona Virus Disease of 2019
CSW	Commission on the Status of Women
DAHH	Dual-Adult Households
DDS	Dietary Diversity Scores
DE	Domain Empowerment
EAs	Enumeration Areas
ETE	Endogenous Treatment Effect
FAHH	Female-Adult-only Households
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FHI	Family Health International
GCA	Ghana Census of Agriculture
GDP	Gross Domestic Product
GLSS	Ghana Living Standards Survey
GPI	Gender Parity Index
HDDS	Household Dietary Diversity Score
ICD	International Cooperation and Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information, Communications and Technology
IDI	In-Depth Interviews
ILO	International Labour Organization
IPWRA	Inverse Probability Weighting and Regression Adjustment
KII	Key Informant Interviews
KNUST	Kwame Nkrumah University of Science and Technology
MDD-W	Minimum Dietary Diversity for Women
MGCSP	Ministry of Gender, Children and Social Protection
MOFA	Ministry of Food and Agriculture
MT	Metric Tons
NCDs	Non-Communicable Diseases
NDA	Northern Development Authority
OECD	Organization for Economic Cooperation and Development
PSM	Propensity Score Matching
PSU	Primary Sampling Unit
RCTs	Randomized Controlled Trials
SD	Standard Deviation
SDG	Sustainable Development Goal
SSU	Secondary Sampling Unit
TZ	Tuo Zaafi
UN	United Nations
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNIFEM	United Nations Development Fund for Women

USAID	United States Agency for International Development
VSLA	Village Savings and Loans Association
WDDS	Women's Dietary Diversity Score
WEAI	Women's Empowerment in Agriculture Index
WEE	Women's Economic Empowerment
WEPs	Women's Empowerment Principles
WIAD	Women in Agricultural Development
WHO	World Health Organization

1. Introduction

Post-production infrastructure is crucial for agriculture, as it affects and controls? the agricultural value chain. It plays a strategic role in producing huge multiplier effects in agriculture (Satish, 2007; Mellor, 1976 in Goswami and Chatterjee, 2009; Axèle and Huaman, 2019). To a large extent, the availability, affordability, of what? and food security in general in a particular country largely depends on the level of development of its post-production infrastructure. Farmers' livelihood outcomes and living standards are much linked to the type of processing facilities, storage facilities and market centres they have access to. It? determines the size/acreage of land they could cultivate, their ability to process, and ultimately, the profit they receive. Nonetheless, a key impediment in Africa continues to be agricultural infrastructure deficit (Mazibuko, et al., 2020).

The United Nations (UN) Food and Agriculture Organization (FAO), estimates that almost half (45%) of the global population (about 3.1 billion people) live in rural areas. Out of this, 2.5 billion depend on agriculture for their livelihoods. A quarter of the world's population is women, living in rural areas. It could therefore be deduced that 1.73 billion women live in rural areas and that for 1.4 billion of these women, agriculture is their primary livelihood (Glazebrook et al., 2020). Rural women contribute substantially to the Ghanaian food and nutrition basket and their agricultural productivity/output is central to meeting food security. The productivity of these women is, however, hampered by limited access to the post-production agricultural infrastructure.

Post-production infrastructures encompass facilities that are used for storing, processing, and marketing of products as well as facilities that are used to ensure the supply of healthy foods in safe environments. These include markets, warehouses and sheds, cold storage facilities, slaughterhouses, processing facilities, fish landing sites, livestock vaccination parks, and sanitary facilities. Processing facilities, storage facilities and market centers have been shown to lead to agricultural expansion by increasing profitability. Without a doubt, the type and level of development of processing facilities, storage facilities and market centers in place determine agricultural growth, economic outcomes, gender equality? and nutrition benefits that reduce poverty (Satish, 2007; Goswami and Chatterjee, 2009). It is posited that about 15 per cent of crop production is lost between the farm gate and the consumer because of poor roads, lack of market networks, warehouses, and inappropriate storage facilities alone (Satish, 2007). The improvement of processing facilities, storage facilities and market centers help to enhance greater access to other factors of production. More importantly, female labour participation rate increases as traditional taboos and entrenched cultural norms that re-emphasize structural inequalities are overcome. In most developing countries including Ghana, the agricultural sector is an important source of employment, poverty reduction and food security and these outcomes have been posited to be critically influenced by the presence of processing facilities, storage facilities and market centres (OECD, 2011).

Due to the all-important role that women play in agriculture, neglecting gender issues in post-production agriculture infrastructure would be costly, both socially and economically. Strengthening women's roles in agriculture has the potential to close the gender gap by ensuring gender equality in access to and control over productive resources while increasing output to improve access to affordable nutrition (Axèle and Huaman, 2019). According to data from the United Nations Development Fund for Women (2014), women perform 66% of the world's work, and produce 50% of the food, yet earn only 10% of the income and own 1% of the property hence empowering women is a critical part of the development equation. Investments in gender equality yield the highest returns of all development investments because women are noted to invest a higher proportion of their earnings in their families and communities (Zambian Governance Foundation, 2010).

Economic empowerment is conceptualized in this research to mean the capacity of women and men to participate in, contribute to and benefit from growth processes in ways which recognize the value of their contributions, respect their dignity, and make it possible to benefit fairly from development efforts.

Women's economic empowerment increases women's access to economic resources and opportunities including jobs, financial services, property and other productive assets, skills development, and market information (OECD, 2011). Women's economic participation is fundamental to strengthening women's rights and enabling them to have control over their lives and exert influence in society. The multiple discrimination and persistent gender inequalities, which most women experience due to financial dependence impede their growth and make their economic empowerment non-negotiable (OECD, 2011).

Investing in women's agriculture would embrace systemic interventions including gender-inclusive post-production infrastructure (Glazebrook et al., 2020). Achieving women's economic empowerment and access to good and affordable nutrition would not be a "quick fix". It requires a painstaking holistic approach and long-term commitment from all development actors including integrating gender-specific perspectives at the design stage of policies, including the provision of processing facilities, storage facilities and market centres. With the existence and proper functioning of processing facilities, storage facilities and marketing centres, and supportive social and cultural norms and practices, female farmers are expected to earn more income, households are projected to have more surplus food stock after selling their produce, most households would have access to affordable nutritious diets and women would be independent enough to participate in decision-making processes that affect them (OECD, 2011; Mazibuko, et al., 2020). It is essential to find out whether these outcomes from the existence and functioning of agricultural infrastructure are evident or otherwise in the Ghanaian context since very limited research has been done in this area. This innovative and cross-cutting research into the specific impacts that processing facilities, storage facilities and marketing centres have on women's economic empowerment and access to affordable nutritious diet is therefore essential for policymakers, donors, and development implementers, hence the need for this study.

1.2 Problem Statement

This project seeks to investigate the extent to which processing infrastructure contributes to improved access to nutritious diets and economic empowerment of women engaged in groundnut processing in Northern Ghana. The rationale for the focus on groundnut, among several leguminous crops grown in Ghana, is motivated by its immense nutritional benefits as well as its contribution to income, employment, and overall livelihoods of producers, traders, processors, and other actors along the supply chain, especially women.

Groundnut constitutes a key ingredient in local diets across Ghana. The nut is predominantly grown and processed by women-led informal micro or small-scale enterprises into a range of products including paste (or peanut butter), and high-quality cooking oil suitable for soup and stew. Other groundnut-based processed products are weaning foods, and snacks such as roasted groundnuts, boiled groundnuts, *kulikuli* (a fried cake made from defatted groundnut paste), *nkatie* burger (coated peanuts), *zowey* (spicy balls from peanut flour), and crispy bars. Groundnut is dense in vital nutrients – fat, fibre, protein, and zinc – that boost the immune system as well as aid physical and cognitive development, especially of children. For instance, studies on its nutrient composition documented that groundnut is dense in proteins (17–25.2%), edible oils (46–52%), as well as in carbohydrates (20%) (Bonku and Yu, 2020; Prathiba and Reddy, 1994). This makes it an indispensable crop for nutrition and food security, and it has been promoted by nutritionists as a good supplement to animal protein, especially for nutritionally vulnerable groups like women and children (Angelucci et al., 2013).

Beyond its important dietary role, peanuts production and processing constitute a major source of income and employment for farmers and workers across the value chain. In Ghana, 85–94% of groundnut production takes place in Northern Ghana, predominantly by smallholder farmers (International Cooperation and Development (ICD), 2020; Angelucci et al., 2013). In 2017, the annual production (with shell) was around 420,000 MT, or 201,000 MT of shelled groundnuts (European Commission, 2020). Women, who form most workers, are primarily involved in the cultivation, marketing, and processing of groundnuts (Ibrahim, 2017; Owusu-Adjei e al., 2017). Processing in the North is predominantly artisanal or informal, involving many small-scale processors (in cottage industries) using locally fabricated processing facilities such as shellers

or decorticators, roasters, and mills/grinders. Formal, large-scale processing facilities (factories) are largely located in the South, where commercial processing of groundnut into paste, edible oils, snacks, and other products occurs for domestic and external markets (ICD, 2020).

Post-production handling of agricultural products entails a series of operations before they reach the final consumer. These include harvesting, shelling, threshing, winnowing, cleaning, drying, bagging, transportation, and processing. For groundnuts in particular, further processing involves roasting, milling/grinding, and oil extraction, among others. Inappropriate handling at any stage can render the peanut products unwholesome, thereby increasing the anti-nutritional component and reducing the market value. Adequate processing infrastructure is, therefore, critical for ensuring food and nutrition security, and agricultural development. Access to processing infrastructure fosters value addition by enabling the conversion of raw agricultural commodities – through primary, secondary, or tertiary processing – into semi-finished or finished products that have a higher market value and/or lengthier shelf-life (Lin and Chang, 2020). Value addition confers several benefits on farmers, processors, consumers, and other value chain actors, especially women, in the form of increased production, income (profitability), employment creation, improved food safety and better food and nutrition security (Warner et al., 2008). Processing facilities can also promote women's economic empowerment by enhancing women's autonomy, and participation in economic activities and decisions (O'Brien et al., 2022). Women's economic empowerment and access to affordable nutrition are a prerequisite for pro-poor growth and achievement of several Sustainable Development Goals (SDGs)- 2, 3 and 5¹.

Despite these potential gains, women continue to face several constraints in participating in and benefiting from agro-processing value chains, including limited access to finance, modern technologies, and other productive resources, as well as gender norms that curtail women's ability to participate in economic activities. Several studies have documented significant effects of irrigation and other production infrastructure on improved nutrition, women empowerment, and overall welfare (Okyere et al., 2021; Passarelli et al. 2018; Bryan and Garner 2022; Shively and Thapa, 2016). For instance, Passarelli et al. (2018) showed that small-scale irrigation contributed to improved diets in Ethiopia (but not in Tanzania). Concerning women's empowerment, Bryan and Garner (2022) reported that several women benefit from participating in irrigated farming activities leading to an increase in their agency and well-being achievements. Okyere et al. (2021) demonstrated that irrigation is associated with health outcomes, that also contribute to women's empowerment. Shively and Thapa (2016) also showed that transportation infrastructure (roads and bridges) is important for mitigating the nutritional risks of high price volatility in Nepal's rice and wheat markets.

While evidence abounds when it comes to the effect of agricultural production on women's empowerment, not much is known about the contribution of processing facilities (post-production infrastructure) on women's nutritional and empowerment outcomes, especially in Ghana. This study aims to fill this dearth in the literature and provide robust evidence to inform nutrition-sensitive and gender-inclusive infrastructural development interventions.

1.3. Objectives

The overall objective of this research project is to investigate the impact and the related pathways between post-production infrastructure on women's diets and economic empowerment. With a focus on groundnuts, this research aims to:

1. Analyze the level of development of processing facilities along the legume value chain in northern Ghana.

¹ End hunger, achieve food security and improved nutrition, and promote sustainable agriculture), number three (ensure healthy lives and promote well-being for all at all ages) and number five (achieve gender equality and empower all women and girls

2. Assess the impact of processing facilities on women's economic empowerment and access to and consumption of nutritious diets.
3. Investigate whether some types of processing infrastructure are more conducive for nutritious diets and women's empowerment.
4. Identify the pathways through which processing facilities contribute to improvements in women's economic empowerment.
5. Offer policy recommendations to promote gender-inclusive agricultural infrastructural development in Ghana.

2. Literature Review

2.1 The Concept of Empowerment and Women's Economic Empowerment

While societal needs and the world of work are changing, structural barriers to gender equality and gender-based discrimination persist in and across countries. This has been evident in gender gaps in labour force participation and pay, occupational segregation, unequal working conditions, and women's burden of unpaid household and care work that characterizes the informal sector (Zakuan and Hassan, 2016; CSW, 2017). This makes women's empowerment a critical goal in achieving sustainable development worldwide (Huis et al., 2017).

Purnamawati and Utama (2019) posit that women's empowerment in recent times has attracted the attention of researchers, industry players and governments. Empowering women has also been explained by UNIDO (2019) to mean empowering humanity. Gender equality is not only a matter of human rights, but also a precondition for economic growth and sustainable development which are necessary for poverty reduction and social inclusion. When women are empowered, economies grow faster, more people are taken out of poverty and household wellbeing is improved. The International Monetary Fund (in UNIDO, 2019) also states that gender equality could be equated to "smart economics" because it can enhance economic efficiency.

Empowering women to fully participate in economic life across all sectors is essential for building stronger economies, achieving internationally agreed goals for development and sustainability, and improving the quality of life for women, men, households, and communities (UNIFEM, 2011; OECD 2014). To guarantee women's empowerment, there is the need to intentionally ensure the inclusion of women's talents, skills, experience and energy through local and international actions and policies (UNIFEM, 2011). Hunt and Samman, (2016) argue that the processes of empowerment necessitate complex and multi-layered solutions. Mondelēz International (2018) strongly argues that women's empowerment is one of the most persistent social processes characterized by challenges and opportunities. Consequentially, women are currently gaining prominence in the labour markets and earning incomes that used to be unimaginable a couple of decades ago.

Notwithstanding, gender equality processes are generally not given intentional support and the status as women still pose a significant barrier? in certain economic, social, and political contexts. Barriers imposed by society and women themselves- not a full sentence. As a result, some women pressurize themselves to fall in line with social roles and expectations. Lohani and Aburaida, (2017) therefore? argue that women's empowerment remains one of the most effective tools for ensuring gender equality and women's financial independence. They further posit that the sustainable path to development could be achieved by providing the same opportunities to women and men in decision-making in all activities to ensure that their various interests are intentionally taken into consideration in resource allocation. The United Nations Women's Empowerment Principles (WEPs) spells out seven principles, namely? endorsed by more than 2,600

companies globally, to include the enforcement of zero-tolerance policies for gender inequality and discrimination in the world of work (UNIFEM, 2011; Young, 2019).

Women's Empowerment Efforts in Ghana

The government of Ghana has formulated plans and policies to promote women's participation in decision-making to reduce gender disparities in decision-making (why are you not citing GOG itself, but using a secondary source? Mondelēz International, 2018). Also, strategic actions such as? have been outlined at the regional, sub-regional and national levels with the government as the principal actor responsible for the empowerment of women. In Ghana, women have the legal right to equal place with men in decision-making at the household, community, and national levels, including parliament and executive councils. The reality is however far from straightforward as there is a wide gap between theory and practice.

Government after government in Ghana have pledged key commitments to ensuring gender equality and women's empowerment. In addition, the government of Ghana adopted various legislations, conventions, and policies to correct the existing seemingly 'unbalanced' gender division of labour. Ghana is a signatory to gender-based international protocols comprising the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the Beijing Platform for Action (Addo, 2012). According to the 2012 World Development Report (in MGCSP, 2015), gender equality is a core development objective. Greater equality can improve productivity, increase development, and make institutions more representative. Ghana in conformity with world standards has therefore committed herself to putting in place several drivers to facilitate the women's empowerment agenda which is critical to the attainment of sustainable national development and to a large extent, the Sustainable Development Goals (MGCSP, 2015).

The Women and Children's Affairs Ministry, now the Ministry of Women, Children and Social Protection was created in 2001 through an Executive Instrument (EI 8). The Ministry's core mandate is to initiate, coordinate and formulate policies. Also, it executes, monitors, and evaluates policies to promote gender equality, women's empowerment, and child development in all aspects (Addo, 2012). More importantly, the 1992 Constitution of Ghana makes provisions for gender equality. Article 17(1) and (2) of the 1992 Constitution guarantees gender equality and freedom of women and men, girls and boys from discrimination based on social or economic status (MGCSP, 2015). In addition to Ghana's commitment to the Millennium and Sustainable Development Goals, Ghana's national development frameworks and other international conventions and protocols on gender, the country in 2015 promulgated the National Gender Policy. The overall goal of the Policy is: *"to mainstream gender equality concerns into the national development processes by improving the social, legal, civic, political, economic and socio-cultural conditions of the people of Ghana particularly women, girls, children, the vulnerable and people with special needs; persons with disability and the marginalized"* (MGCSP, 2015: vii).

In Ghana, there is currently a gradual decline of patriarchal authority, in different cultural and geographical contexts, in both rural and urban localities, with women in southern Ghana especially having relatively high conjugal autonomy and high levels of economic activity (Oppong, 2005) and in northern Ghana. A related study by Wrigley-Asante (2011) further points out that women's socio-economic status is changing due to governmental and non-governmental interventions. As a result, they (women) are able to economically contribute more to their homes, become less vulnerable and also enhance their participation in decision-making processes statistics on women's representation in decision-making structures – e.g., Parliament, district assemblies etc.

Although the various national and international efforts in ensuring women's empowerment have made significant progress through policy prescriptions, situations on the ground are different. Gender inequality remains, especially the marginalization of women in many areas including access to and control over productive resources, the right to education and participation in decision-making (Parliament of Ghana,

2009- we are in 2023- bring it up to speed).

Processing Infrastructure and Women's Economic Empowerment

Infrastructure plays a critical role across the agriculture value chain while processing infrastructure promotes economic development and improves the quality of life in many ways (Satish, 2007). In ways that infrastructure does not? This is not clear. Increasing the capacity of women by giving them access to resources like processing infrastructure not only reduces the time they spend on their work but also increases their income (Zakuan and Hassan, 2016; Purnamawati and Utama, 2019). Achieving WEE and ensuring women's access to decent work is essential for the effective and accelerated implementation of the Beijing Declaration and Platform for Action and the 2030 Agenda for Sustainable Development (CSW, 2017). The world of work is currently changing, with significant innovative ways of doing things. This, therefore, requires transformative and structural changes, including easy access to processing infrastructure that could assist women. The persistent inequality in the gender division of labour further necessitates enhanced interventions to save women time and energy (CSW, 2017).

Innovative interventions in the world of work like processing infrastructure have the potential to increase/strengthen the capacity of women, enhance their opportunities and improve their personal security which would help alleviate/reduce household poverty. Indeed, labor-saving technologies and affordable and reliable care facilities are necessary for women to benefit from and contribute to economic growth. Women's access to processing infrastructure within the agricultural value chain improves their output and is likely to be critical to their economic empowerment (Kabeer, 2009). The agricultural sector has been an essential source of economic growth, employment, poverty reduction and food security. Due to women's critical role along the agricultural value chain, neglecting gender issues in agriculture is often costly, both socially and economically. Strengthening the role of women in agriculture by improving access to processing infrastructure could boost income, close the gender gap, and ensure gender equality (Giroud and Huaman, 2019).

Processing activities involve post-harvest activities that result in the transformation, preservation, and preparation of agricultural produce for intermediary or final consumption (Woldemichael et al., 2017). Legumes in general and groundnuts to be specific are one of the agricultural produces that requires processing before it reaches the final consumer. The nature of groundnuts is also such that, the more processed it is, the more expensive it becomes, and therefore the more income to the farmer or processor. The presence of processing infrastructure is therefore likely to inadvertently bring additional income to farmers and processors while reducing workload and time spent. Studies have further shown that because of their forward and backward linkages, agro-processing has higher multiplier effects in terms of the provision of jobs and value addition for extra income (Woldemichael et al. 2017; Dokurugu, 2015). This draws a direct link between processing infrastructure and women's economic empowerment.

Groundnut is traditionally regarded as a "women's crop" in Ghana and as such, its value chain is dominated by women (Dokurugu, 2015). The presence and improvement in groundnut processing facilities in rural and urban communities would consequentially mean improvement in the lives of most women. Groundnut processing is also important for several reasons, including helping to reduce post-harvest losses, reducing aflatoxin contamination, improving nutrition, and increasing the income of farmers and processors, promoting employment generation, and contributing to enterprise development and diversifying of rural economies (Owoo and Lambon-Quayefio, 2017). Agro-processing infrastructure serves as a women's – only economic empowerment pathway because the time and energy required to process groundnut in addition to their ability to take care of themselves and family is reduced. In essence, groundnut processing facilities are time and labor-saving technologies that can enable women to engage in income-paying activities in addition to their traditionally assigned unpaid care work (Dokurugu, 2015).

Processing infrastructure is further noted to enhance women's ability to overcome the challenges around the

world in pursuing better-paid, productive jobs, and in accumulating assets. Indeed, infrastructural projects have the potential of increasing women's economic earnings and contribute to international and national efforts to promote gender equality (Adetola, 2022). There is therefore the need for governments to invest in gender-responsive public services and time-saving agricultural technologies, such as simple processing infrastructure for groundnut processing like threshers, millers, roasters, and oil extractors (ActionAid, 2018).

2.2 Processing Infrastructure and Access to Nutritious Diets

The Concept of Nutritious Diets

The importance of consuming nutritious diets underpins the popular proverbial phrase "*you are what you eat*", which implies that to be fit and healthy you need to eat high-quality foods. The concept of nutritious diets is central to achieving food security, which "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (1996 World Food Summit, cited in Food and Agriculture Organization, 2008). The United Nations Children's Fund (UNICEF) also identified good diets, driven by adequate food (age-appropriate, nutrient-rich foods) and dietary practices, as an intermediate determinant of maternal and child nutrition (UNICEF, 2021).

Nutritious diets are synonymous with healthy or balanced diets². While there is no universal definition or metric of what constitutes a healthy diet, there is a consensus that high-quality diets should contain a wide variety of foods that provide optimal quantities of macronutrients and vital micronutrients that meet the body's needs to properly function (Global Panel, 2016). Macronutrients, which include carbohydrates, protein, and fats, primarily provide the human body with energy (or *calories*). The body requires them in relatively large (macro) amounts to support different mechanisms or processes in its functioning, including the maintenance and repair of tissue (Davis and Serrano, 2016). Micronutrients, including vitamins and minerals, are needed in minute amounts to assist with an array of other essential activities within the body. Depending on the actual micronutrient, these added functions include controlling the chemical processes that occur in the body; supporting the absorption and utilization of macronutrients; and helping in the formation and maintenance of bones, teeth, muscles, and blood (Davis and Serrano, 2016).

Given that no single nutrient can meet all the body's needs, eating a variety of foods daily and over time ensures the intake of a well-balanced portfolio of nutrients. Low-quality diets (which contain insufficient calories, vitamins and minerals or contain too many calories, saturated fats, salt and sugar) can lead to different forms of malnutrition, namely, overnutrition (overweight/obesity), undernutrition (i.e., stunting, underweight and wasting) and hidden hunger (micronutrient deficiencies) (FAO, 1995). Malnutrition, in turn, can have dire effects on individuals as well as society, some of which are irreversible.

Just to mention a few, poor diets undermine the human immune system and lead to increased risk of several diet-related non-communicable diseases (NCDs), including diabetes, cardiovascular ailments, cancer, stroke, and hypertension. Inadequate vitamin C can result in scurvy; vitamin A deficiency is a major cause of child blindness and increases the risk of child and maternal mortality. Iodine deficiency retards physical growth and mental development and constitutes a risk factor for goiter and anemia. Calcium deficiency can result in osteoporosis, a disease that thins and weakens the bones. Several studies have shown that poor diets and nutrition can have life-long adverse effects on individuals (e.g., sub-optimal cognitive development, ill-

² See the Global Panel's 2016 Foresight report for an overview of different criteria that are used to characterize high-quality diets (Global Panel, 2017). For instance, the World Health Organization's (WHO) definition of a healthy diet emphasizes the importance of starting healthy eating habits in early life (notably through breastfeeding) and limiting the intake of free sugars and salt. It advises people to eat plenty of fruits and vegetables, wholegrains, fiber, nuts and seeds, while limiting free sugars, sugary snacks and beverages, processed meats and salt, and replacing saturated and industrial trans fats with unsaturated fats (WHO, 2015).

health, impaired physical growth, and reduced earning potential) and national development by significantly hampering productivity and inclusive growth (World Bank, 2006; Black et al., 2008; Hoddinott, 2016).

Access to nutritious diets and the role of agro-processing facilities

The afore reiterates that regular access to nutritious diets is critical to human well-being. While an adequate supply of nutritious foods may be available at the local, national, or international level, it does not guarantee that individuals or households would always have access to them for a healthy and productive life. Therefore, *to eliminate hunger, and achieve food security and improved nutrition*, as targeted under the second Sustainable Development Goal (SDG 2), nutritious foods must be consistently affordable and accessible to people. According to the FAO (2006), food accessibility can be described as “access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet”. Relatedly, the United States Agency for International Development (USAID, 1992) noted that food access prevails “when individuals have adequate incomes or other resources to purchase or barter to obtain levels of appropriate foods needed to maintain consumption of an adequate diet or nutrition level”. In other words, access is guaranteed when all individuals or households have enough productive or financial resources to acquire food in adequate quantity, quality, and diversity for a nutritious diet always. It includes their income, expenditure and buying capacity.

Access to nutritious diets covers both economic and physical dimensions (FAO, 2008). From an economic standpoint, food access can be enhanced or constrained by households’ disposable incomes and market prices. Individuals or households who have adequate incomes have the higher purchasing power to access nutritious foods in the marketplace. In the same vein, inflation in consumer prices makes nutritious foods costlier and unaffordable by eroding real incomes, thereby limiting access to sufficient nutritious diets. Economic access also relates to poverty, inequality, unemployment, transaction costs, and other factors that affect the purchasing capacity of individuals or households. As underscored in the *State of Food Security and Nutrition in the World 2022*, the high cost of healthy diets and persistently high levels of poverty and income inequality continue to limit food access and exacerbate undernutrition across the world (FAO, 2022). According to recent estimates, the surge in food prices in recent years, in the wake of the COVID-19 pandemic and its containment measures, has rendered healthy diets unaffordable and inaccessible to almost 3.1 billion people across the world in 2020 – an increase of 112 million more people than in 2019 (FAO, 2022).

The physical dimension of food access relates to the spatial accessibility, infrastructure, facilities, and other physical properties of the food environment, which facilitate (or restrict) access to healthy foods. These encompass the distribution, location, and types of market centers, retail outlets; transport infrastructure and connectivity; processing facilities; refrigerated trucks and cold chain storage facilities; warehouses; and sanitary facilities. As extant literature has shown, the availability (and proximity) of physical market centres (including informal food markets and supermarkets) have been shown to ensure food access by fostering consistent availability and intake of diverse nutritious foods in the marketplace from local and international sources (Koppmair et al. 2017; Abay and Hirvonen, 2017; Sibhatu and Qaim, 2018; Headey et al. 2019; Zanello et al., 2019; Bonuedi et al., 2020; Usman et al., 2021; Bonuedi et al., 2022).

Other studies have also shown that access to markets engenders off-farm income-generating activities and credit access, which bolster the purchasing capacity of households, especially those in rural areas (Bonuedi et al., 2022; Handa and Mlay, 2006; Jacoby and Minten, 2009; Schrieder and Heidhues, 1995; Zeller et al., 1997). Furthermore, access to improved transport infrastructure (e.g., feeder roads, highways, bridges, and railways) also reduces transaction costs (including transport costs and travel time) and encourages market participation and agricultural commercialization (Fafchamps and Hill, 2005; Stifel and Minten, 2017); and facilitate the timely delivery of healthy foods to local markets and consumers (Bonuedi et al., 2020; Djankov et. al., 2010). Limited access to physical infrastructure, namely, transportation, water supply and

sanitation, and energy, have been shown to impose significant time constraint on women, who, because of social roles and cultural norms, disproportionately shoulder the burden of household and domestic chores, and spend a significant amount of time travelling (over long distances) for productive activities, to collect firewood or water, and to access health care and other social services (either for themselves or their children) (Agénor and Agénor, 2019, 2023;). Access to improved (i.e., time- and labour-saving) infrastructure has the beneficial effects of increasing productivity, improving women's well-being, and freeing up their time from backbreaking tasks to engage in caregiving and other domestic activities that are positively linked with more diverse diets and improved nutrition (Komatsu et al., 2018; Khan 2018).

The crux of this study is the role of post-production infrastructure, particularly agro-processing facilities, in promoting physical and economic access to nutritious diets. Access to processing facilities promotes agro-processing, which constitutes a critical engine for structural transformation (Owoo and Lambon-Quayefio, 2018) and ensures healthy diets and good nutrition (Jenane et. al., 2022). Agro-processing, enabled by the availability of (and access to) improved processing technologies, has the potential to boost the availability of nutritious foods by transforming perishable agricultural produce into different forms of high-valued processed and semi-processed foods that are safer, more convenient (ready-to-cook or -eat), and have extended shelf-life. In addition, effective agri-food processing facilities can also foster food preservation and nutrient retention and contribute to a reduction in post-harvest losses (through food spoilage and wastage) (Newfarmer et al. 2018; Quartey and Darkwah, 2015). For smallholder farmers and local firms, the presence of agro-processing facilities and technologies can bolster value addition to primary produce, which is strongly associated with higher prices, increased competitiveness, and employment generation (Kubik et. al., 2022; Jenane et. al., 2022; Saha et al., 2021). These, in turn, promote smallholder commercialization and contribute to increased incomes, importantly in rural areas where agriculture is the mainstay (Owoo and Lambon-Quayefio, 2018), and allow the consumption of purchased nutritious diets (Ogutu et. al., 2020).

Empirical literature on the impact of processing infrastructure on access to nutritious diets. Existing literature on infrastructure-nutrition linkages has largely focused on the impacts of markets and transport-related infrastructure on individual and household dietary and nutritional outcomes.

Markets and transport infrastructure

Shively (2017) analyzed the roles of markets, health, and transport infrastructure in protecting children's nutrition against variations in local agriculture productivity and rainfall shocks in Uganda and Nepal. The results showed that greater road density and improved access to health facilities mitigate the sensitivity of children's health and nutritional status to rainfall variability. Stifel and Minten (2017) documented that in north-western Ethiopia, remote households, isolated from markets by poor rural transport connectivity and the resultant transport cost, tend to be food insecure and consume substantially less diverse diets than households residing nearer to the market. This finding is corroborated by other studies in other contexts which documented that proximity to improved transport and market infrastructure does not only improve dietary diversity, food security and child growth but also mitigates their fluctuation across seasons in Sierra Leone (Bonuedi et al. 2022), northern Ethiopia (Abay and Hirvonen, 2017) and Mozambique (Handa and Mlay, 2007).

Production infrastructure (Irrigation)

Another strand of the literature examined the impact of irrigation and other production infrastructure on improved nutrition, women empowerment, and overall welfare (Okyere and Ahene-Codjoe, 2022; Passarelli et al. 2018; Bryan and Garner 2022; Shively and Thapa, 2016). Shively and Thapa (2016) also showed that

transportation infrastructure (roads and bridges) is important for mitigating the nutritional risks of high price volatility in Nepal's rice and wheat markets. In Peru, Del Carpio et al. (2011) exploited the spatial variations in the proximity of households to a set of irrigation rehabilitation projects implemented over a decade to study their effect on poor farmers. Applying the double-differencing technique on data from household surveys and geographic information, the authors reported that the irrigation projects implemented in Peru had a positive impact on poor beneficiary households by providing them with better employment opportunities in larger farms (and not through increased production in their small plots). Passarelli et al. (2018) showed that small-scale irrigation contributed to improved diets in Ethiopia (but not in Tanzania). This finding is corroborated by Ahmed (2022) who documented that irrigation improves diet quality in Ethiopia, particularly, by promoting the production of micronutrient-rich crops such as vegetables and fruits and the adoption of productivity-enhancing inputs. With respect to women's empowerment, Bryan and Garner (2022) reported that several women benefit from participating in irrigated farming activities leading to an increase in their agency and well-being achievements in Upper East Region of Ghana. Okyere and Ahene-Codjoe, (2022) demonstrated that irrigation is associated with improved health outcomes that also contribute to women's empowerment. On the contrary, Bryan and Mekonnen (2023) found that supplying men and women farmers with motor pumps for small-scale irrigation did not increase women's empowerment in Northern Ghana. Instead, the intervention had harmful spillover effects on women that did not gain access to pumps, possibly due to intensified competition or conflict over resources (i.e., both the technologies and water for irrigation).

Information infrastructure

In their literature review on the impact of information, communications, and technology (ICT) infrastructure, Asenso-Okyere and Mekonnen (2012) documented that existing evidence points to significant beneficial effects of access to ICT-based technologies (including mobile phones, farm radio, radio, Internet and optical media, and computer training facilities) on agricultural productivity, practices, and farmer livelihoods in Africa. Using data from rural Uganda, Sekabira and Qaim (2017) found that mobile phone use is significantly associated with higher household income, women empowerment (gender equality), food security and dietary quality. Gendered decomposition indicated that these favorable effects are stronger for female mobile users than male users. The authors identified income and gender equality pathways as important drivers of the positive nutrition effects, which suggests that promoting equal access to mobile phones and related ICT technologies can foster economic and broader social development. In a recent and related study on pastoral communities in Northern Kenya, Parlasca et al. (2020) also showed that mobile phone adoption and use are positively and significantly associated with dietary diversity, especially for frequent mobile phone users. Further investigations of the underlying mechanisms disclosed that mobile phone use improves dietary diversity mainly through better access to purchased foods. Similarly, Ejemeyovwi et al. (2021) employed different waves of nationwide data to show that household ICT utilization (proxied by mobile phone use) significantly contributes to food security in Nigeria. Namubiru et al. (2018) access to food security information, especially through local FM radios and mobile phones, significantly improves households' food security status in the Acholi sub-region in Northern Uganda. Finally, in rural India, Rajkhowa, and Qaim (2022) reported that mobile phone owners are significantly more likely to participate in various types of off-farm employment, including casual wage labour, salaried employment and non-agricultural self-employment. Their results also demonstrated that this effect is stronger in female-headed than in male-headed households.

Agro-processing and related post-production infrastructure

Evidence from the above studies, albeit not exhaustive, suggests that access to production, transportation, markets and information and communication infrastructure is critical for nutritional improvements and

achieving gender equality, particularly in isolated rural areas. However, not much is known about the contribution of processing facilities (post-production infrastructure) to women's nutritional and empowerment outcomes. This study aims to fill this dearth in the literature and provide robust evidence to inform nutrition-sensitive and gender-inclusive infrastructural development interventions.

Instead of focusing on the impact of infrastructure, Mthombeni et al. (2022) studied the factors affecting access to agro-processing training for small-scale farmers in Gauteng province of South Africa. Based on a sample of 307 smallholder crop farmers, 74% of the farmers who accessed agro-processing training, the authors found that agro-processing training was mainly influenced by farming experience, with more experienced farmers being more likely to receive agro-processing training.

Keding et al. (2013) argued that apart from improved agricultural production, processing of foods provides an important interface between producers and consumers, and is required to achieve healthy and sustainable diets, as well as close the nutrition gap. The authors documented that in settings where processing is poor (partly due to lack of access to processing facilities), high food losses can induce food insecurity or heighten the risk of producing unwholesome and unhealthy foods. Therefore, they concluded that achieving the aims of nutrition-sensitive agriculture calls for investments in efficient storage and food processing technologies to fully exploit the potential of processing at the industrial, village and household level.

Nti et al. (2002) analyzed the economic, health and nutritional impacts of the adoption of an improved fish processing technology among 51 female fish processors in Ghana. Compared to the traditional processing technique which uses round mud ovens, the improved technology, namely the Chorkor smoker disseminated under the Ghana/Netherlands Artisanal Fish Processing and Applied Research Project (AFPP), was touted for its perceived advantages of increased smoking capacity, full economy, and improved quality of smoked fish. While the analyses were primarily qualitative and descriptive, the results showed that the adoption of improved fish processing and preservation technologies was associated with improved household income, nutrient intake (particularly protein, vitamin B1 and calcium), and health status (in terms of alleviating eye problems and headache following reduced exposure to smoke and heat).

In a newsletter³, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 2019) reported that the provision of a groundnut processing facility in the Dattaipally community of Telangana in South India has contributed to women's empowerment by providing them with employment opportunities and permitting them to earn higher incomes as plant workers, groundnut farmers and processors through higher prices in the market after processing, or as shareholders of the women's cooperative that mans the facility. The resultant enhanced income can facilitate access to nutritious diets. While this finding is not substantiated by empirical data and rigorous analysis, it demonstrates the potential benefits of access to agro-processing infrastructure for women's economic empowerment as well as overall well-being.

Abass et al. (2017) investigated the impact of value addition through mechanized processing of cassava in north-eastern Zambia. The small-scale mechanized processing technologies for post-harvest grating, chipping, and pressing of cassava were promoted by the Zambia Agricultural Research Institute and the International Institute of Tropical Agriculture. Using the probit regression technique and a sample of 351 adopters and 348 nonadopters, the authors reported that the adoption of mechanized cassava processing is associated with a significantly lower proportion of poor households in mechanized communities compared to that of nonmechanized cassava processing areas. While the study demonstrated that improved cassava processing infrastructure can better household welfare, it failed to address issues of endogenous placement and adoption of these technologies, which may bias the estimates.

³ <https://www.icrisat.org/small-in-scale-big-on-impact/>

2.3 Conceptual linkages among processing infrastructure, women's empowerment, and nutritious diets

Drawing from the existing literature on the impact of agricultural commercialization on nutrition and women and empowerment (von Braun and Kennedy, 1994; Ongutu et al. 2020, Bonuedi et al. 2021), Figure 2.2 shows a simplified conceptual framework that outlines the pathways through which processing infrastructure may affect women economic empowerment and dietary outcomes. It hypothesizes that access to, and use of processing facilities can have both direct and indirect effects on nutritious diets. They can directly contribute to improved nutrition by making processed nutritious foods available to households and individuals for their own consumption.

They can also indirectly contribute to nutritious diets by enabling households to generate higher income through value addition and the sale of processed products at higher prices (relative to unprocessed products). The income gains can be used to purchase foods in the marketplace. Women empowerment can be enhanced if processing facilities enable women who are directly or indirectly involved in the processing and marketing of groundnut-related products to have greater control over the use of incomes generated from such economic activities; greater involvement in household decision-making processes especially in those that relate to food acquisition, food preparation and intra-household food allocation. These gender-related changes have been associated with significantly improved dietary diversity (Bonuedi et al. 2021; Amugsi et al., 2016; Fischer & Qaim, 2012).

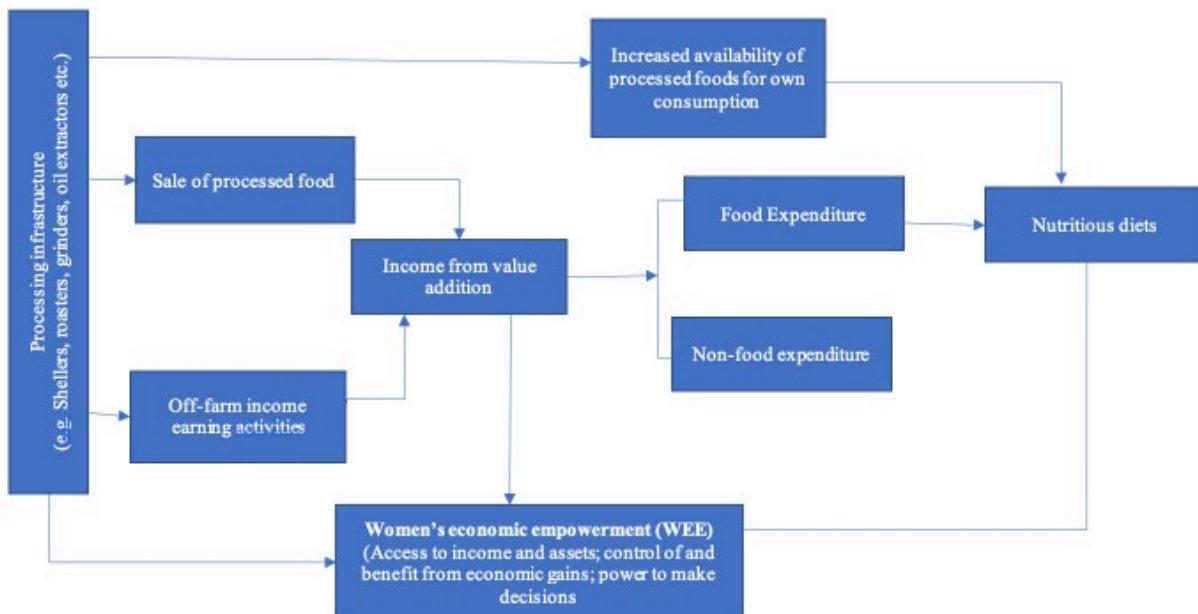


Figure 1: Conceptual framework linking processing infrastructure to women empowerment and nutritious diets.

Source: Adapted from von Braun and Kennedy (1994); Ongutu et al. (2020), Bonuedi et al. (2021)

3. Methodology

3.1 Study setting

The study is situated in selected districts in the Upper West, North-East, Northern and Savannah region of Ghana. These regions, hereafter referred to as northern Ghana, are one of the semi-arid areas in the world, with an annual average temperature of 34 degrees, particularly because of their closeness to the Sahel region. According to the 2021 Population and Housing Census of Ghana, the entire northern Ghana (including the Upper East Region) is home to almost 5.83 million people, 57.6% of whom reside in rural areas (Ghana Statistical Service, 2021). The regions in northern Ghana are starkly underdeveloped, trailing those in southern Ghana in almost all metrics of development. For instance, despite a steady decline in Ghana's poverty incidence from 31.9% in 2005/06 to 23.4% in 2016/17, poverty remains widespread in northern Ghana. The most recent statistics indicate that, as of 2016/17, its poverty rate ranges from 54.8% in Upper East to 70.9% in Upper West (Ghana Statistical Service, 2018). Most of the people in this part of the country are multi-dimensionally poor, suffering extreme deprivations in health, education, and standard of living. According to recent estimates reported by the Ghana Statistical Service (2020), the incidence of multidimensional poverty ranges from 65.5% in Upper West to 80.8% in the Northern region.

Typical diets in northern Ghana are largely undiversified and are dense in macronutrients like carbohydrates and deficient in essential micronutrients like vitamins and minerals. As shown in this study, the average dietary diversity score for women of reproductive age hovers around 4.5 out of 10 food groups, with only 45.2% of them achieving the minimum dietary diversity for women (MDD-W), which is a proxy indicator of micronutrient adequacy of women's diets. At the household level, the dietary diversity score in this part of Ghana is also low (5.9 out of 12 food groups). The limited access to and intake of high-quality diets is reflected in comparably high rates of malnutrition in northern Ghana, with 25.2% and 31.4% of under-five children being underweight and stunted respectively (USAID, 2019). The prevalence of malnutrition in northern Ghana is indicative that concerted efforts directed at improving the consumption of micronutrients are crucial to accelerating progress towards eliminating hunger and all forms of malnutrition and improving food security and nutrition by 2030 at the local and national levels.

Agriculture, primarily food crops farming, is the main economic activity employing between 70.6% (Northern Region) and 83.2% (in Upper East Region) of households in this part of Ghana (Ghana Statistical Service, 2019). Agricultural production in northern Ghana is characterized by low mechanization, the predominance of smallholder farming (with average farm size below 5 acres), and high dependence on short and erratic rainfall patterns for irrigation. The main food crops grown are cereals (rice, sorghum, maize, millet), legumes (groundnuts, soybeans, cowpeas) and roots and tubers (cassava and yam) (Ministry of Food and Agriculture (MoFA), 2019). Among these, this study focuses on groundnuts, which are commonly grown and processed into various food products by women for sale and own consumption. They are widely consumed as fresh, dry, or roasted nuts, snacks, edible oils, and in soups and stews. This makes groundnuts one of the food security crops in the northern regions and Ghana at large. Given that its production and processing are largely in the women's domain, groundnuts are also critical for improving women's empowerment and gender equity, in a context where entrenched gender norms and cultural practices significantly restrain women's access to productive resources, education and other essential services; participation in economic activities; input into decisions; control over use of income; freedom of movement and expression.

3.2 Study design

This study adopted the concurrent mixed methods approach to answer the research questions. The quantitative component focused on quantifying key variables of interest and teasing out the causal impacts of processing and access to processing infrastructure on women's empowerment, and access to nutritious diets. In particular, the quantitative analysis adopted a quasi-experimental design, which involved a comparison of outcomes between treated and untreated groups. The effects of two treatment variables are considered in study. The first treatment indicator is the processing status, which is multivalued treatment

variable comprising of three arms: producer only, processor only and both producer and processor. Women who only produce groundnuts are used as the comparison group with women. The second treatment variable is binary, indicating whether or not a female processor (i.e., processor only and both producer and processor) has access to key groundnut processing facilities (i.e., sheller, roaster, and grinding mill). All quantitative analyses are conducted in the STATA statistical software (version 14).

Qualitative methods are also used to validate the quantitative findings and explore the contextual factors underlying the estimated effects on the outcome variables of interest. That is, the study goes beyond quantitative data to capture some context specific nuances (i.e., norms, practices, and perceptions) on the linkages among processing infrastructure, groundnut processing, women's empowerment, and access to nutritious diets that the econometric estimations may fail to identify and quantify. Qualitative analysis is undertaken with the aid of NVivo 12.

3.3 Sampling

Through the support of officials from the Northern Development Authority (NDA), District Directors of the Department of Agriculture at the Municipal/District Assemblies, Agriculture Extension Agents (AEA) and Women in Agriculture and Development (WIAD) officers, the research team identified districts and communities in Northern Ghana that are noted for groundnut production and processing. The districts and communities were selected from the Northern, North-East, Savannah, and Upper West regions. The Upper East Region was excluded from the study for safety reasons because of an ongoing chieftaincy conflict in Bawku at the time of the survey.

A two-stage stratified sampling design was applied to randomly select the respondents for the quantitative survey. Considering that groundnut production occurs predominantly in rural areas, while processing happens mostly in urban areas, the identified communities were stratified by locality. This was to ensure the representativeness of the final sample of producers and processors across the rural and urban divide. In the second stage, upon a successful community entry (in the sampled communities), the lottery technique of simple random sampling was used to select the target respondents – female groundnut producers and processors and the corresponding male counterparts – who volunteered to participate in the study. Power calculation using the G*Power Software showed that a sample size of 700 respondents was sufficiently large to detect a minimum effect size (Cohen's d) of 0.2, assuming a power of 0.8, an error margin of 5%.⁴ This was split into 400 for treated groups (i.e., 200 processors only and 200 for both producers and processors) and 300 non-treated groups (i.e., producers only). Allowing for a non-response rate of 10% brought the desired sample to 770 respondents, which was exceeded during the fieldwork. Overall, after data cleaning, we remained with 850 respondents. In terms of household type, this sample is composed of 801 adult male and female households and 49 adult female-only households. With regards to processing status, the sample comprised of 355 producers only, 210 processors only, and 285 of both producers and processors.

For the qualitative component, the maximum variation purposive sampling strategy was used to sample participants for the qualitative interviews. This approach enabled us to purposively select a wide range of participants who were deemed as information-rich-case to provide insights into access to processing infrastructure and its impact on women's economic empowerment. The participants sampled for the qualitative component included producers and processors of groundnuts (with a special focus on women) as well as key individuals playing different roles along the groundnut value chain with adequate experience in groundnut production and processing. The key informants comprised officials from the Women in Agricultural Development (WIAD) directorate of the Ministry of Food and Agriculture (MoFA),

⁴ The effect size of 0.2 (20%) is equivalent to raising WDDS from 3.67 to 4.40 or the MDD-W from 40.7% to 48.84% based on estimates from the Feed the Future's Population-based survey on poverty and nutrition in Northern Ghana in 2015 (USAID Ghana 2016). Available at <https://bit.ly/3dy3Sbx>.

Agricultural Extension Agents (AEAs), chiefs, community elders, opinion leaders, Assemblymen- no women? and chief farmers. Respondents for the IDIs? on the other hand were mostly processors and/or producers of groundnuts with appreciable experience in the groundnut business. Participants for the FGDs on the other hand constituted different categories of individuals who were mainly producers and processors of groundnuts. The selection of these categories of respondents was key as they were all involved in various aspects of the production and processing of groundnuts, hence was highly capable of providing the required information on the topic being explored. The sample size for the qualitative component was determined by progress towards saturation reached (Saunders et al., 2018).

3.4. Data collection

Data on women's engagement in groundnut processing was collected through face-to-face interviews between February 23 – April 7, 2023. A total of 850 female groundnut producers and processors were surveyed from 21 communities (8 urban, 13 rural), across 7 districts in four (4) regions in northern Ghana. Specifically, these include the Tolon and Kumbungu districts in the Northern Region; West Mamprusi and East Mamprusi Municipal Assemblies in the North-East Region; the Wa Municipal and Nadowli-Kaleo districts of the Upper West Region and Central Gonja district in the Savannah Region. See Annex 1 for the list of communities.

The data collection instruments were structured questionnaires for the quantitative survey and interview guides for key informant interviews (KII), in-depth interviews (IDIs) and focus group discussions (FGDs) for the qualitative survey. The quantitative survey tools comprised two modules of structured questionnaires, namely, (i) an individual questionnaire; and (ii) a community profile and infrastructure questionnaire. These were entered into the Kobo toolbox deployed on tablets to facilitate quality and efficient data collection. The qualitative interviews were paper-based and conducted in-person and were recorded on audio recorders for transcription and analysis.

For this study, women engaged in groundnut production and processing, either in isolation or combination, constituted the primary respondents of the individual questionnaire. The spouses/partners (or other male adults within the household), who constituted the secondary respondents, were interviewed to aid the construction of the women's empowerment variables. The main respondents of the KII included the regional and district directors of the Department of Agriculture under the Ministry of Food and Agriculture (MOFA); Women in Agricultural Development (WIAD) officers; agriculture extension agents (AEAs); Assemblymen, chiefs and community elders. The IDIs were administered to experienced and lead groundnut producers and processors, who were identified with the aid of the AEAs. The FGDs comprised 6–12 participants, mainly women engaged in groundnut production and processing. In the quantitative survey, data were collected on individual and household socio-demographic characteristics; extent of the woman's engagement in groundnut processing; ownership and access to processing facilities by type; 24-hour recall of food consumption; women's economic empowerment; income by source; and food and non-food expenditures.

To account for community-level contextual factors that may also affect women's empowerment and dietary outcomes, we obtained community-level information (through KII) on livelihood activities, availability of electricity, permanent markets, schools, health facilities, and roads. Data were also collected on the availability of different types of groundnut processing infrastructure, their level of technology (development), ownership and operational characteristics, as well as their challenges. The KII, IDIs, and FGDs were focused on eliciting qualitative data on the level of development, access to and utilization of processing infrastructure; local perceptions of women's empowerment and nutritious diets; and how these outcomes are affected by the presence or absence of processing facilities. All interviews and focus group discussions were audio-recorded with the permission of the participants. Field notes were taken during the focus group discussions and interviews. The data collection instruments are provided in Annex 2 (Click

[here](#)).

3.5 Measurement of variables

Measuring women's empowerment using the Pro-WEAI

Given that women's empowerment is a latent and intricate concept, with multiple domains, several measurement tools have been developed by different organizations based on their focus or dimension of interest (see Buvinic et al., 2020, for a compendium of selected tools for measuring women's economic empowerment). In this study, we adapted the project-level women's empowerment in agriculture index (pro-WEAI), which is a survey-based tool to measure women's and men's empowerment and inclusion in agricultural development projects (Malapit et al., 2019). It is composed of 10 (instead of the original 12) indicators which are mapped to three domains: intrinsic agency (power within), instrumental agency (power to), and collective agency (power with).

The intrinsic agency is made up of 3 primary indicators, including *autonomy in income*, *self-efficacy*, and *attitudes about domestic violence*. Instrumental agency is composed of 6 indicators namely *input in groundnut processing and other productive decisions*, *ownership of land and other assets*, *access to and decisions on credit*, *control over use of income*, *work balance*, and *visiting important locations*. Lastly, the collective agency is captured by *active group membership*. To capture empowerment across groundnut processing, we modify the livelihood activity categories in the pro-WEAI questionnaire to include separate questions about participation, input in decisions and control over the use of income generated from groundnut production, processing, and marketing.

A respondent is considered adequate in a particular indicator if he or she reaches a pre-defined threshold. The indicators are also equally weighted (1/10), and a respondent is considered empowered if he or she is adequate in at least 80 per cent – or at least 8 out of 10 – of the indicators. The adequacy thresholds for the pro-WEAI indicators, as defined by Malapit et al. (2019), are defined in Table 3.1.

Table 1: Pro-WEAI indicators and definitions of adequacy

Indicator	Definition of adequacy	Weight
<i>Intrinsic Agency</i>		
Autonomy in income	More motivated by own values than by coercion or fear of others' disapproval: Relative Autonomy Index score ≥ 1 RAI score is calculated by summing responses to the three vignettes about a person's motivation for how they use income generated from agricultural and non-agricultural activities (yes = 1; no = 0), using the following weighting scheme: 0 for vignette 1 (no alternative), —2 for vignette 2 (external motivation), —1 for vignette 3 (introjected motivation), and +3 for vignette 4 (autonomous motivation)	1/10
Self-efficacy	“Agree” or greater on average with self-efficacy questions: New General Self-Efficacy Scale score ≥ 32	1/10
Attitudes about intimate partner violence against women	Believes husband is NOT justified in hitting or beating his wife in all 5 scenarios: 1) She goes out without telling him 2) She neglects the children 3) She argues with him 4) She refuses to have sex with him 5) She burns the food	1/10
<i>Instrumental Agency</i>		

Input in productive decisions	Meets at least ONE of the following conditions for ALL of the agricultural activities they participate in 1) Makes related decisions solely, 2) Makes the decision jointly and has at least some input into the decisions 3) Feels could make a decision if wanted to (to at least a MEDIUM extent)	1/10
Ownership of land and other assets	Owns, either solely or jointly, at least ONE of the following: 1) At least THREE small assets (poultry, nonmechanized equipment, or small consumer durables) 2) At least TWO large assets 3) Land	1/10
Access to and decisions on financial services	Meets at least ONE of the following conditions: 1) Belongs to a household that used a source of credit in the past year AND participated in at least ONE sole or joint decision about it 2) Belongs to a household that did not use credit in the past year but could have if wanted to from at least ONE source 3) Has access, solely or jointly, to a financial account	1/10
Control over the use of income	Has input in decisions related to how to use BOTH income and output from ALL of the agricultural activities they participate in AND has input in decisions related to income from ALL non-agricultural activities they participate in, unless no decision was made	1/10
Work balance	Works less than 10.5 h per day: Workload = time spent in primary activity + (1/2) time spent in childcare as a secondary activity	1/10
Visiting important locations	Meets at least ONE of the following conditions: 1) Visits at least TWO locations at least ONCE PER WEEK of [city, market, family/relative], or 2) Visits at least ONE location at least ONCE PER MONTH of [health facility, public meeting]	1/10
<i>Collective Agency</i>		
Group membership	An active member of at least ONE Group	1/10

Source: Adapted from Malapit et al. (2019).

Measuring access to nutritious diets

In this study, we measure access to nutritious diets through the women's dietary diversity score (WDDS) and household dietary diversity score (HDDS). According to the FAO (2013), the HDDS assesses a household's economic access to food in terms of its ability to produce, purchase or otherwise obtain food for consumption by all household members. As Kennedy et al. (2011) documented, it is quantified by counting the total number of food groups consumed by a household during the last 24 hours out of 12 food groups: cereals; roots and tubers; vegetables; fruits; meat, poultry, offal; eggs; fish and seafood; pulses, legumes, nuts; milk and milk products; oil and fats; honey, sugar and sweetened products; and spices, condiments and beverages. The potential score ranges from 0 to 12, with higher values indicating more diversified household diets.

In the same vein, to capture women's intake of nutritious diets, we followed FAO and FHI 360 (2016) to construct the WDDS for women of reproductive age (15-49 years). The WDDS is based on ten food groups,

namely, grains, white roots and tubers, and plantains; pulses (beans, peas, and lentils); nuts and seeds; dairy; meat, poultry, and fish; eggs; dark green leafy vegetables; other vitamin A-rich fruits and vegetables; other vegetables; and other fruits (FAO and FHI 360, 2016). Based on these food groups, the minimum dietary diversity for women (MDD-W) is a dichotomous indicator of whether women 15–49 years of age have consumed at least five out of ten food groups during the previous day or night.

A limitation of dietary diversity scores (DDS), worth mentioning, is that they do not capture the extent of individual intake of vital micronutrients, especially vitamin A, zinc, iron, and calcium). Doing so requires individual-level quantitative dietary intake (or food frequency) data, the collection of which can be time-consuming and costly. However, the DDS are utilized in this study because validation studies have shown that the HDDS is strongly correlated with socioeconomic status, and household food security (i.e. household energy availability, or caloric and protein adequacy) (Hoddinot and Yohannes 2002; Swindale & Bilinsky, 2006; Kenedy et al. 2011), and that WDDS/MDD-W is a proxy indicator that reflects micronutrient adequacy of women's diets, which is an important dimension of diet quality (Arimond et al. 2010; FAO and FHI 360, 2016; Nguyen et al. 2018).

Measuring access to processing infrastructure

Access to processing infrastructure promotes value addition by facilitating the transformation of raw produce into semi-finished or finished products that possess higher market value and longer lifespans. In the extant literature, the distance or time it takes to reach the nearest facility (market center, road, hospital, etc.) from the household's residence has been commonly used as proxy indicators of access because of their strong association with transport and other transaction costs (Bonuedi et al. 2021; Usman and Callo-Concha 2021; Abay and Hirvonen, 2017; Headey et al. 2019). Given our focus on groundnuts, access to processing infrastructure was measured by the individual's ownership of or access to different facilities within/outside the community for shelling, roasting, grinding (milling), and oil extraction, among others. The main processing facilities considered in this study were shelling machines (shellers), roasting machines (roasters) and grinding machines (millers). Irrespective of the level of technology (manual, semi-mechanized or fully mechanized), access to a given infrastructure was constructed as a binary or dichotomous variable which was equal to 1 if the individual owns or has access to it for groundnut processing activities, and 0 if the individual neither owns nor has access to it.

Measuring control variables

To account for the role of individual, household and community characteristics in influencing groundnut processing decisions, access to groundnut processing infrastructure and, ultimately, the outcome variables of interest (i.e., women's empowerment and access to nutritious diets), several control variables were included in the study. The individual characteristics include the respondent's age, level of education, and marital status. The household level variables include household size, dependency ratio, educational level of the household head, and household access to electricity. At the community level, we control for locality (rural or urban) and access to basic infrastructure such as the existence of a permanent market center, and health facility. Table 2 provides a brief description of the covariates used in the empirical models. Annex 3 also reports their summary statistics (click [here](#) for Annex 3).

Table 1: Description of variables

Label	Description
<i>Indicators of Women's empowerment</i>	
Empowered (<i>EMP</i>)	Takes the value of 1 if a woman is empowered by achieving adequacy in at least 8 out of 10 Pro-WEAI indicators.
Self-efficacy (<i>SELF EFF</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Attitudes about domestic violence (<i>ADV</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Autonomy in income (<i>AUTO INC</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Input in groundnut processing and other livelihood decisions (<i>INPUTDEC</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Ownership of land and other assets (<i>ASSETS</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Control over the use of income (<i>CTRL INC</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Work balance (<i>WORKBAL</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Mobility (<i>MOB</i>) captured by visiting important locations	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
Active group membership (<i>AGM</i>)	Equals 1 if adequacy is achieved based on the cut-off criterion defined in Table 3.1 and 0 otherwise.
<i>Indicators of access to nutritious diets</i>	
Women's dietary diversity score (WDDS)	The number of food groups consumed out of 10 food groups by women of reproductive age (15-49 years) in the past 24 hours.
Minimum dietary diversity for women (MDD-W)	A binary variable which takes a value of 1 if a woman (aged 15-49 years) consumed at least 5 food groups in the last 24 hours
Household dietary diversity score (HDDS)	The number of food groups consumed out of 12 food groups by any household member during the last 24 hours.
<i>Processing status and processing infrastructure</i>	
Processing status	Multivalued treatment indicator which equals 1 if producer only; equal 2 if processor only and equal 3 if both producer and processor.
Access to sheller	Binary variable which equals 1 if the individual owns a groundnut shelling machine or has access to it either within or outside the community
Access to roaster	Binary variable which equals 1 if the individual owns a groundnut roasting machine or has access to it either within or outside the community
Access to grinding mill	Binary variable which equals 1 if the individual owns a grinding mill or has access to it either within or outside the community
<i>Control variables</i>	

Age	This is a numeric (continuous) variable capturing the age in years of the interview at the last birthday.
Married	Dummy variable which equals 1 if the respondent is married, or 0 if otherwise
Educational status	Dummy variable which equals 1 if the respondent had formal education (reached at least primary level) and 0 if otherwise
Household size	The number of household members
Dependency ratio	The sum of the number of children (0-17 years) and the number of elderly (above 60 years) divided by the number of household members within the working age (18-60 years)
Electricity access	Dummy variable which equals 1 if the respondent's household had access to electricity, and 0 if otherwise
Permanent market	Dummy variable which equals 1 if a permanent market exists in the community, and 0 if otherwise
Health facility	Dummy variable which equals 1 if a health facility exists in the community, and 0 if otherwise

3.6 Data Collection Procedures

Training

All enumerators and supervisors underwent an extensive three-day survey training. The training was delivered by the Principal Investigator (PIs) and Co-PIs to provide information on survey instrument design, and to answer questions. The goal of the training was both to ensure all enumerators had a strong understanding of the questionnaire structure, proper procedures for each module, and knowledge of how to use the tablets for electronic data collection. Throughout the training, the data collection instrument was displayed on tablets given to the enumerators and supervisors so that each enumerator could verify they were collecting the same information as the trainer. Sections that required specific procedures, such as women economic empowerment and processing infrastructure were thoroughly explained by the PIs, then role-played by the enumerators, with time devoted after each role play for enumerators to ask questions and provide peer feedback. The training was also used to test the electronic questionnaire, which was updated daily to remove errors, improve translations, and add additional notes or instructions to enumerators based on issues which arose during the training.

Fieldwork

Enumerators were organized into teams of four, each led by a supervisor, who in turn reported to the PIs overseeing the fieldwork in the respective regions. All team supervisors and enumerators had significant previous experience implementing surveys in rural areas and underwent additional internal training in managing logistics, reporting procedures and troubleshooting.

Considering the socio-cultural norms in Northern Ghana, for the Pro-WEAI modules, the individual questionnaire was administered by an enumerator of the same gender as the participant, to minimize discomfort around sensitive topics. The individual interview was conducted privately. Enumerators were trained to ensure that they did not share any detail of the individual interviews (or other data collection activities) with anyone else, including other household or community members to ensure the privacy and security of the respondent.

Quality Assurance

The enumerators were all issued with mobile data, to enable them to upload data to the project server, which was carried out by supervisors each evening following the conclusion of surveying for the day. Each

supervisor was required to complete a tracking sheet throughout data collection which was shared with the PIs. The tracking sheet provided an up-to-date report of survey progress which could be compared to server submissions to ensure consistency.

As results were submitted, the PI ran a series of automated data checks to ensure that interviews were being completed properly and to check for anomalies such as large numbers of missing values. The PI was in regular correspondence with the co-PIs who led the field teams throughout to follow up on any such issues and to ensure proper procedures were followed. To improve data quality, after each day of enumeration, debriefing sessions were held to address any challenges faced by enumerators. The debriefing sessions also served as an important avenue for gathering qualitative information from the enumerators and supervisors, which provided nuances and contexts to the quantitative data.

Photographs

Permission was sought from participants to take photographs to be used as part of data collection activities. These pictures were used to generate photobooks which provided the study team a better appreciation of the level of processing infrastructure, the groundnut processing processes that women go through, and issues around women economic empowerment. To protect participant confidentiality, images were submitted to a secure server then downloaded to an encrypted laptop accessible only to the research team. Personally, identifying information was stored separately from image files.

3.7 Data Analysis Methods

Quantitative analysis

Model Specification

The premise of this study is to analyze the effects of processing as well as access to processing facilities on the empowerment and dietary outcomes of women engaged in groundnut processing in Northern Ghana. To this end, we consider the following hypothetical models:

$$Y_i = \alpha + \delta Proc_i + \beta X_i + \varepsilon_i \quad (1)$$

$$Y_i = \varphi + \gamma ProcInfras_i + \theta X_i + \mu_i \quad (2)$$

where Y represents the outcome variables for women's empowerment and access to nutritious diets for women and their household i . In this study, women's empowerment is measured using 10 pro-WEAI indicators (see Table 1). Besides the overall empowerment indicator, disaggregated analyses are conducted for each of the 10 underlying empowerment indicators to unravel which dimension(s) of women empowerment is (are) most affected by their engagement in groundnut processing ($Proc$) and access to processing infrastructure ($ProcInfras$). With respect to access to nutritious diets, the outcome variables considered in this study are women's and household dietary diversity scores: WDDS, MDD-W, and HDDS.

$Proc$ is a multivalued treatment indicator whether the woman is a producer-only (1), or a processor only (2) or both processor and producer (3). $ProcInfras$ is a binary indicator of access to groundnut processing facilities. The specific facilities analyzed in the study are groundnut shelling machines (sheller), roasting machines (roaster) and grinding mills. The oil extraction machine (oil processor) is excluded from the analysis because of its non-existence. It is found during the field survey, almost all processors use rudimentary tools, such as plastic or aluminum basins, mortar and *banku* stick (wooden spatula), to manually extract groundnut oil. X_i is a vector of control variables including individual, household and community-level characteristics that may influence women's empowerment and nutritional outcomes. ε_i and μ_i are the random error terms for models 1 and 2 respectively. $\alpha (\varphi)$, $\delta (\gamma)$ and $\beta (\theta)$ are the parameters to be estimated for model 1 (2).

Estimation Strategy

The audio files and field notes were all transcribed. The research team engaged in reading all the transcribed files and compared them several times with the audio recordings to ensure accuracy. This process also ensured familiarization of the data. Following the transcription, a coding frame which contains codes and sub-codes was developed. The inductive and deductive approach was combined in developing the coding frame. The codes were developed based on our readings and understanding literature and participants owned responses as they emerged from the interview transcripts. This approach enabled us to cover a wide range of expressions, concepts, and opinions as they emerged from the research.

The next step involved coding the transcribed data. The coding process involved assigning words, phrases, quotations, and chunks of the textual data and this helped to sort, reduce, and distil the content of the interviews. The coding process was iterative in that it involved reading and re-reading the interview transcripts, revising, re-organizing codes and relating the data to questions that were asked during fieldwork. The use of NVivo version 20 software enabled the research team to sort, group and link clusters of codes from the focus group discussions and interviews to form themes relating to questions or issues discussed. Themes were grouped in line with the study objectives or research questions to aid further analysis and report writing. The NVivo version 20 software offered efficient management and retrieval of information.

3.8 Ethical Considerations

Ethical review board approval for the study was sought from the Humanities and Social Sciences Research Ethics Committee (HuSSRECC) at the Kwame Nkrumah University of Science and Technology, Ghana. We obtained oral informed consent from all study participants. Ethical principles such as voluntary participation, confidentiality, anonymity, and strict use of the information for research purposes were stressed and adhered to throughout the data collection process.

Rigor

To ensure credibility and transparency in the research process, the research team kept a memo throughout the research process for recording thoughts, feelings, insights, and ideas in relation to the study aims. The memo served as a reflective journal, which aided research reflexivity. Additional strategies used to ensure trustworthiness and authenticity include data cleaning, verification of data and coding of transcripts through peer and member checking (e.g., seeking clarifications from participants during interviews, and discussion of codes and themes emanating from qualitative data during team meetings).

3.9 Strengths and limitations

This study has several strengths. It is one of the first that we are aware of to use the pro-WEAI modules to assess the impact of post-production infrastructure on women's economic empowerment and access to nutritious diets among female legume growers and processors in Northern Ghana, using a quasi-experimental design. The use of methodological triangulation (questionnaires, interviews, and focus groups) and data triangulation (multiple sites for data collection) in this study strengthened the credibility and generalizability of the findings.

This study's limitations include the possibility that a question will be misunderstood or that it will not measure what it was intended to measure. This is not surprising as difficulties in understanding questions have been reported in other studies cognitively testing the pro-WEAI modules (Lambrecht et al., 2020; Hannan et al., 2020). The research team avoided such measurement issues by pilot testing of the data collection instruments to ensure questions are easy to understand and response choices made sense to the respondents. Further, in surveys of this nature, recall bias, which results from asking respondents to provide information from a period in the past, is inevitable. The team mitigated this potential bias by triangulating

responses between the quantitative survey and qualitative survey. The research team also took time to explain the purpose of the study at the start of all interviews and focus groups to avoid social desirability bias.

4. Results and Discussion

4.1 Quantitative Results

Socio-demographic characteristics of respondents

This section presents the socio-demographic characteristics of the survey participants. As shown in Table 3 a total of 1,651 were captured by the surveyed comprising groundnut producers (41.8%) and processors (58.2%). The sample comprised females 850 (51.5%) and males 801(48.5%) in the groundnut value chain. In terms of locality, most of the respondents were from rural areas (59.3%). The mean age of respondents was 42.2 (SD=13.5). Most of the respondents had no formal education (70.4%). The average household size was 8.8.

Table 3: Socio-demographic characteristics of Respondents

Variable	Female	Male	Total
<i>Observations</i>			
Frequency (n)	850	801	1,651
Per cent of respondents (%)	51.5	48.5	100
<i>Type of locality</i>			
Rural	509 (58.9%)	470 (58.7%)	979 (59.3%)
Urban	341 (40.1%)	331 (41.3%)	672 (40.7%)
Age (years) [SD]	41.9 [12.6]	42.6 [14.6]	42.2 [13.5]
<i>Educational level reached/completed (%)</i>			
No formal education	695 (81.7%)	467 (58.3%)	1,162 (70.4%)
Primary	60 (7.1%)	71 (8.9%)	131 (7.9%)
Junior Secondary	51 (6.0%)	105 (13.1%)	156 (9.5%)
Senior Secondary	42 (4.9%)	112 (13.9%)	154 (9.3%)
Tertiary	2 (0.2%)	46 (5.7%)	48 (2.9%)
<i>Marital status (%)</i>			
Monogamously married	398 (46.8%)		
Polygamously married	364 (42.8%)		
Divorced/Separated/Widowed	81 (9.5%)		
Never married/Single	7 (0.8%)		
<i>Main source of livelihood (%)</i>			
Farming	537 (63.2%)	642 (80.2%)	1,179 (71.4%)
Trading	292 (34.4%)	25 (3.1%)	317 (19.2%)
Other informal employment	18 (2.1%)	60 (7.5%)	78 (4.8%)
Formal employment	1 (0.1%)	34 (4.3%)	4 (2.1%)
Unemployed	40 (5.0%)	2 (0.2%)	52 (2.6%)
<i>Household composition: Mean [SD, n]</i>			
Children (0-17years)	4.2 [2.7, 848]		
Adults (18-60years)	4.2 [2.5, 848]		
Elderly (60+years)	0.4 [0.7, 849]		
Household size	8.8 [4.3, 850]		
<i>Type of respondent (%)</i>			
Producer only	285 (41.8%)		
Processor only	210 (24.7%)		

Both producer and processor	355 (33.5%)
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Note: SD represents Standard Deviation; n stands for frequency.

Source: Field Data, 2023

State of groundnut processing infrastructure in Northern Ghana

The study explored individual-level infrastructure or facilities that support groundnut processing. As shown Table 4, the most common types of infrastructure owned by women processors were roasters, drying floors, and tarpaulins. Grinding mills, oil processors and shellers were less commonly owned by individual women processors. In terms of the level of technology, the processing infrastructure were predominantly traditional. Apart from one woman who owned a fully mechanized grinding mill, none of the women respondents owned a fully mechanized processing infrastructure.

Table 4: Individual ownership of processing infrastructure by type and level of technology

Type of Infrastructure	Number of owners	Quantity owned	Level of technology		
			Traditional (Manual)	Semi-mechanized	Fully mechanized
Tarpaulin	109	120	120	0	0
Drying floor	140	142	142	0	0
Sheller	50	55	42	13	0
Roaster	187	227	185	42	0
Grinding mill	6	6	1	4	1
Oil processor	83	97	81	16	0

Aside from the individual women ownership? of processing infrastructure, the study examined the availability of different types of groundnut processing infrastructure at the community level. As shown in Table 5, the community level infrastructures were predominantly fully mechanized. We identified one oil processor facility that was fully mechanized in one community (Wapani, Upper West region).

Table 5: Community level availability of processing infrastructure

Type of infrastructure	No. of communities with access (out of 21)	Quantity of infrastructure surveyed	Quantity by level of technology		
			Traditional (Manual)	Semi-mechanized	Fully mechanized
Tarpaulin	6	19	19	0	0
Sheller	17	57	0	20	37
Roaster	4	13	0	12	1
Grinding mill	20	67	0	10	57
Oil processor	1	1	0	0	1

Shelling machine

After harvesting, groundnuts go through a process of shelling. Shelling is a form of value addition although the value-added is minimal. Groundnut shelling machine is a machine used to remove the shell of groundnut to obtain the groundnut seeds. Various types of groundnuts shellers of different sophistication (semi-

mechanized and fully mechanized) were identified in the study areas. It was reported that there is a higher demand for shelled groundnuts than for unshelled groundnuts because most buyers do not want to invest in the high labour demand and cost of shelling. The findings from the qualitative interviews, however, revealed some limitations of existing groundnut shelling machines including irregular power supply which affect shellers designed to use electricity, shellers with no adjustable concave clearance to accommodate different groundnut varieties – which affect shelling and clearing efficiency, shellers beyond the reach of processors as the cost of fabrication is high, and fabricators having no technical knowledge on the design aspect, which makes their fabrication substandard (see Table 6.).



Plate 1: Semi-mechanized shellers
sheller



Plate 2: Plate 2: Fully mechanized

Roasting machines

Roasted groundnuts were identified a major source of income for women processors in Northern Ghana. It is often prepared traditionally using an open fire with the groundnuts mixed with sand or ash to aid in the roasting process. This method is unhygienic, inefficient, and time-consuming. We identified 42 semi-mechanized roasting machines at the individual level and 12 at the community level. We identified only one fully mechanized roasting machine at the community level. Data gathered from the qualitative interviews indicate that roasting time has a significant influence on the strength of the odor and flavor of roasted groundnuts making access to roasting machines imperative for women processors. Roasted groundnuts produced using the traditional method necessitates cleaning which leads to more time waste and unwanted expenses.



Plate 3: Plate 3: Traditional roaster

Plate 4: Semi-mechanized Roaster

Groundnut Milling Machine

The findings indicate that least developed groundnut processing infrastructure in the study areas is groundnut milling machine. There were no available milling machines specifically meant for milling groundnut seeds. Rather, the groundnut milling usually takes place at the local mill (Plate 5), where grains, pepper, and tomatoes are milled. The challenges faced in carrying out the milling operation identified include the use of a local mill where grains, pepper and tomatoes are milled. A great amount of time is utilized in order to carry out the milling due to inadequate milling machines. There is also loss or/and contamination of paste in the mill. As shown in Plate 6, we identified only one groundnut kneading machine for oil extraction.



Plate 5: Fully mechanized Grinding mill



Plate 6: Fully mechanized Oil extractor

Table 6 provides information on the operational characteristics of groundnut processing infrastructure. The results show a gender dimension to ownership and use of the processing infrastructure. Except for grinding mills, which were mostly operated by men, women mostly owned and operated the other types of processing infrastructure. Several challenges were reported by the operators of these processing facilities as captured in Table 6.

Table 6: Characteristics of groundnut processing infrastructure by type

	Sheller	Roaster	Grinding Mill	Oil processor
Main type of fuel (%)				
Electricity	53.9	0.0	80.3	100
Fuel (petrol/Diesel)	2.6	0.0	18.2	0.0
Firewood	0.0	100	0.0	0.0
Manpower	43.5	0.0	1.5	0.0
Owned by (%)				
Individuals	100	100	95.5	100
Jointly/communal	0.0	0.0	4.5	0.0
Sex of operator (%)				
Male	25.6	0.0	84.9	100
Female	51.3	100	7.6	0.0
Both male and female	23.1	0.0	7.5	0.0
Mostly used by (%)				
Male	5.1		13.6	0.0
Female	71.8	100	48.5	100
Both male and female	23.1	0.0	37.9	0.0
Frequency of operation (%)				
Daily	51.3	38.5	90.9	100
1-2 days a week	25.6	38.5	4.6	0.0
3-5 days a week	17.9	23.1	3.0	0.0
6-7 days a week	5.1	0.0	0.0	0.0
Other	0.0	0.0	1.5	0.0
Main challenges (%)				
Unreliable supply of electricity/energy	42.9	0.0	52.2	0.0
High cost of fuel	4.8	53.8	23.9	0.0
High cost of electricity	45.2	0.0	76.1	0.0
Lack of access to finance	16.7	38.5	44.8	0.0
Limited supply of raw input for processing	23.8	0.0	7.5	0.0
Low patronage	2.4	0.0	5.9	0.0
Lack of technical knowledge/skilled labour	4.8	3.0	0.0	0.0
Unavailability/High cost of spare parts	66.7	7.7	67.2	0.0

Note: Due to multiple responses, totals may exceed 100%.

Self-reported benefits of access to groundnut processing infrastructure

Groundnut processing was a vital economic activity in the research communities, providing a source of livelihood for most women. However, the traditional methods of groundnut processing were time-consuming, and labor-intensive, and did not improve their productivity. On the other hand, access to modern processing infrastructure like shellers and millers was noted to accrue several benefits for women

as shown in Figure 2.

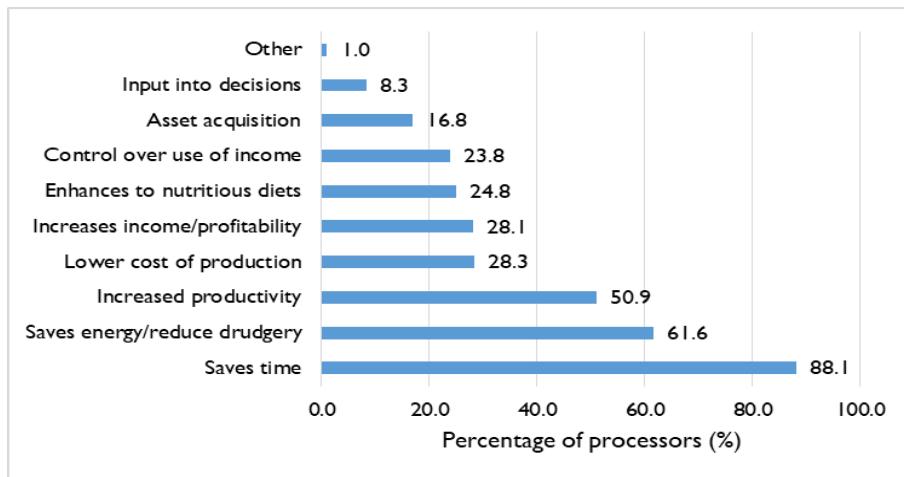


Figure 2: Self-reported benefits of access to processing infrastructure

Most of the women noted that access to adequate processing infrastructure saves time (88.1%), energy (61.6%) and increased productivity (50.9%).

Level of development of groundnut processing infrastructure in Northern Ghana.

Forms of groundnut processing

Figure 3 shows the various forms of groundnut processing activities performed by women. The major groundnut processing activities were roasting, boiling or frying of groundnuts (74.1%), drying (68.5%), grinding (65.9%), shelling (64.2%), cleaning (53.7%), and oil extraction (51.9%).

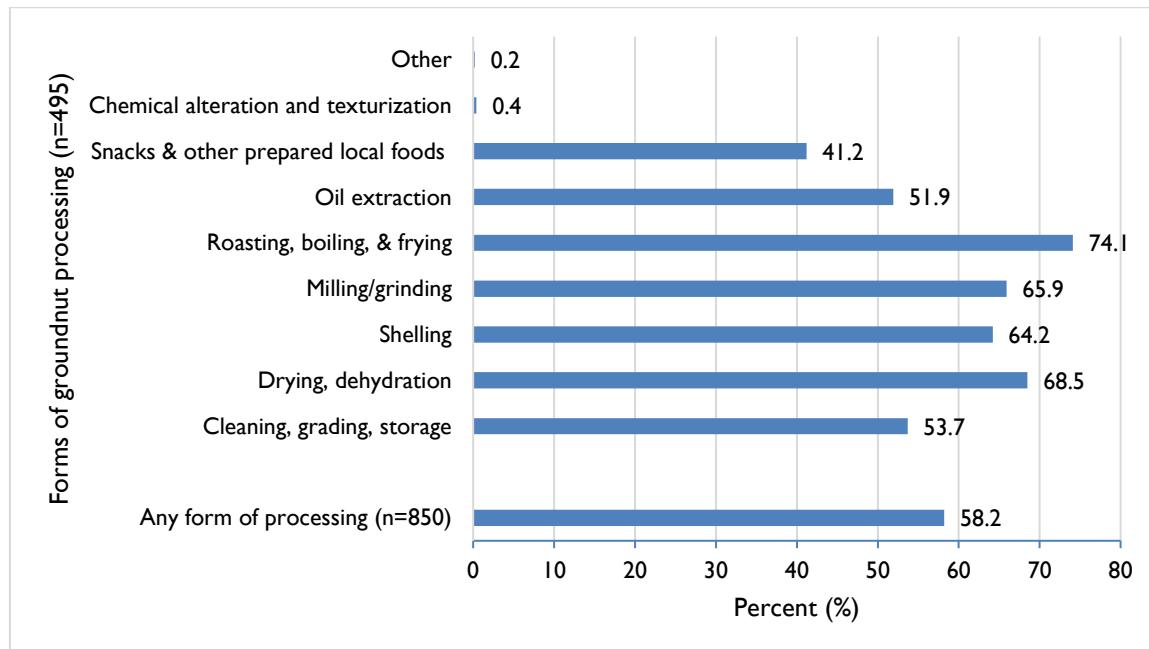


Figure 3: Forms of groundnut processing

Below are some field pictures of the various processing facilities.



Plate 7: Tarpaulin for drying groundnut



Plate 8: Traditional roaster



**Plate 9: Shelling of groundnut
of groundnut**



Plate 10: Traditional roasting

Types of ground-based processed products

As shown in Figure 4) indicate that the predominate groundnut product processed by women was kulikuli and suya spice (72.3%) followed by groundnut oil (48.3%), whilst the least processed products were peanut cake, spicy balls, tom brown and coated nuts (4.2%).

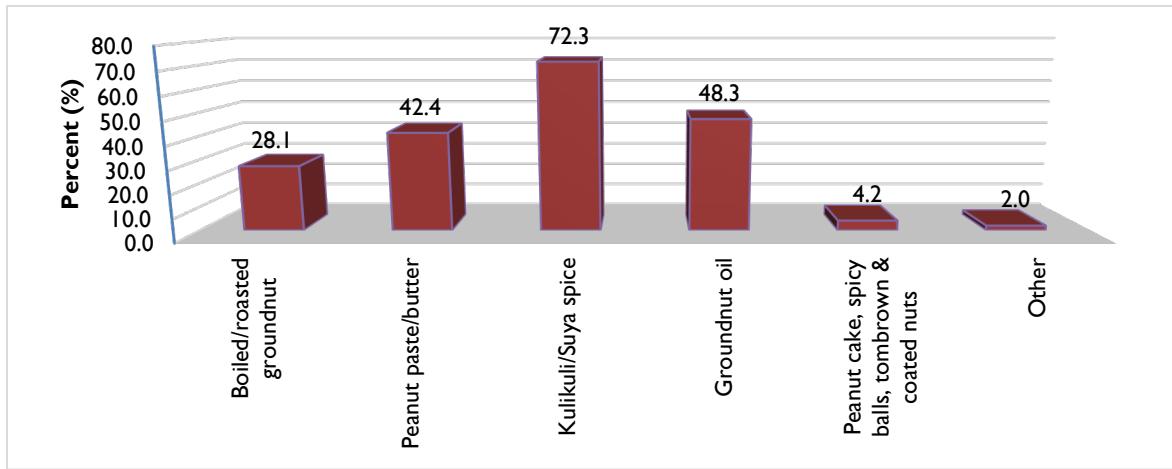


Figure 4: Types of ground-based processed products

Source: Field Data, 2023

Below are some field pictures of groundnut-based processed products.



Plate 11: Kulikuli (locally packaged)



Plate 12: Kulikuli (modernized-packaged)



Plate 13: Kulikuli (modernized-packaged) (modernized-packaged)



Plate 14: Groundnut oil



Plate 15: Groundnut paste (freshly milled) (freshly milled)



Plate 16: Suya sauce spice (freshly milled)

Main reason for processing groundnut

The reasons women are engaged in groundnut processing were for both consumption and sales (71%), own consumption only (15.3%) and sales only (13.7%). See Figure 4.

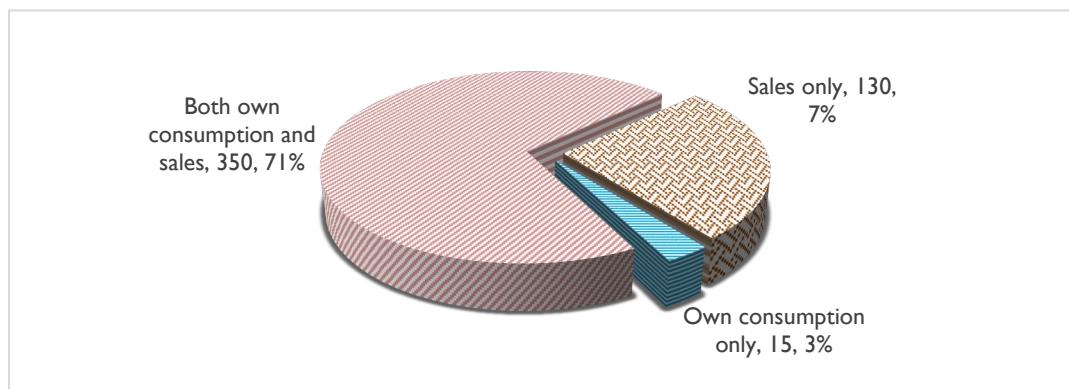


Figure 5: Main reason for processing groundnut

Training received by groundnut processors.

The study sought to establish whether women (495) who were into groundnut processing have received training and the forms of training received. Only a few women (13%) had received training in groundnut processing which mostly covered oil extraction (8.1%), roasting (7.8%) and drying (7.1%) through to milling (3.4%). Further details on the various training regimes received by women are indicated in Figure 6

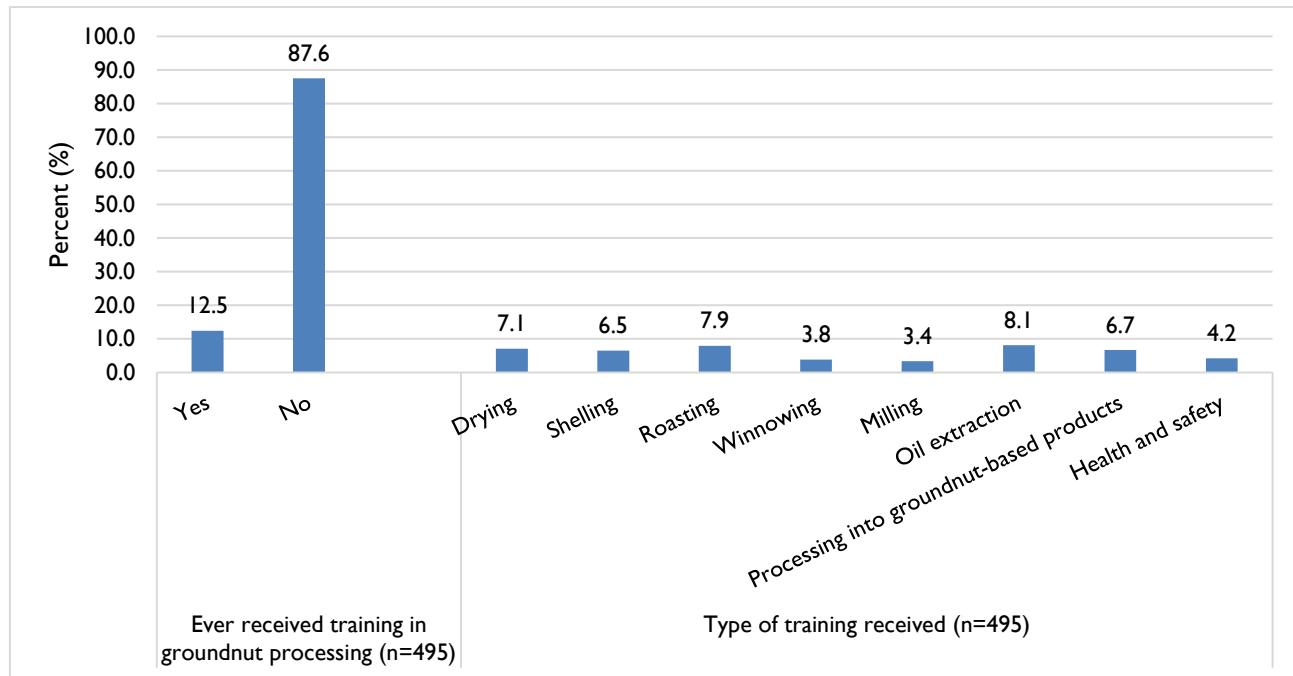


Figure 6: Forms of training received by groundnut processors.

Most women (42%) had received training in the last 12 months preceding the survey (see Figure 7)

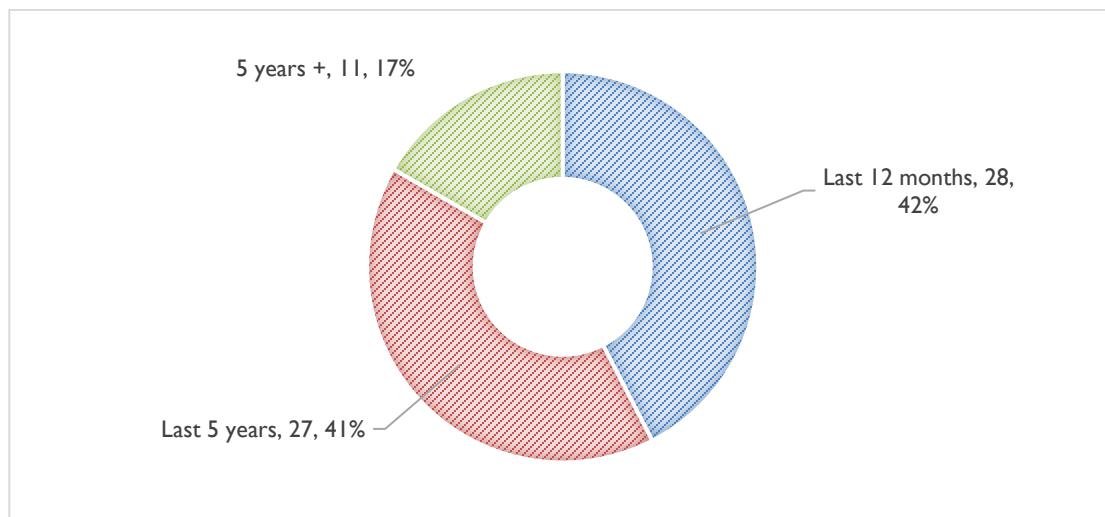


Figure 7: Last training received.

Place of groundnut processing

Figure 8 indicates that most of the processing activities (76%) took place in homes.

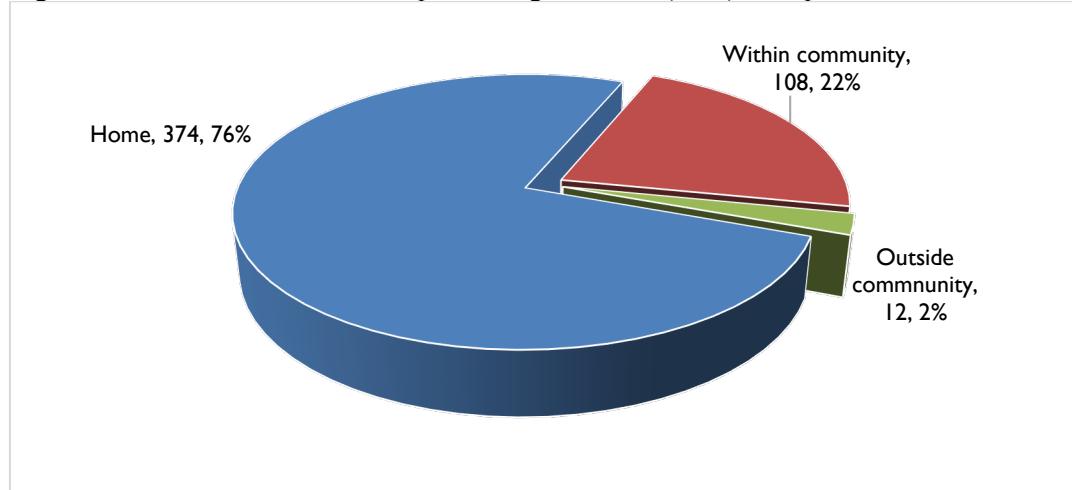


Figure 8: Place of groundnut processing

Self-reported profitability of groundnut processing

As shown in Figure 9, the majority (59.6) had experienced small gain/profit from groundnut processing, with very few (0.6%) recording significant losses.

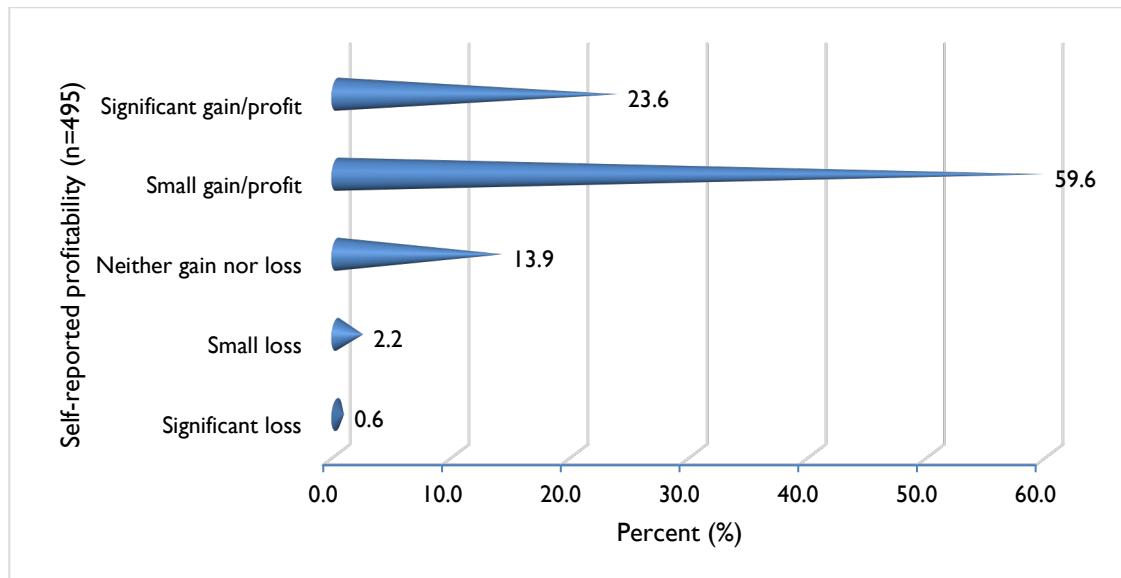


Figure 9: Self-reported profitability of groundnut processing

4.2 The impact of groundnut processing on women's economic empowerment

Description of women's empowerment in Northern Ghana

Table 7 presents the results of the pro-WEAI, calculated as the weighted mean of two sub-indices: the three domains of empowerment index (3DE), with a weight of 90% and the gender parity index (GPI), with a weight of 10%. The average 3DE score for women is 0.74 with an aggregate pro-WEAI score of 0.76 for women. In terms of overall empowerment, 48.5% of women and 52.6% of men in this sample are empowered. This implies that more than half (51.5%) of women is not yet empowered compared to 47.4% of men. About 94.2% (801) of the 850 women in the sample belong to dual-adult households, with the remaining 5.8% (49) belonging to adult female-only households. The overall GPI for the sample was 0.92.

The GPI score shows that in 59.9% of households the female respondent achieved empowerment in as many domains as the male respondent. In households where gender parity was not present, the average empowerment gap between women and men was 19%. The table also reports the average number of adequacies achieved across the 10 pro-WEAI indicators, as well as the three pro-WEAI domains. For instance, out of 10 indicators, the average number of adequacies achieved is 6.8 indicators for women and 6.7 for men. The largest driver of disempowerment – for both male and female respondents – were access to and decisions about credit, attitudes about intimate partner violence against women, autonomy in income, self-efficacy, and work balance (see Figure 10).

Table 7: Pro-WEAI results of women's empowerment in Northern Ghana

Indicator	Women	Men
Number of observations	850	801
Three Domain Empowerment (3DE) score	0.74	0.75
Disempowerment score (1-3DE)	0.26	0.25
% achieving empowerment	48.5	52.6
% not achieving empowerment	51.5	47.4
Number of dual-adult households	801	
Gender Parity Index (GPI)	0.92	
% achieving gender parity	59.9	
% not achieving gender parity	40.1	
Average empowerment gap	0.19	
Pro-WEAI score	0.76	
Number of adequacies achieved (out of 10 pro-WEAI indicators)	6.8	6.7
Number of adequacies achieved for intrinsic agency (0-3)	1.7	1.8
Number of adequacies achieved for instrumental agency (0-6)	4.6	4.5
Proportion achieving adequacy for collective agency (0-1)	0.5	0.4

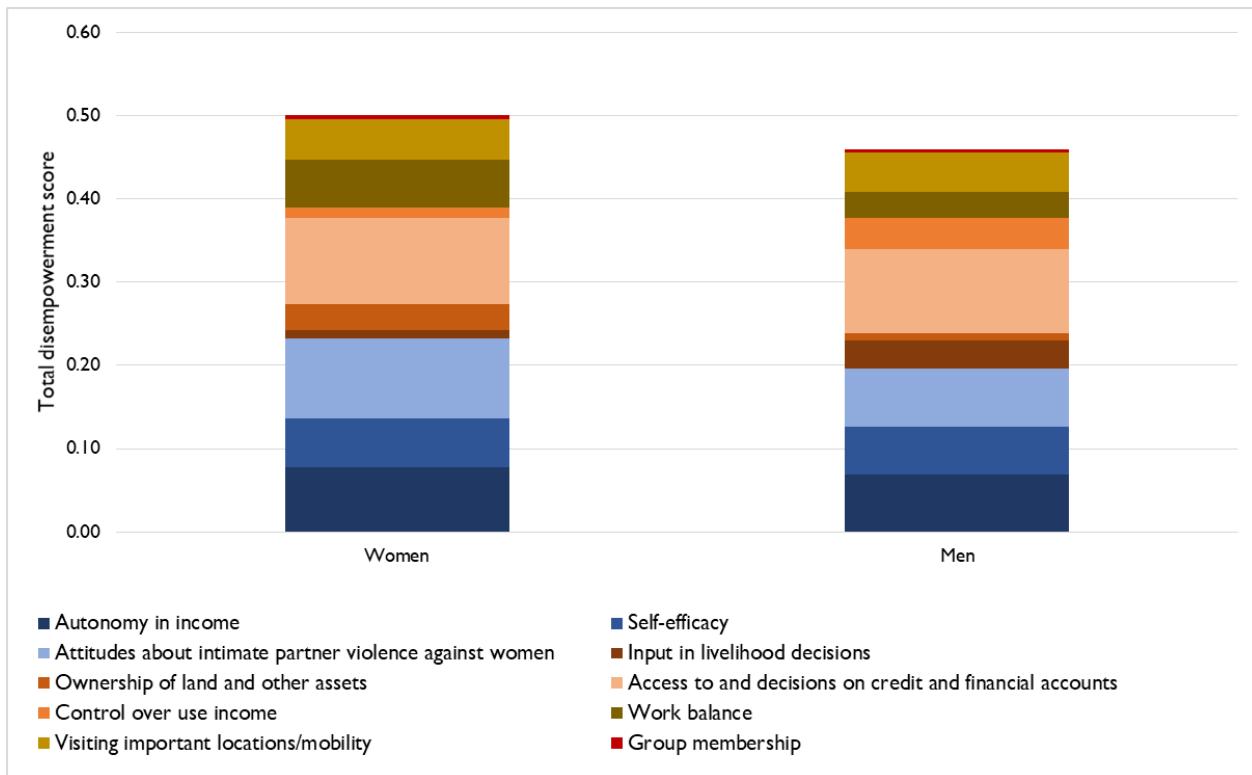


Figure 10: Proportional contribution of Pro-WEAI indicators to disempowerment,

Table 8 reports the adequacy status for each of the 10 pro-WEAI indicators by household type and processing status of women. It is found that women in female-adult-only households (FAHH) are more likely to achieve adequacy across the 10 indicators than their counterparts in dual-adult households (DAHH). This is not surprising because, in adult male and female households, men are traditionally the breadwinners and, therefore, wield most of the intra-household decision-making power. Hence, the absence of men in FAHHs confer all the decision-making powers on the woman; thereby making them more likely to achieve adequacy and become more empowered than women in DAHHs. In DAHHs, women tend to achieve adequacy than men in input into livelihood decisions (94.4%), access to and decisions on credit (45.1%), control over the use of income generated from participation in groundnut processing and other economic activities (92.9%), and active membership of groups (44.3%). However, below 50% of women in DAHHs achieved adequacy in attitudes about domestic violence (43.7%), access to and decisions on credit (45.1%) and active group membership (44.3%). Men are more likely to achieve adequacy in autonomy in income (60.4%), attitudes about domestic violence (56.1%), ownership of land and other assets (94.6%) and work balance (82.1%) than the women in their households.

With respect to the processing category of the women, the results in Table 8 also show that those who only process groundnuts are most likely to achieve adequacy in 5 out of 10 empowerment indicators than their counterparts: autonomy in income (67.6%) self-efficacy (72.9%), input in livelihood decisions (97.6%), control over the use of income (95.2%) and mobility or visiting important locations (78.1%). In contrast, women who produce groundnut only are most likely to achieve adequacy in attitudes about domestic violence (49.9%), access to and decisions on credit (49.3%), work balance (74.5%) and active group membership (49.3%). Women involved in both groundnut production and processing are only most likely to achieve adequacy in the ownership of land and other assets than processors only and producers only. Irrespective of their processing status, it is observed that while more than 70% of the women achieved

adequacy in input in livelihood decisions, ownership of land and other assets, control over the use of income and visiting important locations (physical mobility), less than 50% of women achieved adequacy in attitudes about domestic violence, access to and decisions on credit and active group membership.

Table 8: Percent achieving adequacy for each pro-WEAI indicator by gender and processing category.

Empowerment Indicator	Per cent (%) achieving adequacy					
	Gender			Female respondent category (n=850)		
	Men in DAHH (n=801)	Women in DAHH (n=801)	Women in FAHH (n=49)	Both producer & processor (n=285)	Processor only (n=210)	Producer only (n=355)
Per cent of empowered	49.6	43.3	71.4	35.1	52.9	48.2
<i>Intrinsic agency</i>						
Autonomy in income	60.4	57.9	71.4	57.5	67.6	54.4
Self-efficacy	67.2	67.3	85.7	65.6	72.9	67.9
Attitudes about domestic violence	56.1	43.7	65.3	38.2	45.7	49.9
<i>Instrumental agency</i>						
Input in livelihood decisions	80.5	94.4	100	93.7	97.6	93.8
Ownership of land and other assets	94.6	82.3	91.8	86.3	77.1	83.4
Access to and decisions on credit	42.6	45.1	51	38.9	47.6	49.3
Control over the use of income	78.4	92.9	95.9	92.3	95.2	92.4
Work balance	82.1	68.4	81.6	61.4	70.5	74.6
Visiting important locations	73.4	73.5	81.6	75.8	78.1	70.1
<i>Collective agency</i>						
Active group membership	35.1	44.3	69.4	44.6	41.4	49.3
Number of adequacies achieved (out of 10 pro-WEAI indicators)	6.7	6.7	7.9	6.5	6.9	6.9
Number of adequacies achieved for intrinsic agency (0-3)	1.8	1.7	2.2	1.6	1.9	1.7
Number of adequacies achieved for instrumental agency (0-6)	4.5	4.6	5.0	4.5	4.7	4.6
Proportion achieving adequacy for collective agency (0-1)	0.4	0.4	0.7	0.4	0.4	0.5

Empirical results on the impact of grounding processing on women's economic empowerment

The treatment effects of groundnut processing on women's empowerment are reported in Table 9. The effects on overall empowerment are reported in column 1, while columns 2-11 reports the estimated effects on the 10 pro-WEAI indicators. The results suggest mixed but statistically insignificant effects of groundnut

processing on overall women's economic empowerment. In particular, the ATET results show that relative to producers only, women who only process groundnut are about 4% more likely to be empowered. In contrast, women who combine both production and processing of groundnut are about 7% less likely to be empowered than those who primarily produce groundnut. This negative effect of processing on women's empowerment among women who both produce and process groundnut is statistically significant at 5% level when the ATE is considered instead. This seemingly unexpected finding can be attributed to the fact that most of the processing of groundnuts into snacks, pastes, oil, and other products is done on a very small scale, largely for household consumption rather than for commercial purposes. As reported by most processors (60.2%), considering the monetary and time costs of groundnut processing, this consumption-based model of processing is not profitable enough to influence women's empowerment broadly and significantly. This is because women only make "*small gains or profits*" which are often channeled into household food consumption. From a policy perspective, this finding suggests that women's economic empowerment interventions stand to benefit from supporting women to specialize in (large-scale) processing of groundnuts instead of combining both production and processing.

Considering the sub-indicators of women's empowerment, the results show that compared to producers only, women who specialize in groundnut processing are more likely to achieve adequacy in self-efficacy (14%), attitude about domestic violence (5%), input into groundnut processing and other livelihood decisions (4%), control over the use of income (3%), and physical mobility (5%). The effects on self-efficacy and input into livelihood decisions are found to be statistically significant at 5% level. However, the probabilities of achieving adequacy in the autonomy in income, ownership of land and other assets, access to and decisions about credit, and active group membership are lower relative to producers only. Noticeably, the negative effects on asset ownership and active membership are significant at 10%. The former can be ascribed to deep-rooted cultural norms which constrain women from acquiring or owning major assets, even when they have the capacity to do so. The latter may be because, with most women using traditional (manual) means of processing, groundnut processing can be time-consuming, which leaves them with limited free time to actively participate in group activities.

Furthermore, the results show that both producers and processors are also more likely to be empowered in the areas of self-efficacy, attitudes about domestic violence, input into livelihood decisions (including groundnut production and processing), ownership of assets, control over the use of income and physical mobility. Except for physical mobility (which is statistically significant at 5%), the effect sizes for both producers and processors in these indicators of empowerment are generally smaller than those for processors only. This further reiterates the argument that fostering specialization in groundnut processing may be more instrumental in improving women's economic empowerment than combined production and processing of groundnut.

Table 9: Treatment effects of processing on women's economic empowerment

	(1) <i>EMP</i>	(2) <i>SELF EFF</i>	(3) <i>ADV</i>	(4) <i>AUT O INC</i>	(5) <i>INPUT DEC</i>	(6) <i>ASSET S</i>	(7) <i>CREDI T</i>	(8) <i>CTRL INC</i>	(9) <i>WORK BAL</i>	(10) <i>MOB</i>	(11) <i>AGM</i>
ATET											
Processor only	0.04 (0.05)	0.14*** (0.04)	0.05 (0.04)	-0.07)	0.04** (0.05)	-0.07* (0.04)	-0.05 (0.05)	0.03 (0.02)	-0.04 (0.04)	0.05 (0.04)	-0.08* (0.05)
Both processor & producer	-0.07 (0.05)	0.06 (0.05)	0.00 (0.04)	-0.09* (0.05)	0.02 (0.02)	0.03 (0.04)	-0.09* (0.05)	0.01 (0.02)	-0.10** (0.05)	0.08** (0.04)	-0.10* (0.05)
Potential-outcome means											
Producer only	0.49*** (0.03)	0.54*** (0.03)	0.69* ** (0.03)	0.53** * (0.03)	0.94** * (0.01)	0.84*** (0.02)	0.52*** (0.03)	0.93** * (0.02)	0.75*** * (0.03)	0.73** * (0.03)	0.49*** (0.03)
ATE											
Processor only	0.03 (0.05)	0.13*** (0.04)	0.09* * (0.04)	-0.04 (0.05)	0.04** (0.02)	-0.05 (0.03)	-0.05 (0.05)	0.03 (0.02)	-0.02 (0.04)	0.02 (0.04)	-0.12** (0.05)
Both processor & producer	-0.08** (0.04)	0.05 (0.04)	-0.00 0.09** (0.04)	- (0.04)	0.01 (0.04)	0.03 (0.02)	-0.08* (0.03)	0.01 (0.04)	- (0.02)	0.07** 0.11*** (0.04)	-0.08* (0.03)
Potential-outcome means											
Producer only	0.47*** (0.03)	0.53*** (0.03)	0.67* ** (0.03)	0.49** * (0.03)	0.93*** (0.01)	0.84*** (0.02)	0.49*** (0.03)	0.92*** (0.02)	0.74*** (0.02)	0.70*** (0.02)	0.50*** (0.03)
No. of observations, <i>N</i>	829	829	829	829	829	829	829	829	829	829	829

Notes: Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. These results are based on the outcome model of the IPWRA estimator (using *teffects ipwra* in Stata). The multinomial logit regression was used for the first stage (treatment model) and the probit model for the second stage (outcome model). ATET and ATE are respectively the average treatment effect on the treated and average treatment effect. *EMP* is the overall binary indicator of women's empowerment, assuming the value of 1 if a woman is empowered, 0 otherwise. Its constituents, self-efficacy (*SELF EFF*), attitudes about domestic violence (*ADV*), autonomy in income (*AUTOINC*), input in groundnut processing and other livelihood decisions (*INPUTDEC*), ownership of land and other assets (*ASSETS*), access to and decisions on credit (*CREDIT*), control over the use of income (*CTRLINC*), work balance (*WORKBAL*), mobility captured by visiting important locations (*MOB*), and active group membership (*AGM*) are also measured similarly. Each empowerment indicator is equal to 1 if adequacy is achieved and 0 otherwise. The control variables include the age of the female respondent, married status, household size, dependency in ratio, female and household head's educational status, access to electricity in the household, and the presence of a permanent market and health facility in the communities.

4.3 The impact of groundnut processing on access to, and consumption of nutritious diets

Description of individual and household dietary diversity

Based on 24-hour dietary recalls, Table 10 shows the percentage of women and their households consuming any food item from different food groups as well as their dietary diversity scores across the processing categories. For women of reproductive age (15-49 years), the average dietary diversity score is 4.5 (out of 10 food groups), with that of both producers and processors (4.8) being slightly higher than producers only (4.1). This suggests that the women in this study consumed less diverse diets, with grains (98.0%), other vegetables (73.9%) and meat, poultry, and fish (73.9%) being the most consumed food groups. The consumption of micronutrient-rich food groups like vitamin-A rich fruits and vegetables (20.7%), dairy products (15.5%), other fruits (18.2%), and eggs (8.1%) are less common. Not more than half of the women reported having consumed pulses (41.4%), nuts and pulses (50.6%), and dark green leafy vegetables (47.6%). In all, only 45.2% of the women in this study achieved the minimum dietary diversity for women (MDD-W) by consuming at least 5 food groups. That is, most of the women (54.8%) consume poor-quality diets, that lack adequate micronutrients.

Considering HDDS, which is an indicator of a household's food security, similar consumption patterns are observed. Out of 12 food groups, the average HDDS is 5.9, with households in processing categories consuming relatively more diverse diets (6.4) than producers only (5.2). As reflective of key ingredients in local diets, cereals (97.4%), vegetables (82.7%), oil and fats (73.1%), fish and other seafood (67.9%) and pulses, nuts and seeds (63.8%) are consumed by most households. The intake of fruits (25.9%), meat (30.8%), milk and milk products (15.5%) and eggs (8.1%) are less common, plausibly due to their limited availability and relatively higher costs for low-income households surveyed in this study.

In sum, the results show that the surveyed women, who are engaged in groundnut growing and processing in northern Ghana, have limited access to nutritious diets, and this is manifested in the low diversity of individual and household diets. However, it is interesting to note that a higher percentage of women who are engaged in any form of processing, either as processors only or both producers and processors, tend to consume more nutritious diets across all food groups than women who only produce groundnuts.

Table 10: Summary statistics of indicators of access to nutritious diets

	Both producer and processor	Processor only	Producer only	Total
<i>Per cent of women consuming food items (24-hour recall) (%)</i>				
Grains	97.9	99.5	97.2	98.0
Pulses	49.1	40.0	36.1	41.4
Nuts and seeds	63.2	55.2	37.7	50.6
Dairy products	16.5	19.0	12.7	15.5
Meat, poultry and fish	73.0	82.9	69.3	73.9
Eggs	11.2	6.2	6.8	8.1
Dark green leafy vegetables	46.7	53.8	44.8	47.6
Vitamin-A-rich fruits & vegetables	26.7	19.0	16.9	20.7
Other vegetables	73.0	80.0	71.0	73.9
Other fruits	23.2	20.0	13.2	18.2
Dietary diversity score for women (count, 0-10)	4.8	4.8	4.1	4.5
Percent of reproductive-age women (15-49 yrs) consuming 5 or more food	49.3	53.6	36.8	45.2

groups	(%)			
<i>Household dietary diversity indicators</i>				
Cereals	97.9	98.6	96.3	97.4
White roots and tubers	50.9	45.2	31.3	41.3
Vegetables	80.4	89.5	80.6	82.7
Fruits	30.2	27.6	21.4	25.9
Meat	34.4	39.0	23.1	30.8
Fish and other seafood	68.8	75.7	62.5	67.9
Pulses, nuts and seeds	75.1	68.6	51.8	63.8
Milk and other dairy products	16.5	19.0	12.7	15.5
Eggs	11.2	6.2	6.8	8.1
Oil and fats	80.7	74.3	66.2	73.1
Sweets and other sugary	38.6	36.2	29.9	34.4
Spices, condiments, and beverages	58.2	58.6	41.1	51.2
Household dietary diversity score (HDDS) (count, 0-12)	6.4	6.4	5.2	5.9
Observations	285	210	355	850

The impact of groundnut processing on access to nutritious diets

Table 11 reports the treatment effects of processing on access to nutritious diets by women and their households. Considering the preferred ATET results in column 1, women (of reproductive age) who only process groundnuts are found to consume 0.42 more food groups than their counterparts who only produce, which is about 10% higher than the average WDDS of producers only (4.1). Similarly, both producers and processors are found to consume 0.46 more food groups (11.2% of 4.1) than producers only. The results in column 3 reveal that processors only are 14%, and both producers and processors are 10% more likely to achieve the minimum dietary diversity for micronutrient adequacy than those who are primary producers. Furthermore, at the household level, it is found that households with stand-alone processors or women who jointly produce, and process groundnut consume about 1.1 more food groups than households with primary producers only. This corresponds to about 21.1% more food groups relative to the average HDDS of 5.2 for producer-only households. These findings are confirmed by the corresponding ATE estimates, albeit a bit larger in magnitude than ATET. In summary, the results show that engagement in groundnut processing either in isolation or in combination with production contributes significantly improved individual and household dietary diversity in northern Ghana.

Table 11: Impact on processing women's and household dietary diversity

	WDDS		MDD-W		HDDS	
	(1) ATET	(2) ATE	(3) ATET	(4) ATE	(5) ATET	(6) ATE
Processor only	0.42** (0.18)	0.69*** (0.20)	0.14*** (0.05)	0.20*** (0.05)	1.08*** (0.20)	1.42*** (0.22)
Both processor and producer	0.46** (0.23)	0.63*** (0.20)	0.10* (0.06)	0.13*** (0.05)	1.11*** (0.26)	1.23*** (0.21)
Potential-outcome means						
Producer only	4.31***	4.16***	0.39***	0.37***	5.29***	5.22***

	(0.13)	(0.12)	(0.04)	(0.03)	(0.12)	(0.12)
No. of observations	619	619	619	619	829	829

Notes: Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. These results are based on the outcome model of the IPWRA estimator. ATE and ATET are respectively the average treatment effect and average treatment effect on the treated. WDDS is the dietary diversity score (out of 10 food groups) for women aged 15-49 years. MDD-W is the minimum dietary diversity for women. It is a dichotomous indicator of whether women 15-49 years of age consumed at least 5 out of 10 food groups the previous day or night. HDDS is the household dietary diversity score, which ranges from 0 to 12 food groups consumed by any household member within the last 24 hours. The outcome models for WDDS and HDDS models are estimated using the Poisson regression, while those for MDD-W are estimated using the probit regression. The control variables include age of the female respondent, married status, household size, dependency in ratio, female and household head's educational status, access to electricity in the household, and the presence of a permanent market and health facility in the communities.

4.4 Impact of processing infrastructure on women's empowerment and access to nutritious diets.

With a focus on the sub-sample of women who are engaged in any form of groundnut processing, this section presents the estimated results of the impacts of processing infrastructure on women's empowerment and access to nutritious diets. The aim is to identify which types of processing facilities are more conducive to women's economic empowerment and consumption of improved diets in northern Ghana.

The impact of processing infrastructure on women's economic empowerment

Table 12 reports the estimated effect of access to different types of processing infrastructure on women's economic empowerment. The specific types of processing infrastructure considered in this study are shellers, roasters and grinding mills.

Effects of access to groundnut shelling machines on women's economic empowerment

The results in panel A show that among the processors, women who have access to shelling machines are significantly more empowered than their counterparts who lack access to them. Those who have access to shelling machines are between 11% (ATET) to 52% (ATE) more likely to be empowered than processors without access to shellers. Both treatment effects are statistically significant at 1%, highlighting the crucial role of increased access to shelling machines in fostering women economic empowerment among groundnut processors.

A possible reason for this finding is that having access to shellers, especially the motor-powered or fully mechanized ones, can save women's time in shelling the raw groundnuts, reduce stress and drudgery from manual shelling, encourage large-scale processing, increase incomes generated from groundnut processing and facilitate the acquisition of assets. In fact, 88.1% and 61.6% of the processors identified timesaving and energy-saving as the key channels through which access to processing facilities can improve their welfare. Other mechanisms identified by processors include increased productivity/efficiency (50.9%), increased income (28.1%), lower costs of production (28.3%), improved control over the use of income (23.8%) and acquisition of assets (16.8%).

Table 12: The effect of processing infrastructure on women's empowerment

A. Access to groundnut sheller	(1) EMP	(2) AUTOI NC	(3) SELFEF F	(4) ADV	(5) INPUTDE C	(6) ASSET S	(7) CREDI T	(8) CTRL INC	(9) WORK BAL	(10) MOB	(11) AGM
ATET											
Access to sheller	0.11** *	0.00	-0.03	0.08	0.14***	0.01	0.10***	0.00	0.02	0.12** *	0.04
	(0.03)	(0.05)	(0.03)	(0.05)	(0.02)	(0.03)	(0.02)	(0.01)	(0.05)	(0.03)	(0.06)
Potential-outcome means											
No access to sheller	0.05	0.65***	0.78***	0.16	0.46***	0.78***	0.03	0.94***	0.61*** *	0.36** *	0.28
	(0.08)	(0.17)	(0.10)	(0.18)	(0.08)	(0.10)	(0.04)	(0.04)	(0.18)	(0.11)	(0.23)
ATE											
Access to sheller	0.52** *	0.25***	0.17***	0.40** *	0.17***	0.12***	0.44***	0.05***	0.03	0.29	0.17
	(0.04)	(0.06)	(0.03)	(0.15)	(0.03)	(0.03)	(0.11)	(0.01)	(0.32)	(0.30)	(0.31)
Potential-outcome means											
No access to sheller	0.32** *	0.61***	0.72***	0.33** *	0.82***	0.82***	0.32***	0.94***	0.64*** *	0.65** *	0.39** *
	(0.04)	(0.05)	(0.03)	(0.06)	(0.03)	(0.03)	(0.03)	(0.01)	(0.05)	(0.04)	(0.07)
Observations (excluding producers only)	485	485	485	485	485	485	485	485	485	485	485
B. Access to groundnut roaster											
ATET											
Access to roaster	-0.01	0.12**	0.06	0.03	0.00	-0.04	-0.08	0.01	-0.04	-0.07** *	0.17** *
	(0.08)	(0.05)	(0.06)	(0.08)	(0.10)	(0.03)	(0.07)	(0.02)	(0.04)	(0.01)	(0.03)
Potential-outcome means											
No access to roaster	0.45* *	0.25	0.48**	0.34	0.96***	0.92***	0.66***	0.92***	0.77*** *	0.97** *	0.94** *
	(0.26)	(0.16)	(0.20)	(0.25)	(0.10)	(0.10)	(0.21)	(0.06)	(0.12)	(0.01)	(0.06)
ATE											
Access to roaster	0.13	0.30***	0.23***	-0.14	0.27**	0.01	0.17	0.06***	-0.39***	-0.07	-0.23

Potential-outcome means	(0.26)	(0.09)	(0.07)	(0.15)	(0.12)	(0.05)	(0.23)	(0.02)	(0.11)	(0.11)	(0.29)
No access to roaster	0.44** *	0.50***	0.63***	0.38** *	0.95***	0.87***	0.50***	0.93***	0.69***	0.83** *	0.60** *
	(0.09)	(0.06)	(0.07)	(0.09)	(0.03)	(0.03)	(0.07)	(0.02)	(0.04)	(0.01)	(0.03)
C. Access to grinding mill											
ATET											
Access to grinding mill	0.05	-0.05	-0.01	0.12** *	0.14	-0.05**	0.09*	-0.01	0.04	-0.03	-0.15** *
	(0.12)	(0.07)	(0.07)	(0.03)	(0.17)	(0.02)	(0.05)	(0.00)	(0.10)	(0.03)	(0.05)
Potential-outcome means											
No access to grinding mill	0.29	0.78***	0.68***	0.03	0.83***	0.94***	0.08	0.99***	0.60*	0.89** *	0.94** *
	(0.41)	(0.25)	(0.23)	(0.09)	(0.16)	(0.06)	(0.16)	(0.02)	(0.33)	(0.11)	(0.14)
ATE											
Access to grinding mill	0.45** *	0.19**	0.15	0.48**	0.27**	0.06**	0.49***	0.04***	-0.11	-0.03	-0.44** *
	(0.13)	(0.09)	(0.13)	(0.22)	(0.11)	(0.02)	(0.06)	(0.01)	(0.30)	(0.32)	(0.06)
Potential-outcome means											
No access to grinding mill	0.38** *	0.66***	0.70***	0.29** *	0.91***	0.88***	0.33***	0.95***	0.62***	0.79** *	0.58** *
Observations (excluding producers only)	(0.13) 485	(0.08) 485	(0.07) 485	(0.04) 485	(0.05) 485	(0.02) 485	(0.06) 485	(0.01) 485	(0.10) 485	(0.03) 485	(0.05) 485

Notes: Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

These results are based on the outcome (probit) model of the control-function approach to estimating endogenous treatment effects (using *teffects ipwra* in Stata). The multinomial logit regression was used for the first stage (treatment model) and the probit model for the second stage (outcome model). ATET and ATE are respectively the average treatment effect on the treated and average treatment effect. Access to infrastructure is equal to unity if the woman either owns a given infrastructure or has access to it at the community level. *EMP* is the overall binary indicator of women's empowerment. It assumes the value of 1 if a woman is empowered, and 0 if otherwise. Its constituents, self-efficacy (*SELFEFF*), attitudes about domestic violence (*ADV*), autonomy in income (*AUTOINC*), input in groundnut processing and other livelihood decisions (*INPUTDEC*), ownership of land and other assets (*ASSETS*), access to and decisions on credit (*CREDIT*), control over the use of income (*CTRLINC*), work balance (*WORKBAL*), mobility captured by visiting important locations (*MOB*), and active group membership (*AGM*) are also measured similarly. Each empowerment indicator is equal to 1 if adequacy is achieved and 0 otherwise. The control variables include age of the female respondent, married status, household size, dependency in ratio, female and household head's educational status, access to electricity in the household, the presence of a permanent market and health facility in the communities. The difference in the quantity of each infrastructure available within the community and the quantity owned by individuals are included as an additional (instrumental) variable in the first stage regression.

These assertions are to some extent confirmed by the remaining results in Table 12. The results on the sub-components of empowerment reveal that having access to shelling machines increases the likelihood of achieving adequacy in autonomy in income, attitudes about domestic violence, input into livelihood decisions, ownership of assets, credit access and related decisions, control over the use of income, work balance, physical mobility (i.e., visiting important locations) and active group membership. The ATET coefficients are generally not statistically significant, except for input into livelihood decisions, access to and decisions about credit, and mobility). However, most ATE coefficients are both larger than the ATET coefficients and highly significant at a 1% level (except for models 9–11). In essence, the ATE results show that larger improvements in the empowerment outcomes would be experienced by all processors if they had access to shellers.

Effects of access to groundnut roasters on women's economic empowerment

The results in Panel B show the effects of access to groundnut shellers on women's economic empowerment. As shown in column 1, the treatment effects (ATET and ATE) on overall empowerment are mixed and statistically insignificant. This may be due to the limited availability and access to improved roasting techniques/facilities. It is observed that groundnut roasting is predominantly manual (traditional), which tends to be laborious, time-consuming, and hazardous as women are exposed excessively to heat and smoke. These undermine their health and women's empowerment. In this sample, only a handful of processors either own or have access to the semi-mechanized cylindrical roasting drums.

The disaggregated results on the sub-indicators show that women who have access to roasters have higher likelihoods of being adequate (or empowered) in the autonomy in income, self-efficacy, input into livelihood decisions (including groundnut processing), and control over the use of income. These are particularly significant when the ATE results are considered. However, access to roaster is found to hurt work balance, mobility, and active group membership. Arguably, the traditional means of roasting groundnut places a significant burden on women's time, thereby restricting their engagement in other activities including visiting important locations and actively participating in groups/associations.

Effects of access to grinding mills on women's economic empowerment

Another critical processing infrastructure along the groundnut value chain is the grinding mill. It is important for milling roasted groundnut into paste. The paste is often further processed into cooking oil (groundnut oil), and snacks (mainly *kulikuli*), which command higher market values than unshelled, shelled, or roasted groundnuts. The results in Panel C show the treatment effects of access to milling machines on overall empowerment as well as its sub-components. The estimated effects of grinding mills are 0.05 and 0.45 for ATE and ATET respectively (column 1). They are both positive suggesting that groundnut processors who have access to a grinding mill are about 5% to 45% more likely to be empowered than those who have no access. The estimated ATE is statistically significant at 1%. This empowering effect of grinding mills is plausible because, relative to shelling or roasting, milling groundnut into paste constitutes and leads to higher forms of value addition (including oil extraction and processing into snacks), which attract higher market values. This may improve their incomes and broadly promote women's empowerment. The results also show that having access to the mills can markedly improve their attitudes about domestic violence, input into livelihood decisions, and access to and decisions about credit. Again, the estimated ATE coefficients on autonomy in income and control over the use of income are positive and statistically significant at the conventional confidence levels. However, access to grinding mills may significantly lower active group membership, possibly due to long waiting times at the milling facilities. As noted, before (see section 4.2) most grinding mills are not dedicated to milling groundnuts, so the majority of the processors have to wait in long queues, sometimes even late into the night, for their groundnuts to be milled. According to the mill operators interviewed, unlike maize, the groundnut paste is sticky and leaves residues in the milling machines; the cleaning of which takes time as the machine would have to be dismantled and later re-assembled. In view of these disruptions, the operators do not prioritize the milling of groundnuts. This results in long waiting times, which may inhibit processors from actively participating in their group activities.

The effect of processing infrastructure on access to nutritious diets

Table 4.11 presents the effects of processing infrastructure on women's and households' dietary outcomes. The results show that access to groundnut shellers positively affects the dietary diversity of both women and their households. Contrary to prior expectations, the results indicate that access to roasters and grinding mills may impede the intake of diverse diets, especially at the household level. However, these effects are generally not statistically significant. Overall, the quantitative results show no conclusive evidence of the direct effects of processing infrastructure on access to, and consumption of nutritious diets.

Table 13: The effect of processing infrastructure of women's and household dietary diversity

	WDDS		MDD-W		HDDS	
	(1) ATET	(2) ATE	(3) ATET	(4) ATE	(5) ATET	(6) ATE
Type of infrastructure						
Access to groundnut sheller	0.28 (0.22)	0.18 (0.21)	0.08* (0.05)	0.05 (0.05)	0.36 (0.23)	0.33 (0.23)
Potential-outcome means						
No access to groundnut sheller	4.67*** (0.11)	4.54*** (0.13)	0.49*** (0.03)	0.48*** (0.03)	6.31*** (0.13)	6.12*** (0.15)
Access to roaster	-0.15 (0.23)	-0.01 (0.21)	-0.03 (0.05)	0.00 (0.05)	-0.52** (0.25)	-0.39* (0.22)
Potential-outcome means						
No access to groundnut roaster	4.77*** (0.16)	4.78*** (0.13)	0.53*** (0.03)	0.52*** (0.03)	6.66*** (0.17)	6.56*** (0.14)
Access to grinding mill	-0.19 (0.21)	-0.28 (0.20)	0.00 (0.05)	-0.00 (0.05)	-0.39* (0.24)	-0.41* (0.22)
Potential-outcome means						
No access to grinding mill	4.67*** (0.14)	4.78*** (0.12)	0.49*** (0.03)	0.50*** (0.03)	6.43*** (0.17)	6.51*** (0.14)
No. of observations	365	365	365	365	485	485

Notes: Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. These results are based on the outcome model of the IPWRA estimator. ATE and ATET are respectively the average treatment effect and average treatment effect on the treated. WDDS is the dietary diversity score (out of 10 food groups) for women aged 15-49 years. MDD-W is the minimum dietary diversity for women. It is a dichotomous indicator of whether or not women 15-49 years of age consumed at least 5 out of 10 food groups the previous day or night. HDDS is the household dietary diversity score, which ranges from 0 to 12 food groups consumed by any household member within the last 24 hours. The outcome models for WDDS and HDDS models are estimated using the Poisson regression, while those for MDD-W are estimated using the probit regression. The control variables include the age of the female respondent, married status, household size, dependency in ratio, female and household head's educational status, access to electricity in the household, the presence of a permanent market and health facility in the communities. The difference in the quantity of each infrastructure available within the community and the quantity owned by individuals are included as an additional control variable in the first stage regression.

4.5 Pathways through which groundnut processing contribute to improvements in women's economic empowerment.

Results of the treatment models

Reported in Table 14 are the results of the estimated treatment models for groundnut processing decisions and access to processing infrastructure. Based on a multinomial logit estimated the results in columns 1 and 2 show the potential determinants of decisions to be a processor only or both producer and processor relative to being a producer-only. The probit regressions in columns 4–5 model the drivers of access to processing facilities among women who engage in any form of groundnut processing. While most of the coefficients in all specifications are not statistically significant, some general conclusions can be drawn about the

association of the covariates and the treatment variables.

Women who had any form of formal education, achieve control over the use of income, own more assets either solely or jointly with their spouse and have access to the market within their communities, are more likely to engage in groundnut processing only than only producing it. Control over use income and higher community infrastructure index is found to significantly encourage women who only process groundnut. In contrast, it is found that age, being married, household size, dependency ratio, household head's educational status, the presence of electricity in the household and residing in a rural area are inversely associated with the likelihood of processing compared with producing only. Geographically, it is shown that women in Nandowli-Kaleo, East and West Mamprusi, Tolon, Kumbugu and Central Gonja districts are significantly less likely to be processors only than those in Wa Municipal. Among women who combine groundnut production and processing, the results show that asset ownership is an important factor. Like the producers only, formal education, control over the use of income, and access to markets are estimated to be positively associated with the decision to combine both production and processing of groundnuts.

With respect to access to processing infrastructure (columns 3–5), it is found that household size, dependency, and control over the use of income market access are associated with access to shelling machines, roasting machines, and grinding mills. Interestingly, it is observed that the presence of these processing facilities within the community does guarantee access, given their negative and statistically significant coefficients. This can be explained by the field observation that although the facilities may be available in their communities, some processors access processing facilities in other communities because the local user fee may be comparably too expensive; long queues at existing facilities in their communities of residence; or these facilities are inoperative.

Table 14: Estimated treatment models of groundnut processing and access to processing infrastructure

	Multinomial logit for processing status		Probit model for access to infrastructure among processors		
	(1)	(2)	(3)	(4)	(5)
	Processor	Both producer & processor	Shelling machine	Roasting machine	Grinding Mill
Age of respondent (years)	-0.01 (0.01)	0.00 (0.01)	-0.01 (0.01)	-0.01* (0.01)	-0.01 (0.01)
Woman is married	-0.17 (0.36)	0.43 (0.35)	-0.00 (0.22)	0.10 (0.23)	-0.19 (0.22)
Household size	-0.03 (0.03)	0.03 (0.02)	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Dependency ratio	-0.08 (0.11)	-0.06 (0.09)	0.07 (0.07)	0.09 (0.07)	0.12* (0.07)
Women had any formal educ.	0.01 (0.32)	0.04 (0.29)	-0.47** (0.20)	-0.17 (0.19)	-0.05 (0.19)
Head had any formal educ.	-0.01 (0.27)	-0.42 (0.27)	0.40** (0.17)	0.08 (0.17)	0.23 (0.17)
Woman achieved control over the use of income	1.30*** (0.49)	0.32 (0.35)	0.10 (0.28)	0.29 (0.29)	0.50* (0.30)
Number of assets solely/jointly owned	0.07 (0.05)	0.15*** (0.04)	-0.01 (0.03)	-0.06** (0.03)	-0.10*** (0.03)
Electricity in household	-0.26 (0.57)	-0.04 (0.57)	0.19 (0.33)	0.29 (0.33)	0.66* (0.37)

Health facilities in community	0.25 (0.66)	-0.01 (0.50)	-0.42 (0.46)	1.26 *** (0.36)	0.72 ** (0.33)
Market in community	0.27 (0.54)	0.02 (0.55)	0.38 (0.40)	0.46 (0.31)	-0.46 (0.31)
Community infrastructure index	1.13 *** (0.43)	-0.13 (0.39)			
Leave-out number of shelling machines in community			-0.07 *** (0.02)		
Leave-out number of roasting machines in community				-0.18 *** (0.04)	
Leave-out number of grinding mills in community					-0.02 ** (0.01)
Resides in a rural area	-0.74 (0.48)	-0.16 (0.52)	-0.42 * (0.24)	0.36 (0.24)	-0.43 * (0.24)
Nandowli-Kaleo	-4.11 *** (0.78)	-16.33 (397.18)			
West Mamprusi	-0.92 * (0.49)	1.05 * (0.56)	0.20 (0.25)	0.32 (0.26)	0.10 (0.34)
East Mamprusi	-3.68 *** (0.73)	-1.43 ** (0.59)	0.26 (0.42)	1.23 ** (0.51)	-0.41 (0.37)
Tolon	-3.52 *** (0.63)	0.27 (0.67)	0.92 ** (0.43)	-0.26 (0.27)	-0.66 ** (0.26)
Kumbugu	-0.11 (0.63)	1.06 (0.71)	0.64 * (0.36)	0.33 (0.30)	-0.33 (0.30)
Central Gonja	-0.91 * (0.55)	1.35 ** (0.61)	0.82 (0.53)	-0.66 ** (0.29)	-1.02 *** (0.29)
Constant	-0.19 (1.37)	-1.64 (1.33)	-0.12 (0.73)	-2.04 *** (0.74)	-0.67 (0.76)
Observations	850		495	495	495
LR χ^2	450.8		49.3	74.6	47.9
p-value	0.00		0.00	0.00	0.00
Pseudo R ²	0.25		0.09	0.12	0.08

Pathways to women's economic empowerment

Given that most of the covariates included in the outcome models of women's empowerment have low explanatory power (see Annex 7. Click [here](#) for Appendix 7), in this section we conduct some bivariate analysis to explore the potential pathways through which processing might influence women's economic empowerment. The results are reported in Table 15. The results in panel A suggest a significant association between having a formal education on overall women's economic empowerment, specifically through increasing the likelihood of achieving adequacy autonomy in income, self-efficacy, access to and decisions about credit, and mobility (visiting important locations). However, formal education alone is shown not to be enough in fostering holistic empowerment among female processors, given that it is negatively associated with probabilities of being adequate? (empowered) in the areas of attitudes about domestic violence, input into groundnut processing and other livelihood decisions, control over the use of income and work balance.

Panel B shows that having access to credit is empowering as a whole and fosters active group membership. Processors who received training in groundnut processing are more likely to be empowered than those who did not (Panel C). Training which builds the capacity of the processors is shown to positively influence the individual indicators of women's empowerment, except autonomy in income, control over income and work balance (as training places extra demand on women's time). Furthermore, processors who belong to the high-income households (i.e., third- and fourth-income quartile) have a higher chance of being empowered than in lower-income households (Panel D). This finding is consistent across all specifications for the individual indicators of women's empowerment. In Panel E, the results that the higher the household size, the lower the probability of being empowered overall and in all of its forms. With women being the primary caregivers, relatively high household size puts an extra burden on them by increasing both domestic (reproductive) and productive responsibilities, depleting limited household resources, and constraining her time for other activities that may bolster their empowerment.

Put together, Panel F shows that access to formal education and credit are statistically important factors determining women's economic empowerment among the processors. While income and access to training in groundnut processing are positively associated with women's empowerment, their effects are not statistically different from zero. High household size may be inimical to efforts to promote women's empowerment, especially among the groundnut processors in Northern Ghana.

Table 15: Probit estimates on potential drivers of women's empowerment among processors

	(1) <i>EMP</i>	(2) <i>AUTOIN C</i>	(3) <i>SELFEF F</i>	(4) <i>ADV</i>	(5) <i>INPUTD EC</i>	(6) <i>ASSET S</i>	(7) <i>CREDI T</i>	(8) <i>CTRL INC</i>	(9) <i>WORK BAL</i>	(10) <i>MOB</i>	(11) <i>AGM</i>
Panel A											
Had any formal education	0.41*** (0.15)	0.29* (0.16)	0.60*** (0.18)	-0.07 (0.15)	-0.40* (0.23)	0.08 (0.18)	0.45*** (0.15)	-0.28 (0.21)	-0.14 (0.15)	0.73** (0.21)	0.17 (0.15)
Constant	-0.25*** (0.06)	0.25*** (0.06)	0.40*** (0.06)	-0.20*** (0.06)	1.77*** (0.11)	0.92*** (0.07)	-0.26*** (0.06)	1.57*** (0.10)	0.42*** (0.06)	0.64** (0.07)	-0.20** (0.06)
Panel B											
Had access to credit	0.71* (0.37)	0.21 (0.37)	0.02 (0.37)	-0.08 (0.36)		0.50 (0.52)		-0.09 (0.52)	-0.30 (0.35)		0.93** (0.39)
Constant	-0.20*** (0.06)	0.30*** (0.06)	0.49*** (0.06)	-0.21*** (0.06)	1.67*** (0.10)	0.92*** (0.07)	-0.23*** (0.06)	1.52*** (0.09)	0.40*** (0.06)	0.71** (0.06)	-0.19** (0.06)
Panel C											
Received training on processing	0.19 (0.17)	-0.03 (0.17)	0.29 (0.19)	0.18 (0.17)	0.50 (0.41)	0.40* (0.23)	0.33* (0.17)	-0.14 (0.25)	-0.47*** (0.17)	0.28 (0.20)	0.22 (0.17)
Constant	-0.21*** (0.06)	0.30*** (0.06)	0.45*** (0.06)	-0.24*** (0.06)	1.64*** (0.10)	0.89*** (0.07)	-0.23*** (0.06)	1.54*** (0.09)	0.45*** (0.06)	0.70** (0.07)	-0.20** (0.06)
Panel D											
High-income household	0.11 (0.11)	-0.05 (0.11)	-0.12 (0.12)	-0.11 (0.11)	0.03 (0.19)	0.13 (0.13)	0.28** (0.11)	-0.07 (0.18)	0.00 (0.12)	0.32** (0.13)	0.42** (0.11)
Constant	-0.24*** (0.08)	0.33*** (0.08)	0.55*** (0.08)	-0.16** (0.08)	1.66*** (0.14)	0.87*** (0.09)	-0.33*** (0.08)	1.55*** (0.13)	0.39*** (0.08)	0.58** (0.08)	-0.38** (0.08)
Panel E											

Household size	-0.05*** (0.02)	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.02)	-0.01 (0.02)	-0.04*** (0.01)	-0.01 (0.02)	-0.02 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Constant	0.24	0.46***	0.66***	-0.04	1.83***	1.00***	0.18	1.60***	0.55***	0.86**	* -0.04
	(0.15)	(0.13)	(0.13)	(0.14)	(0.19)	(0.16)	(0.14)	(0.18)	(0.13)	(0.15)	(0.13)
Panel F											
Had any formal education	0.34** (0.15)	0.27* (0.16)	0.59*** (0.18)	-0.11 (0.15)	-0.44* (0.24)	0.06 (0.18)	0.39** (0.16)	-0.29 (0.22)	-0.17 (0.16)	0.72** * (0.21)	0.12 (0.16)
Had access to credit	0.71** (0.36)	0.23	0.06 (0.37)	-0.05 (0.36)	0.48 (0.36)	-0.08 (0.51)	-0.08 (0.52)	-0.31 (0.36)	0.81** (0.41)	-0.31 (0.21)	
Received training on processing	0.13 (0.17)	-0.05 (0.17)	0.29 (0.19)	0.18 (0.17)	0.48 (0.43)	0.38 (0.23)	0.25 (0.18)	-0.15 (0.25)	-0.50*** (0.18)	0.20 (0.21)	0.14 (0.17)
High-income household	0.13 (0.12)	-0.05 (0.12)	-0.14 (0.12)	-0.10 (0.12)	0.04 (0.20)	0.11 (0.14)	0.27** (0.12)	-0.04 (0.18)	0.07 (0.12)	0.29** (0.13)	0.41** (0.12)
Household size	-0.05*** (0.02)	-0.01	-0.01 (0.01)	-0.02 (0.01)	-0.02 (0.02)	-0.01 (0.02)	-0.04*** (0.01)	-0.01 (0.02)	-0.02* (0.01)	-0.01 (0.02)	-0.02 (0.01)
Constant	0.06 (0.16)	0.41*** (0.15)	0.54*** (0.15)	0.00 (0.15)	1.90*** (0.23)	0.88*** (0.18)	-0.09 (0.15)	1.74*** (0.20)	0.67*** (0.15)	0.57** * (0.17)	-0.27* (0.15)
Observations	495	495	495	495	482	495	482	495	495	482	495

Robust standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.6 Qualitative Results

Background of study participants

Table 16 presents information on the number of interviews conducted and the number of participants per interviews. In all 24 In-depth Interviews (IDIs), 18 Key Informant Interviews (KIIIs) and 20 Focus Group Discussions (FGDs) were conducted across the four project regions (Northern, Savannah, North-East and Upper West). A total of 156 participants were involved in the various interviews conducted.

Table 16: Number of interviews per interview type

Type of Interview	Number conducted	Number of participants
Northern Region		
In-depth Interviews (IDIs)	4	4
Key Informant Interviews (KIIIs)	5	5
Focus Group Discussion (FGD)	2	18
Savannah Region		
In-depth Interviews (IDIs)	3	3
Key Informant Interviews (KIIIs)	4	4
Focus Group Discussion (FGD)	2	15
North-East Region		
In-depth Interviews (IDIs)	4	4
Key Informant Interviews (KIIIs)	2	2
Focus Group Discussion	4	33
Upper West Region		
In-depth Interviews (IDIs)	13	13
Key Informant Interviews (KIIIs)	7	7
Focus Group Discussion	12	48
TOTAL	62	156

The ages of all three categories of the respondents (KIIIs, IDIs and FGDs) ranged from 20 to 65 years. All the participants (especially the women) were married with their farm sizes ranging from 1 acre to 11 acres.

4.7 Perceptions on Level of Development and Access to Processing Infrastructure

This section presents the qualitative findings on the perceived level of development of processing infrastructure focusing on availability, and women's access to processing infrastructure in northern Ghana. The analysis is structured along the lines of three main themes that emerged from the data: i) level of development and availability of processing infrastructure, ii) access to, and use of processing infrastructure, and iii) challenges that inhibit access to and use of processing infrastructure by women in Northern Ghana.

Perceptions on level of development and availability of processing infrastructure

A common theme that emerged from the interviews and FGDs was concerns about the low level of development of processing infrastructure along the leguminous value chain. Across all the interviews, participants expressed a general concern that while groundnut production and processing is a key economic activity engaged in by women in northern Ghana there remains insufficient processing infrastructure to facilitate the development of the groundnut value chain. A key informant interviewed for instance rated the level of development of processing facilities along the leguminous value chain as follows:

On a scale of 1-10, I will say 2. 1 is the lowest and 10 is the highest. This means that the legume

value chain is not developed in terms of processing capacities. There is not enough development around that area partly because there hasn't been attention towards the legume processing value chain (KII, WIAD Officer, West Mamprusi)

In line with the quantitative findings, the processing infrastructure that participants frequently mentioned to be key to groundnut processing infrastructure are shellers, roasters, oil extractor, and grinding mill. A consistent theme from the interviews is that shellers appear to be the common processing infrastructure available to women processors compared to roasters, oil extractors and grinding mills. However, in most cases, the available shellers were said to be few (e.g., either one or two) serving all women processors in an entire community. Even with this, some women interviewed indicated that it is the traditional, rather than the mechanized sheller, that is commonly available.

We have the groundnut Sheller, but we don't have the other processing infrastructure here. We have a corn mill in this community that is used for both groundnut processing and milling of corn (FGD, woman processor, Nakori).

No, I don't have a tarpaulin. What I have is just fertilizer sacks that I washed and sewed together to form a large one to be using for my drying. Roaster too we don't have, I mostly use a pot to roast the groundnut (IDI, Woman processor, Sankpala).

The qualitative findings support the quantitative findings that the limited availability of processing infrastructure meant that women processors resort to traditional or manual processing mechanism as a way to process their groundnut. A 48-year-old male noted that:

The machines they don't have it. Most of them do it using their labour and the traditional practice. They [women] use some plane wood/board to process the kulikuli, and they also use a pot to roast the groundnut as well (IDI, Male Respondent, Nakori).

We lack some of the processing facilities. For example, the roaster because we don't have some here, we have to use our pots and open fire to roast the groundnut and I takes a lot of time and energy (IDI, Female Processor and producer, Tosinape).

In some communities there were no processing facilities even though the women were engaged in groundnut processing as the main source of livelihood activity.

In this community, we do not have any processing machines. They are all at Zangbalang. We usually have to wet the groundnut after harvesting and take it to Zangbalang to shell. Because we don't have the machines here, it is an additional cost to carry the groundnut to the next community to shell (FGD, Female Processor, Gbugbli).

The problems we face are many. But I can say the main one is the lack of processing infrastructure in the community. We don't even have one machine here and it costs us a lot to carry it to the next community to process (IDI, Female processor and producer, Gbugbli).

Access to and Use of Processing Infrastructure

This section focuses on women's access to and use of processing infrastructure focusing on the ownership structure of available processing infrastructure, accessibility and cost associated with the use of processing infrastructure, type of groundnut products processed by women, and sources of groundnut for processing.

Ownership, access, and cost associated with the use of processing infrastructure.

The few existing processing infrastructures were situated mostly in the urban areas. In some cases, the few available infrastructures are mostly owned and operated by men. This is probably a reflection of the huge capital outlay required in procuring and establishing a groundnut processing factory. The women at the interviews and FGDs provided insights into the ownership structure of the available processing infrastructure at the community level:

The sheller and grinding mill are all owned by men. The shellers and corn mill here belongs to a certain man so, anytime you want to shell your groundnut, you go there and do it (IDI, female processor, Naro)

All of us sitting here usually use the public infrastructure in the town mostly owned and operated by the men (FGD, Female processor, Walewale).

A key informant interviewed in one of the communities also confirmed that:

For the ownership, they are owned by men. So far, I have not seen any woman owning one yet (KII, Male respondent, Wambong).

Field observations and interviews show that in most cases the women processors prefer to use processing infrastructure that is owned by women provided this is available in the community.

"I have been operating this machine for more than 13 years. Recently one woman also put up some of the facility here. so now all the women go to that place. It has made my sales go down (IDI, Male respondent, Wapani).

Analysis of the interview reveals that in some cases, women also served as owners of processing infrastructure. Where this was the case, the infrastructure was mostly owned by women in a group or association and not necessarily individual women. Although men were found to be the dominant owners of available processing infrastructure, the operations or day-to-day running of the infrastructure are mostly done by women (e.g., wives) as evident in the quote below:

The grinding mill yes, it is operated by the owner himself. But for the shellers, it is the owners' wives that operate them. Unless there is a lot of pressure on them that the owners himself will also come to operate them (IDI, Female processor, Sankpala).

There was a consensus among the interviewees that there is no cultural, gender or generational division or restriction in terms of access to processing facilities. All social groups including women, youth and even men of different ages can access the processing facilities provided they have the means (i.e., money) to access and use them. In other words, there is no gender division in access to processing facilities, and that the only restrictions to the use of processing facilities is the money needed to pay for the service charge.

No gender bias in access, as far as you have money you can have access whether you are a man or woman and you have the means to pay and use it (IDI, Female Processor, Kparigu)

We normally access service with no barrier whether a man or a woman as far as we have our monies so there are no restrictions (IDI, Female Processor, Nakori)

These narrations demonstrate that access to groundnut processing facilities attracts a fee. Data collected on the cost of processing groundnut shows that the service charge is dependent on the type of service being rendered and local contextual circumstances. For example, the cost of shelling a bag of groundnut ranged from GHS7 to GHS10. The reported service charge for roasting is GHS 2 per bowl. Others however reported paying usually GHC15 per bag for roasting groundnut, but this had increased to GHC 20 during the field research owing to the upward rise in electricity bills.

With the cost of roasting, at first, it was GH₵15.00 per bag but now because of the light bill it has increased to GH₵20.00 per bag (Female, FGD, Processor and Producer, Tosinape)

In terms of the cost of milling groundnuts the findings show that the service charge ranges from GHS 2-5 per bowl. However, in some communities where women processors resort to using corn-mill facilities to process their groundnut, they are sometimes compelled to pay a relatively higher price for the service. This is evident in the narrative below:

Because it's a corn mill and the only one in the community, the man charges huge if he accepts to grind groundnut. Sometimes, the man feels like we are forcing him. So, he always charged you anyhow if you want to grind ten bowls of groundnut, sometimes even take you about 50cedis or 40 cedis to grind instead of 10cedis (IDI, Female Processor, Gbanko).

This suggests that in communities where there is lack of a dedicated processing facility for milling groundnut, corn mill operators may charge more than the prevailing service charge for processing groundnut.

Type of products processed by women.

In terms of the type of products processed, analysis of the interviews revealed that women are engaged in the processing of different groundnut products of which the most cited ones include groundnut paste, kulikuli and groundnut oil. Many of the women interviewed spoke about the various products that they process using groundnut:

*We use groundnut to produce Kulikuli, oil, groundnut paste, salted groundnut for chewing, groundnut cake, "yaage" (Spiced groundnut flour for chichenga) (FGD, Female Processor Busa)
We can process it into only groundnut paste and kulikuli. Yes, we always do this. Okay, so in preparing the kulikuli you always mash it, and the oil will come so we sell the oil and make the kulikuli too to sell (IDI, Female Processor, Gbanko).*

The key informants confirmed that groundnut paste, kulikuli and groundnut oil are the major products that women processors engage in processing:

Yes. Most of our women are into groundnut production, and after producing the groundnut, they try to add value to it by shelling or doing other processing activities to it. A lot of them are into kulikuli production, others too extract the oil from the groundnut, and some too do groundnut paste, if we had these facilities they could produce at a larger scale (KII, WIAD officer, Wa)

Other women participants reported processing groundnut into other products such as groundnut cake locally called 'yaage', as well as roasting groundnut for sale. In a minority of cases, some women reported mixing the groundnut with beans, maize, and soya bean to prepare Tom Brown for sale.

we sometimes mix it with beans maize and soya beans to make local "tom brown". We also process into "yaaje," boiled/salted groundnut for chewing (FGD, female processor, Nakori)

Three main themes emerged on the sources of groundnut for processing. First, some women processors are producers themselves and therefore source groundnut from their own or family farms. Second, some women reported buying groundnut from farmers or the local market for processing.

I usually buy it. Those that farm the groundnut usually bring it to Sankpala here and then I buy it. But when I buy it, it is not yet shelled. I must now take it to the sheller to be shelled (IDI, female processor, Busa).

Third, others reported sourcing groundnut both from their farm and purchase groundnut from the local market for processing. Irrespective of the source of groundnut for processing the scale of processing is generally low. A key factor accounting for this is because the women who are producers and processors are mostly smallholder farmers with land holdings of not more than 3 acres. The findings show that women engaged in the production of groundnut would mostly harvest between 2-8 bags but would process between 2-5 bags. The remaining is stored for sale in the future to meet household expenditure be it for children's school expenses or buying of household items among others. Those who buy from the local market equally lamented that they have limited capital to buy groundnut in large quantities for processing:

I mostly buy the groundnut at the local market and process it. Now the price of groundnut is high. It is not easy to buy a lot of the groundnut for processing (IDI, Female processor, Wapani).

Interestingly while groundnut paste appears to be one common type of product processed by women processors, our analysis of the interview data revealed that most communities lack a dedicated grinding mill for groundnut processing. Field observations and interviews show that there is only one processing center in Wa Municipality in the Upper West region where women had access to groundnut oil extractors in addition to a dedicated groundnut mill, shellers and roasters. This was confirmed by the Women in Agricultural Development (WIAD) Officer interviewed in Wa:

We have the sheller, roaster and milling machine for groundnut processing. Some of the milling machines have the oil extractor, but those that do not have it means you have to send it to where they have the oil extractor for you to do it (KII, WIAD officer, Wa).

The limited availability of a dedicated groundnut milling facility meant that most women would mostly make improvisation to process their groundnut. They mostly resort to operators of corn mills to process their groundnut. However, there is a downside to this with most participants reporting that operators of corn mills would only process groundnut for women in the evenings when they are done with processing of all corn that are brought to the facility during the day.

In this community, we do not have a grinding machwe thank Godine for groundnut. We have the corn -mill which we use also for groundnut. But when you go to the facility during the day, the man will tell you that you have to wait until he has processed all the maize. Sometimes it is frustrating because you want to get your groundnut processed early but you have to wait till it is evening (IDI, Female Processor, Busa).

When the women go and the machine operator is grinding corn at the mill, we have to wait till the operator is done with everything before he can attend to us (IDI, Female Processor, Wapani)

These quotes exemplify the concerns shared by the women processors interviewed who narrated their frustration of not being able to process their groundnut during the day. The implication is that women have to spend more time at corn-mill facilities to get their groundnut processed. Moreover, some women also reported paying well over the prevailing market price for milling their groundnut when they visit corn mill processing centres to process their groundnut.

Challenges associated with access to processing infrastructure.

This section focuses on the perceived challenges associated with the use of processing infrastructure in northern Ghana. Three main themes emerged from the interviews and FGDs regarding the challenges faced by women concerning access to processing infrastructure. These relate to i) proximity to processing infrastructure, ii) electricity/power concerns, and iii) the nature of the processing infrastructure.

Proximity to processing infrastructure.

A key theme that runs through the interviews and FGDS on challenges faced by women in relation to access to processing infrastructure is proximity or distance to the facility. It emerged that within a given district the distribution of processing facilities is not evenly spread. Observations and interviews show that urban areas seem to have more different kinds of processing facilities compared to rural areas.

Well, to be honest, they are not very uniformly distributed. Most of them are centered in the Walewale township and a few in the outskirts so for some of them you have to journey for several kilometers from the boundaries to the town to access them (KII, WIAD officer West Mamprusi).

This finding suggests that rural women engaged in processing are more likely to move beyond their communities to access processing infrastructure. Indeed, interviews confirmed the fact that depending on their location rural women have to travel long distances to access processing infrastructure such as roasters, shellers and mills.

If we have it here, we wouldn't be moving to other neighboring towns to process our groundnuts, they will be coming to us (FGD, Female processor, Gbanko)

One of the obvious implications of not having processing facilities within the communities is the extra cost associated with transporting the ground to and from the nearby processing facility. This extra burden is likely to be more related to women processors in rural areas many of whom indicated that not having processing facilities within their communities contributes to the extra cost of processing. This cost manifests mainly in the transport and labour of people to support the transportation. Others reported that transporting the groundnut to nearby communities or towns is time-consuming and stressful.

Sometimes the hustle in carrying 5 basins of groundnut to process in Wa is very stressful, very costly and time wasting. Some people even know how to do Kulikuli but the absence or inability to access the facilities is making them not to even venture into it (FDG, Female Processor, Nakor).

Going to Kaleo to grind has to do with the lorry fare and how much they will charge you. The lorry fare is expensive. You will have to add the cost to the price of the groundnut paste, that is how you can get some profit after selling it. Because there is none in this community and we always must go to Wa, we incur a lot of costs. Sometimes after the sale of the groundnut, you would not make enough profit because of the cost of transportation (IDI, Female processor, Gbanko)

In a situation where the women do not have the financial resources to travel to the next available town to process their groundnut, they resort to manual processing.

We mostly travel to Wa to get our groundnuts processed. Some of us too resort to manual processing. We have a corn mill in this community that is used for both groundnut processing and milling of corn, but it is not easy to get your groundnut processed compared to the corn (FGD, Female processor, Nakori)

Because there are no processing facilities, it is very difficult to process the groundnut. Unless we take the groundnut to a very far distance to access the processing facility. If I have no means, I can't do anything about the situation (IDI, Female Processor, Nakori).

In contrast, women especially those who live in urban areas or near communities where processing facilities are available reported that the situation is currently better compared to previous years when they had to transport their groundnut to and from processing centres with the additional burden of extra cost.

In the past when the machines were not there, we had to carry the groundnut all the way to the next community just to process and that was an extra cost. But now that we have some here, we can manage and get some processing done (FGD, Female Processor, Tosinape).

In effect, the distance to processing facilities represent a major challenge for all women processors although the extra burden is likely to be more common for rural women engaged in the processing of groundnuts.

Unreliable power supply

Unreliable power supply represents another challenge that affects women's ability to process groundnuts. In some communities, the interviewees noted that unreliable power supply has contributed in part to the breaking down of some processing facilities (e.g., corn mills.)

Another is the power/ electricity to power some of the machines. We have only one transformer which causes a lot of fluctuations and has even spoilt one of the mills (KII, Assemblyman Wambong)

Some women noted that in the absence of electricity they are compelled to resort to traditional means to process their groundnut:

Sometimes we have no option but to resort to processing machines powered by manpower which is too slow and consumes a lot of time (FGD, Female processor, Walewale).

Discussions with women processors and operators of processing facilities indicate that in addition to the unreliable power supply, there has also been a recent spike in electricity tariffs which has compelled operators to increase the service charge for processing groundnut and other commodities. Moreover, the women reported that the prolonged power outages affect their ability to prepare their household meals.

If the absence of electricity persists for a week, we will not be able to prepare food in our houses as most of our food goes through the grinding mills before preparation (FGD, Female processor, Walewale).

Nature of processing facilities

Some interviewees stated that the processing facilities they use have deteriorated which sometimes affects the quality of the processed groundnut. Others noted that because they have no access to mechanized processing infrastructure, they are compelled to resort to the traditional way of processing groundnut which is highly labor-intensive and time-consuming. This leads to drudgery and affects the quality of the processed groundnut.

The machine we have here is old. So, I employ the services of many people to help me in manually kneading the grinded groundnut which makes the entire process tiring, time-consuming and inefficient (FGD, Female processor, Busa).

Sometimes the delays at the grinding mills cause a lot of fatigue and delay the timely production of products, the use of the corn mill doesn't also help in the proper grinding/processing of the groundnut. Manual shelling also impedes on producing at a higher scale (Woman Processor, FGD, Busa)

This was also confirmed by a key informant interviewed in Wa. The participants complained about high levels of aflatoxin, which was said to sometimes affect the taste and quality of processed groundnuts. The women processors noted that high levels of aflatoxin contamination are generally caused by poor drying and storage methods of groundnuts. The WIAD Officers and MoFA Directors interviewed noted that the high levels of aflatoxin in groundnuts pose serious threats to human health and has serious economic implications resulting from lost trade opportunities. Currently, it is not known how much damage aflatoxin has caused among the consumers. At the time of the study, testing for aflatoxin was not available in the

study areas. This means that investing in aflatoxin testing and detection centres as well as sensitizing farmers and processors on appropriate methods of drying and storing will promote exports.

Benefits of Access to processing infrastructure

This section focuses on women's perception of the benefits connected with their access to processing infrastructure. Two main themes emerged on the benefits of access to processing infrastructure: i) efficiency and timesaving and ii) value addition and income.

Efficiency and Timesaving

Across all interviews, participants expressed the view that having access to processing infrastructure contributes to efficiency in the ways that women process their groundnut. According to the interviewees, the traditional processing method is extremely labor-intensive and time-consuming. For example, a participant expressed the view that it could take about a week or several days to shell a bag of groundnut. Achieving the target sometimes required the support of the labour of family and other relations. A downside to this is that those helpers may sometimes consume some of the groundnuts while assisting with shelling as reported by a key informant:

Also, in the past when the machines were not there, they did the processing by hand. For instance, the shelling of the groundnut was done by hand, and it could take about a week to deshell a whole bag. Sometimes they needed help and when people come to help, they would be eating some of the groundnuts when shelling it by hand (KII, Assembly Man, Wambong).

In the past, we used to do all our shelling by hand. And you can imagine shelling a bag of groundnuts. By the time you finish all your fingers are hurting. In addition, it can take about 1 week to shell just 1 bag of groundnuts (KII, Traditional leader, Wambong).

However, having access to processing infrastructure has meant that women processors could get their groundnut processed in the most convenient, efficient, and faster way which contributes to reducing drudgery.

.....now I can process my groundnut faster because at first, after roasting the groundnut, I had to pound the groundnut until it was smooth, and it was very tiring. But now that the processing machines are there, I can just process my groundnut today and tomorrow I'm selling the products in the market (IDI, Female processor, Tolon).

Value addition and income

Another important theme that runs through the interviews on the benefits of processing infrastructure is value addition and associated income. Across all interviews, participants expressed concerns about the quality of processed groundnut especially when processed using traditional methods. This had implications on their ability to sell their processed groundnut at a good price. However, having access to processing infrastructure contributes to improvement in the quality of the product.

Now that the processing infrastructure is around, we can now shell our groundnuts faster and much easier. Because of the fast nature, we can now sell the groundnut at higher prices to earn enough money (IDI, Female Processor, Tolon)

I think access to the processing infrastructure generally improves product quality and adds value to your products. So, anybody who gets access to these is on the upper hand to make money (KII WIAD officer, Mamprusi).

4.8 Processing Infrastructure and Women's Economic Empowerment

This section presents the findings on the participants' conceptualization and understanding of empowerment, attitudes towards women's economic empowerment and the impact of processing infrastructure on women's economic empowerment.

General perceptions and understanding of empowerment.

Four main themes emerged from the interviews on participants' conceptualization of empowerment, namely access to income and providing for the household, freedom of movement, being a member of an association/group and respect among household members/social recognition.

Access to Income and Providing for the household.

Participants' conceptualization of empowerment highly reflected access to income and the ability to provide for the household. Respondents conceptualized women's empowerment as "*the ability to acquire income (the means) to be able to take care of your family*". They perceived empowerment as being able to achieve economic independence and overcoming financial constraints, which in turn could improve social status and enhance decision-making power within the household. For them, access to income and the capacity to provide for ones' family's basic needs is evidence of empowerment. Women's ability to exercise agency and to contribute to meeting household basic needs is equated to women's empowerment. When a woman can provide food and other necessities for the children, she is said to be empowered.

"I will use the leader of our women's group to define an empowered woman. She makes her own money and can provide and take care of her family. Also, before entering groundnut processing, I was not able to buy basic things but now, my living conditions have improved. When you have money, you can take care of yourself and your family, I will call that empowerment" (FDG, Female Processor, Kumbugu).

"I can buy my children's clothing, send them to school and buy uniforms. Also, when my husband provides money, I support it with what I have. So yes, I will use my condition to define empowerment and an empowered woman. I even pay our health insurance" (IDI, Female Processor, Gbugli).

"An empowered woman can provide for herself and her family. An empowered woman supports the husband when he does not have. We even have one woman in our group that is economically empowered. Even though the husband is late she can do everything on her own the way she wants it" (FDG, female Processor, Samategu).

"Women empowerment is just about helping someone, especially the women...it is about giving women money or support that will enable the women to be on their own without depending or relying on their husbands or on other men" (IDI, Female Processor, Gambaga).

Most of the women in the selected communities are usually provided only the staples like maize, millet, and rice by their husbands. Therefore, being able to earn income to support and buy ingredients to prepare meals for the household was considered as a form of empowerment. This feeds into the autonomy in income (intrinsic agency) and access to and decisions on financial services and control over the use of income (instrumental agency) within the Pro-WEAI framework.

Freedom of movement and ability to attend functions.

Another dominant theme within the conceptualization of empowerment was freedom of movement and the ability to attend functions. Participants' perception of empowerment involved being free to go to places that are of importance to them and being able to attend social functions. Participants emphasized the importance of being able to attend social functions such as group meetings, funerals, weddings, naming ceremonies and participating in market days and other gatherings without any constraints or limitations.

“Our group leader can make her own money and is able to attend functions. Even though she must inform her husband about attending important functions, she is able to be present at different gatherings because she has nice clothes to wear and the means to get there. So, if someone can do this, we will say that she is empowered (FDG, Female Processor, Kumbugu).

“I will see empowerment as being able to travel from this community. We do inform our husbands when travelling and when we return. But being able to travel from the house is empowerment” (FDG, Female Farmer and Processor, Gbugli).

The idea of empowerment as freedom of movement and social participation highlights the role of social and physical mobility in empowering individuals and communities. This reflects the “visiting important locations” indicator under the intrinsic domain of the Pro-WEAI framework.

Being a Member of a Group or Association

The women processors in our study reported that one of the ways through which people may experience empowerment is by being a member of a group or an association. This was said to offer women a sense of belonging, social support, and collective action. The women discussed that being part of a group provide a form of social support as well as the emotional and practical assistance that members of a group offer each other. The participants emphasized that being part of a group also creates a sense of belonging and connection, which in turn enhances their self-esteem, motivation, and resilience. The value of peer learning and mentoring within a group context was said to enable women acquire new skills and knowledge and overcome challenges. The women often cited the Village Savings and Loans (VSLA) as a practical avenue for women’s empowerment. They highlighted the value of collective decision-making within the VSLA which enables them to pool their resources to satisfy their individual and collective needs.

I will say that empowerment is being part of a group. We have a women’s group. Forming it was our idea, but the efforts of an NGO have augmented it. We are about 50 in number. We always help each other, attend each other’s functions, and help one another when in need. The group has also empowered us because of unity in mind. We are also on the WIAD platform. The WIAD platform gives us information on our processing business and agriculture in general (IDI, Female Processor, Gbugli).

Empowerment means the ability to belong to a group or an association. I belong to a women’s group, and we have Adakabla. In this community, we have about four of them with 30 women in each of them. We meet every week, and we contribute a minimum of 10 Ghana Cedis a week and share it at the end of the year according to what everyone contributed. Being part of this group really helps us a lot so I will see it as a form of empowerment (FDG, Female Producer and Processor, Tosinape).

Generally, the women in our study believe that they have gained a voice in saying what needs to be done in their local communities after they became members of groups/associations. These findings provide insights into the complex and nuanced ways through which individuals experience empowerment in a group setting. It further highlights the importance of social support and collective action, in shaping women’s sense of agency, autonomy, and control.

Respect among Household Members and Social Recognition

Participants also conceptualized empowerment to encompass respect among household members and social recognition. Across the interviews and FGDs participants agreed that feeling respected by household members is an important aspect of empowerment. This include being able to make decisions that affect ones’ lives, being heard, and being able to speak about their needs. Also, gaining recognition from the social environment is recognized as an important aspect of empowerment. This recognition often comes from

various sources, including community members, household members and society. It was revealed that once a person's contributions, abilities, and achievements, are recognized by the people around them, they feel a sense of pride, their self-worth is improved, and they feel comfortable being part of their household and the larger community.

"The women also see empowerment as gaining respect in the household. Women must feed the family and they are part of VSLA and are able to support their family. Once they can do this, they gain some form of respect and recognition from the household. So, socially, they are gaining recognition in their households and communities" (IDI, Northern Regional WIAD Officer, Tamale).

When you have money, you can take care of yourself and not depend so much on your husband. In that case, you are respected by your husband and other family members. You are even recognized by other members, especially when you are part of and able to contribute to the Adakabla (FDG, Female Processor, Kumbugu).

As observed in some selected communities, respect among household members, being able to voice opinions and social recognition are considered important components of empowerment, particularly for women who face social barriers or discrimination.

"I will call a woman who is able to make important decisions in her life and to put those into action an empowered woman because knowing the kind of society we have where it is male dominated with respect to owning assets, decision making, a woman of that caliber is empowered. She can have control over her assets, has control over her decision making and even has control over the money that she is making. She decides where or how she uses it, so I call such a person an empowered woman" (KII, WIAD officer, West Mamprusi)

These contribute to the understanding of empowerment as a multidimensional and context-dependent concept that is shaped by individual, social, and cultural factors. It was found that household relationships impact women's sense of empowerment and disempowerment. The threat of domestic violence or conflict for instance, may inhibit some women from exercising their agency to make decisions to benefit themselves, their children, or others. This was largely the case in polygamous households as co-wives could come into conflict with the study's women processors due to jealousy and the obligation to rotate cooking days for the household. It is important to consider such diversity among women and across households in groundnut processing interventions.

4.9 Attitudes Towards Women's Economic Empowerment.

The general attitudes of individuals towards women's economic empowerment play a significant role in determining the success of gender equality efforts. The analyses revealed two divergent themes in terms of attitudes towards women's economic empowerment namely, positive, and negative attitudes.

Positive Attitudes Towards Women's Empowerment

Most of the participants expressed a positive attitude towards women's empowerment. The positive perceptions came from participants' understanding that when women are empowered, they not only benefit personally, but also contribute to the overall development of their families and communities. They recounted improvement in household well-being, health, and nutrition outcomes as well as general household stability that comes with women's economic empowerment. In Gbugli, a male respondent expressed that:

Well, I can say the husband will be happy because it means she will be supporting him in taking care of the household (KII, Male Respondent, Gdugli).

This is an important and revealing assertion, particularly coming from a male in a context where gender norms and patriarchy are highly dominant. He gladly accepts a woman being empowered and further agrees that women providing financial support in the household does not undermine the man's authority but constitutes a great help in response to household needs. This reflects the growing recognition of the importance of gender equality and the need to support women's access to productive resources for development. Throughout the interviews, participants recounted the support that empowered women provide for their husbands and family:

Men in this community take the glory when their wives are empowered because it lessens their burden. The Man doesn't have to worry so much about children's school fees, no worries about what the household members will eat as his wife is already supportive and can handle that. Men who have women that are empowered enjoy some degree of support and if you chat with them one-on-one, they can tell you that as for my wife if I hadn't met her, I don't know where I will be (KII, WIAD Officer, West Mamprusi District).

Their husbands respect them and mostly see them as help mates since they can also contribute to the development of the family. If a woman is empowered to do what she pleases, it even helps the man to shred off some of his burdens. It even goes a long way to save some of the produce of the farm since the family wouldn't be selling everything because of the woman's help (FDG, Female Producer and Processor, Gbankor).

Another important aspect of the positive attitude towards empowerment is the fact that the female participants saw such empowered fellows as role models and that they consult for advice and guidance. They saw such women as those who have been able to break the status quo and are worth emulating.

For this community, we the women, when we happen to see a woman like that, we are happy because we can approach her to also show us how she managed to empower herself. If it is that she can help, then she does but if she can't help then maybe she can give us some advice as to what to do (FDG, Female Producer and Processor, Tosinape).

We perceive an empowered woman to be a good thing and aspire to be like that. We see empowered women as one who could help other women in need. We go to such people for advice; they are role models (IDI, Female Producer and Processor, Wambong).

across all interviews and FGDs, participants generally had positive attitudes towards empowered women which mainly arose from the empowered woman's contribution to the provision of food, paying of fees, support of the household and acting as a role model for other women in society.

Well, I cannot speak for everybody, but for most of us, we do not see it as a problem because it is the benefits that they will use to take care of their family – like providing food and supporting the husband (KII, Male Respondent, Tolon).

"Husbands encourage the empowerment of women because the money is used to help the entire household. The men even give the women money for processing so that the household gets a lot of money. So, empowerment is generally seen as a good thing." (FDG, Female Processor, Kumbugu).

This is indicative of a positive shift in societal norms and values, towards gender equality and the empowerment of women. The results further point out that people are becoming more accepting and supportive of women earning income through groundnut processing to support the family and taking charge of their lives irrespective of gender norms and stereotypes.

Negative Attitudes Towards Women's Economic Empowerment

Some of the respondents had personal reservations about empowered women and the need for women's economic empowerment in totality. These attitudes were often manifested in the restriction of women's

access to resources, employment, household, and communal decision making and in extreme cases gender-based violence. The negative attitudes held by a section of the respondents were hinged around the perception of empowered women as either “*disobedient or having stubborn ears*”. Empowered women were “allowed” to keep their empowerment to themselves and help their families in silence, but not to rub it in the faces of their husbands or become “*arrogant*”.

From where we are, that is Dagbani culture, even if you the woman are that strong and God willing you are able to get even more money than your husband to look after the family, you have to hide and do it because if you come out to brag about it, people will talk bad about you and your husband will not be happy with that (IDI, Female Processor, Tolon).

A woman can be enlightened, wise, abled, and independent who can stand on her own. But a woman should not be so vociferous or try to exhibit any domineering character as this can break a home or lead to divorce (FDG, Female Producer and Processor, Busa).

The woman who is empowered must help her husband in private. If she does not let their household issues come out and is able to help her husband, then we see her as good. But when she does not do that, like every time she comes out to brag about helping her husband then in that case the men or her husband will not see her in a good image, but it will be like she is challenging them (IDI, Female processor, Tolon).

It could be deduced that being empowered as a woman had dire consequences, including negative talks by society, conflicts in the household and as severe as divorce. When these negative attitudes persist, even when some women can attain “power within” (intrinsic agency), they will not be able to exercise “power to” (instrumental agency) and “power with” (collective agency). The attitudes of individuals towards women's empowerment are shaped by a complex range of factors, particularly cultural norms, and personal experiences.

4.10 Impact of Groundnut Processing on Women's Economic Empowerment

The key themes that emerged from the analyses of the interviews and FGDs in terms of the impact of groundnut processing on women's economic empowerment are access to income, input into decision making, ability to save, asset acquisition, freedom of movement, social recognition and improved self-worth, group association and general economic well-being.

Access to Income

Access to income was identified by the interviews and FGD participants as a crucial component of women's economic empowerment. Groundnut processing using the available (and accessible) processing facilities have provided a valuable source of income for most of the women in the communities. One of the main responsibilities of the women was providing for the general upkeep of their families, including turning the staples provided by their husbands into full meals every day, and paying children's school fees, and hospital bills, among other things. It was evident that the women who were into groundnut processing, could sell the processed groundnuts and earn income, which was used to meet their household needs. The participants recounted how groundnut processing using processing facilities has provided women with the means to support themselves and their families.

...with the processing that is basically my livelihood. I can make my own money instead of depending on what my husband gives me to take care of my needs (IDI, Female Processor, Tolon).

As for the money, nowadays it is the women who are getting more money than we the men oo. You're laughing but it is true. Now most of them are doing other works that are getting them more money like this groundnut processing (KII, Assembly Man, Wambong).

The benefits are many. But what I can say is that, in terms of money, I have been able to get some money through the processing and sale of the oil and the kulikuli. When the market is good and I use about GHS100.00 to invest I can get about GHS35.00 or GHS40.00 on it and that money I can use to solve my problems and other things (IDI, Female Processor, Sankpala).

The main benefit I can say is that I have been able to get enough money from the sale of the groundnut to look after myself and my children. I can buy the things I want without having to always ask my husband for money (IDI, Female Processor, Sankpala).

The cloth I am wearing right now, I was able to buy it using the income I got from the processing of the groundnut (FDG, Female Processor, Tosinape).

The women that engage in the groundnut processing can sell and get some money to take care of some of their needs but the women who don't process the groundnut will have to depend on what their husbands give them to take care of their needs. Also, it gives some form of work rather than sitting down idle (FDG, Female Producer and Processor, Tosinape).

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It is evident from the interviews and FDGs that groundnut processing infrastructure is improving women's access to income and promoting their economic independence.

Input into Decision Making

Experiences shared by the participants indicate groundnut processing with the aid of the available processing infrastructure has increased women's bargaining power within households and communities, giving them greater influence over decision-making. This included decision-making related to groundnut production and processing and decision-making related to income.

Production and processing decisions

It was observed that women usually made decisions related to groundnut production and processing. Because men were the primary decision-makers, women needed to inform them in most decision-making processes. This notwithstanding, women initiated the decision to either produce or process groundnuts or both. They normally discuss with their husbands and seek their approval. Regarding production, they get the land from their husbands to cultivate because access to land was largely in the hands of men. With groundnut processing, women usually get some capital from the husband in addition to the husband's "blessings" to start the venture. However, once the business was in motion, the woman solely decides the percentage of groundnut to sell in the raw state or process, how and when to process, which facilities to use and which products to process the groundnuts into. This enabled the women some degree of autonomy to undertake the groundnut processing venture.

We make processing decisions together. We decide together. So that when I am in need, he could help. When I don't have groundnut, my husband gives me some groundnut to process. This brings us income. We are not given daily chop money so this what we do for income (IDI, Female Producer and Processor, Wambong).

We inform our husbands about what we do when we are travelling and the business, we do that, so they know what is happening and support us. The decision about processing groundnut is done with our husbands (FDG, Female Producer and Processor, Gbugli).

When I want to engage in any activity, I tell my husband about it and get his consent. But I can make some decisions even though my husband's consent is important. Getting his consent is necessary to get his support when the need arises (IDI, Female Processor, Kumbugu).

I was processing before marriage and after marriage, I informed my husband, and he gave me his consent and money to add to what I had. We therefore make decisions regarding processing together. Whatever activity you engage in, you must inform your husband and get consent (IDI, Female Processor, Sankpala).

Another important issue observed was that, even though women were able to make decisions regarding the production and processing of groundnuts, they saw seeking the consent of the husband as critical. This was not necessarily to get their approval, they saw it as a way of getting the husband on board, so he would help them when they run into trouble or when something bad happens.

Decision-Making Regarding the Use of Income

The ability to decide how to use income is a crucial component of WEE. Barriers to financial independence and control over income however remain a challenge in some societies. Meanwhile, this lack of autonomy can limit their economic potential, as well as their ability to make choices that benefit themselves and their families. The analysis of the interview and FGD data revealed that most women have control over their income and can make decisions about how to allocate resources in a way that best meets their own needs and the needs of their families. They were able to decide on, for instance, investing in their children's education, saving for the future, acquiring assets, buying food for the family, or doing nice things for themselves.

I inform my husband about my income. He does not take the money from me. I use it how I want. I only inform him of the money I get but I decide what to do with it (IDI, Female Processor, Kumbugu).

Once I earn money, I inform my husband about it, not necessarily the amount of profit but for him to know that I did not incur a loss. I then use some for-household expenses and save some. My husband also asks me for money, and I am able to give him (IDI, Female Processor, Sankpala).

We inform our husbands about the money, but he does not take it. We use the money for the household. Our husband can ask to use the money for the hospital, school fees and other things (FDG, Female Producer and Processor, Wambong).

Yes, I can say groundnut processing has helped a lot. Because through it, I have been able to get some money to take care of myself and my family and take certain decisions in the house than when I didn't have the business (IDI, Female Processor, Tolon).

It is evident that decisions regarding the incomes made by the women were done almost entirely by most of the women. The men were only informed, but they do not take the money from the women or instruct how the money could be used.

Ability to Save

The qualitative findings suggest that the savings ability of most women had improved due to their engagement in groundnut processing. The savings culture of most women had improved with most women involved in the Village Savings and Loans (VSLA) Through the groundnut processing, the women were able to contribute an amount of money weekly into the VSLA and could access loans periodically or take their monies at the end of the year. Through this, most women were able to put monies aside to buy important assets, pay their children's school fees, and improve their general living conditions. Aside from the VSLAs, some women were also able to save on their mobile money wallets.

I have a mobile money account that I deposit money in from time to time. I am also willing to open a bank account to deposit my money (IDI, Female Processor, Sankpala).

I can save my money in the VSLA box for future use (FDG, Female Producer and Processor, Sankpala).

The VSLA is made up of 30 members, we have about 4 smaller groups. In the groups, we meet once every week on a selected day and then we make contributions or savings. If you have GH₵10.00 or more, you can save it in the box. At the end of the year, we open the box and share the money based on each person's contribution" (FDG, Female Processor, Tosinape).

The women who are doing the groundnut processing are doing much better than those not engaged in it. The reason I said this is because with the groundnut processing the women are able to get work to do and from that work, they have gotten some income to take care of their families and also save some money to start other businesses, but the women not engaged in the groundnut processing are just stagnant unless their husbands give them money or they farm, they cannot get money from anywhere else (KII, Chief, Wambong).

Asset Acquisition and ownership

Another key aspect of women's economic empowerment is the acquisition of assets. Asset acquisition in this context encompasses the process of obtaining and accumulating valuable resources including buildings, land, household items, livestock, and financial assets among others. Asset ownership is a critical factor in determining economic power and stability, as it provides a means of generating income and even building wealth over time. The findings indicate that land acquisition and ownership, as well as other productive resources, lie in the hands of men because "*the man has the power to own so many resources*" (FDG, Female Producer and Processor, Nnora).

This notwithstanding, most women in the research communities were found to have benefited from asset acquisition and ownership because of groundnut processing. While some women were able to solely acquire household assets, others were able to actively contribute to jointly build and/or renovate their houses with their husbands. Some women noted that they had jointly built houses with their husbands and started other building projects.

The one I can remember off-head is the renovation of my house. Through the groundnut processing, I have been able to buy furniture and other nice things for my house (IDI, Female Processor, Tolon). Last year, I was able to buy a fridge for iced selling water and other drinks... (IDI, Female Processor, Kumbugu).

Using myself as an example, my husband has married a second wife, but through the groundnut processing, I was able to get enough money to take care of myself and understand and accepted my husband's second wife. Through this understanding, I have been able to help him to build the house you see behind you [pointing to the house]. Even though it is not finished but because it is for the benefit of all of us, I still contribute my part (IDI, Female Processor, Sankpala)

An interesting finding was when a woman narrated how she actively assisted in the purchase of farm machinery with money from her groundnut processing venture. However, after the purchase, the husband took possession of the machinery due to existing cultural norms that put men in charge of household assets. Nonetheless, her ability to contribute to the purchase of the said assets meant that she could also decide how it was used for the benefit of the household. She explained that:

I helped my husband to buy some tools/machinery for farming. He took ownership of them even though I can decide how they should be used. Sometimes we even buy it ourselves for the family, but the men will eventually take possession of them" (FDG, Female Processor, Busa).

These shared stories and experiences are refreshing, especially where women can actively contribute to the

building of houses and accumulation of other assets.

Freedom of Movement

Another impact of groundnut processing identified by the participants is freedom of movement among women processors. This is an important indicator of women's economic empowerment. It also includes their ability to attend functions for various reasons. Women's ability to attend social, cultural, and religious functions is not only a personal choice but also an essential component of their social and economic well-being.

It was gathered from the study communities that women's mobility has greatly improved through their access to processing infrastructure and their engagement in groundnut processing. First, moving from their households to processing centres made them form networks as they usually moved in groups, especially during peak seasons. In this connection, processing groundnuts is not just a matter of work or business, but a form of socializing, meeting other women and sharing ideas. It emerged that groundnut processing gives women the opportunity to actively participate in almost every market day, to sell their products, buy foodstuffs, and purchase other things that are of importance to them. This ability to move was very important to the women who previously had a home-farm-home routine. Also, the coming together of these women groundnut processors into groups meant they could easily attend functions together with fewer restrictions.

Yes, groundnut processing helps them to move from one place to another. When you want to travel, and it happens you don't have money then you cannot travel. But when the women have their own money, they can move to different places, partake in market days, and attend other social functions (KII, MoFA Rep, Wapaani).

So, as I said, because the miller is in the town, the women move to Wa to process their groundnuts. I think it is impacting positively on their movement (KII, WIAD Officer, Nandowli).

Social Recognition and Improved Self-Worth

Women's access to processing infrastructure and groundnut processing activities has had a significant impact on their self-worth and social recognition. Their access to economic opportunities, such as employment, has increased their income, given them financial independence, and helped them to gain knowledge. This newfound economic power has increased their self-worth and confidence. As the women could earn income, make their own decisions, and take control of their lives, their self-esteem and sense of agency improved. Another important observation was that women found a great sense of self-worth in having something to do other than their traditionally assigned responsibilities.

It always feels good to wake up and know you have some form of activity to do especially in the lean season when farming ceases (FDG, Female Processor, Kumbugu).

So, the groundnut processing helps them in terms of food, and income to supplement the family's needs as well. And, due to that most of them are now part of these groups (VSLAs), where they can save so that they are able to support their husbands and their family heads and their family in general. So, yes, it is empowering them economically, and socially, they are gaining some recognition (KII, Northern Regional WIAD Officer, Tamale).

Evidently, access to processing infrastructure and groundnut processing was found to have had a transformative effect on the lives of most women, leading to increased self-worth, confidence, and social recognition.

Improvement in general economic wellbeing

Interview data shows that access to processing infrastructure for groundnut processing contributes to the general improvement in the economic conditions of women. This manifested largely through an increase in

household income, which in turn contributes to the improvement of the standard of living of most households. Other improved socio-economic outcomes included reduced gender-based violence and discrimination because women become more economically empowered and were better recognized for their contributions to the households.

Through the groundnut processing, I've been able to send one of my children to school and the other has started learning how to sew (FGD, Female Producer and Processor, Gbugli).

For me, I am able to buy the books, pens, pencils and others that my children need for school" (FGD, Female Producer and Processor, Gbugli).

My children, one of them is in SHS and when she needs money or comes home, I'm able to process the groundnut into the groundnut pastes to sell. With the money I get, I give some to her for pocket money and also send some of the Kulikulizim to school, that is what they mix with their gari to eat" (FGD, Female Producer and Processor, Gbugli).

Groundnut processing using processing facilities helps me to get money to pay my children's school fees. It has improved my household cooking and nutrition. It has improved my household's access to good food. I am able to get money for my upkeep and buy clothes, veil, earrings and other things" (FGD, Female Producer and Processor, Kumbugu).

4.11 Perceived impact of processing infrastructure on access to, and consumption of nutritious diets. This section focuses on qualitative findings on the perceived impact of processing infrastructure on women's access to and consumption of nutritious diets. The analysis is structured to cover the two main themes that emerged from the data: i) everyday foods and their affordability; ii) the perceived impact of processing infrastructure on the consumption of nutritious diet.

Everyday foods and its affordability

A common theme that runs through the interviews is that most women engaged in groundnut processing and their households eat three times daily. It is only in a limited number of cases that some women reported not being able to afford three square meals a day. It is striking that most women and their households eat TZ three times daily, especially in the dry season when there is limited access to other food crops.

TZ is our main staple food, and we also cultivate maize in larger quantities as compared to other crops, so it makes it easier to prepare without incurring more expenses (FGD, Female Processor, Nakori).

Almost daily, we eat TZ. We mostly augment the TZ with other foods like rice and beans, but the main food is TZ. When the season of yam is at its peak, we mostly eat fufu but once the season is over, we resort to TZ as our main meal (FGD, Female processor, Busa).

In some cases, interviewees reported that in addition to TZ, they can eat other foods as part of their daily food intake. This was more likely to be the case for households in urban areas with relatively good financial situations. For example, some women interviewed especially those in the urban areas reported that they take in porridge in the morning, eat rice or kenkey or TZ in the afternoon and TZ or fufu in the evening. However, the ability to diversify one's diet was dependent on the household's economic situation.

in the morning it is mostly koko (porridge) or if there is money tea and in the afternoon is mostly TZ or banku or rice. The banku and rice it's only when we get the money to buy. In the evening we mostly eat TZ for the whole house (DI, Female Producer, Gbrumani)

Participants unanimously agreed that prices of foodstuffs and other general items are on the rise which makes it difficult to purchase and consume a variety of foods. The pace at which prices of food are increasing does not match the rise in the income of the women and their households which makes it challenging to

access and consume a variety of foods. The following quotes perfectly sum up this point:

"As we speak now the foodstuff are expensive. Now a bowl of dry okra sells for GHS100.00 and then the dry fish, abowl is about GHS80.00. The things that are somehow affordable are the dry leafy vegetables" (FGD, Female producer, Gbugbli).

"Well now most of the foodstuffs are expensive. You cannot carry the same money to the market and expect to get the same quantity of foodstuffs. So, we just manage with what we have" (IDI, Female Processor, Tolon).

In terms of access to and consumption of fruits, analysis of the interview data demonstrates that there is a wide variety of fruits such as watermelon, mango, orange, pineapple, and banana among others which women processors and their households may consume. However, there was a consensus among the participants that access to, and consumption of fruits is mainly dependent on the farming season and the economic situation of the household in question. It emerged that it is common to find many households consuming fruits especially in the fruit season when fruits are relatively less expensive (affordable).

When fruits are in season, we can eat mangoes, oranges, watermelon, pineapple, and many fruits (IDI, Female Processor, Tolon)

Moreover, urban households were found to be more likely to access and consume fruits in contrast to rural households. This is due mainly to differences in income between urban and rural households:

it depends, when fruits are in season, they can consume but even with that there are still issues because mostly those in the rural communities don't consume the wholesome ones. The story is different when you come to the urban and peri-urban communities. But even in the rural communities where they gather the mangoes to come and sell in the urban communities, they sell the best and reserve those that people will not buy and rather give to the kids to consume. So, the wholesomeness is questionable even at that level where it is available (KII, Female, Nadowli).

It emerged that there is a huge gap in terms of access to and consumption of vegetables. This was attributed to the price associated with vegetables against the odds of budgetary constraints at the households.

Perceived impact of processing infrastructure on access to and consumption of nutritious diet

Analysis of the interview data reveals both a direct and indirect impact of processing infrastructure on women's access to and consumption of nutritious diet.

Direct impact

The direct impact manifests mainly through the consumption of different nutritious foods/meals made from groundnut. It emerged that in addition to processing groundnut for sale, women processors also process groundnut for household consumption. Thus, women engaged in groundnut processing and their households can access and consume various kinds of food made from groundnut. For example, some women interviewees noted that they consume kulikuli as part of their breakfast. In addition, others mentioned using groundnut to prepare groundnut soup for household consumption. Some also reported using groundnut oil to prepare stews and sauces whereas others also consume roasted groundnut as part of their afternoon or evening meals.

Yes, processing groundnut has helped in getting access to a nutritious diet. The oil we get from processing kulikuli is used for household consumption, so we don't have to buy cooking oil. Once I sell my products, I am able to buy other ingredients for the house. When my husband is not able to provide enough, I am able to support (IDI, Female Processor, Sankpala)

Groundnut processing has helped a lot. Because most of our meals have groundnut in them. We use it for our koko, pounded, groundnut with bra, groundnut soup, and also provide money to buy other ingredients (IDI, female Processor, Wambong).

Indirect impact

In terms of the indirect impact of the processing of groundnut on access to and consumption of nutritious diet, it was found that in addition to household consumption, the women process groundnut (e.g., kulikuli, groundnut oil, roasted groundnut etc.) for sale at the local market. The income derived from the sale of processed groundnut provides an avenue for women processors and their households to purchase or access other foods including fish, meat, fruits, vegetables, and other staple foods (aside TZ) among others.

Groundnut processing helps me to access good food/nutritious diet. I am able to sometimes make a profit of 100-200 cedis from kulikuli out of which I am able to buy foodstuffs for the family. This is however not static but fluctuates depending on the market (IDI, Female Processor, Kumbugu)

The processing activities we carry out help us in getting nutritious food. We sell our products to buy ingredients to prepare our food. The by-products from the groundnut processing are also used in the preparation of our food (FDG, Female Processor, Tosinape)

Yes, groundnut processing is helping them because they are now able to buy other ingredients for the house even while at the market (KII, WIAD Officer, Tamale).

In effect access to processing facilities has the potential to provide the opportunity for women to earn income which is invested in a wide range of food items and in the process, women can diversify their diets.

5. Discussion, Policy Implication and Conclusion

5.1 Summary and discussion of key findings

A key finding from this research is that access to time- and labor-saving technology for groundnut processing at individual and community levels is limited. This is also buttressed by the perceived low level of development of processing infrastructure along the legume value chain. Most women processors especially those in the rural areas have limited access to processing infrastructure. In most cases, the available processing infrastructure is the traditional rather than the mechanized type. While the advent of locally fabricated semi- or fully mechanized processing facilities (i.e., shellers, roasters, grinding mills and oil extractors) has the potential to save time, reduce drudgery, and make groundnut processing more efficient and profitable, their availability or uptake remains quite low in most rural communities in northern Ghana. As Owusu and Lambon-Quayefio (2018) and Akpo et al. (2020) documented, the limited access and usage is mainly due to the high cost of these processing equipment, which makes it prohibitive for resource-poor individuals or groups in northern Ghana to acquire. Coupled with rising energy (fuel/electricity) costs, this translates into higher user/service fees, and consequently constrain access and profitability among groundnut processors. This finding is unsurprising, as at the macro level, Ghana has an infrastructure funding gap of about \$0.4 billion per year according to Foster and Pushak (2013). Indeed, the availability and provision of efficient infrastructure services can become a key determinant of growth in output and the development of markets (ILO, 2019).

Another key finding from the study is that the few available processing infrastructures are mostly owned by men and access attracts a fee. However, the cost of access was dependent on the type of processing infrastructure. It is evident that most women utilize corn mill facilities to process their groundnut. This is due to the absence of dedicated groundnut mill facilities in nearly all the communities studied. Across the northern region, the use of corn mill facilities for groundnut processing had implications for women who are compelled to join long queues or spend more time at processing facilities. This is mainly because

operators would prefer to process all corn products before attending to those who would want to process their groundnut. Nevertheless, the research establishes that there is no gender division or cultural restriction to access to processing infrastructure and that the only factor which can act as a barrier is the cost associated with utilization of processing infrastructure. The main product that women processed includes groundnut paste, kulikuli and groundnut oil, in addition to groundnut case and Tom Brown. Most women source groundnut from their farms in addition to purchasing groundnut from the local market. The findings also suggest that in most cases the scale of processing is generally low. This finding is consistent with the work of Tsigbey et al (2003) who found that in Northern Ghana, groundnut oil, peanut cake, roasted ground, and peanut butter (groundnut paste) are key products that women processors engage in.

Three key issues emerged as the factors which impact women's access to processing infrastructure. They include distance to facilities, unreliable power supply and the nature of the processing infrastructure themselves. Most women are burdened by the distance they would have to cover all the time to access processing infrastructure. The fact that many covers long distances to access processing infrastructure had implications on the cost of processing manifested in transportation charges. Unreliable power supply manifested in frequent power cuts, had implications on the ability of women processors to visit processing facilities to process their groundnut. In such a situation they are forced to resort to the traditional way of processing groundnut which involves using their labour. The poor state of some processing infrastructure also affects the quality of processed groundnut. These findings are not new. In contrast to the south, northern Ghana has consistently lagged the availability of infrastructure including good roads, an efficient supply of electricity and other social infrastructure (Nyaaba and Bob-Milliar, 2019; Yaro, 2013).

The limited access and supply of existing infrastructure have the potential to impact the productivity, income and well-being of all workers including women processors whose work or livelihood is highly dependent on these facilities. The poor state of processing infrastructure which compels women to resort to the traditional ways of processing is likely to negatively impact their income, health and well-being (Sapkota, 2018). As Sapkota (2018), observed in the case of Nepal, the limited availability of quality infrastructure has the potential to impact the well-being of users.

Despite these challenges, the findings show that access to processing infrastructure improves the efficiency, and quality of processed groundnut, saves time and reduces the drudgery associated with the traditional mechanism of processing groundnut. We also found that access to processing infrastructure allows women to add value to groundnut which potentially could increase the incomes of women processors. The research also establishes that access to processing infrastructure had both direct and indirect impacts on women's access to and consumption of nutritious diets. The direct impact manifested in the women processors and their households consuming different products made from groundnut. The indirect impact manifested in the sale of various processed groundnut products of which the income is invested in the purchase of diverse foods such as fish, meat, fruits, vegetables, and other staple foods (aside from TZ) among others. This finding is consistent with the growing body of studies that have shown that access to diverse forms of infrastructure including market, communication, irrigation and efficient storage and food processing technologies has the potential to enhance households' access to nutritious diets (Keding et al. (2013; Abass et al. (2017; Nti et al. 2002).

The participants' understanding of empowerment revolved around: access to income and providing for the household, freedom of movement and ability to attend functions, being a member of a group or association and respect among household members and social recognition. This strongly aligns with the definition of empowerment by Lohani and Aburaida, (2017:27) as a "multi-dimensional social process that helps people gain control over their own lives; a process that fosters power (that is, the capacity to implement) in people, for use in their own lives, their communities, and in their society, by acting on issues that they define as important". The participants' conceptualizations of empowerment as the ability to acquire income, take care of your family, and be able to achieve economic independence and overcome financial constraints resonates with the INODO's (2019) conceptualization of empowerment as having increased access to and control over

productive resources (UNIDO, 2019).

In this study, participants further conceptualized empowerment as being free to go to places that were of importance to them, being able to attend social functions and accessing different resources at various places without hindrance, as well as being a member of a group or an association, which provides one with a sense of belonging, social support, and collective action. Finally, feeling respected by household members, being able to make decisions that affect their lives, being heard, and being able to speak about their needs were also considered empowerment. This involved attaining more power and control over their lives to gradually overcome their continued disadvantage in economic, socio-cultural, and political terms. These definitions of empowerment by respondents truly reflect the description of an empowered woman by the de Silva (2021), as someone with a sense of self-worth.

Based on a sample of 801 dual-adult male and female and 49 adult-female-only households who engaged in groundnut production and processing, it is estimated that less than half (48.5%) of women are empowered (relative to 52.6% of men in the sample). Relative to men in their households, it is found that over 80% of the women achieved empowerment adequacy in the areas of input in livelihood decisions, ownership of land and other assets, and control over the use of income, especially from groundnut processing. In contrast, less than half of them achieved adequacy in the areas of attitudes about domestic violence, access to and decisions on credit and active group membership. Similarly, the findings highlight how women's economic empowerment is viewed as a positive development, recognizing the benefits that could emerge for the household and community in general, others held more traditional or conservative views, believing that women should be confined to certain gender roles and responsibilities.

Most of the respondents expressed a positive attitude towards women's empowerment which reflects the growing recognition of the importance of gender equality and the need to support women's access to productive resources for development. The positive perceptions were based on respondents' understanding that when women are empowered, they not only benefit personally but also contribute to the overall development of their families and communities. This aligns with the argument by Mondelēz International (2018) that women's empowerment is one of the most persistent social processes characterized by challenges and opportunities. The results further reflect the assertion by OECD (2014) that a major systemic and persistent constraint to women's economic empowerment has been entrenched social and cultural norms that dictate the unequal status of women, define their roles and expectations in society, and limit their control over productive resources and as well as their reproductive health rights. It further affirms Young's (2019) position that certain subtle gender biases impact people's perceptions and normalization of certain gender roles and positions in society. Further, Kabeer's (2009) assertion that women's economic empowerment has been impeded by the long-established power relations and the perception that women's independence constitute disempowerment to men.

The findings indicate that groundnut processing facilities offered unique opportunities for women to process their groundnuts, add value to them and increase their profitability. The results from the quantitative analysis show that relative to primary producers of groundnut, women who specialize in groundnut processing are more likely to be empowered, especially in the areas of self-efficacy, attitudes about domestic violence, input into livelihood decisions, control over use income and physical mobility. Among groundnut processors, the study finds that access to shelling machines and grinding mills (most of which are fully mechanized) contributes to women's empowerment, particularly through input into livelihood decisions and control over the use of income. While the literature on women's empowerment and nutritional impacts of agro-processing (and processing infrastructure) is thin, this finding is comparable with Abass et al. (2017) who found that value addition through mechanized processing of cassava contributes to poverty reduction in northern Zambia. It is also consistent with Nti e al. (2002) who showed that the adoption of improved fish processing and preservation technologies in coastal Ghana is associated with better household income, consumption of nutritious diets and health status.

This finding is corroborated by the qualitative results, which revealed that groundnut processing infrastructure has had a significant positive impact on women's economic empowerment. This is manifested in women's ability to provide for families' upkeep by getting access to income, input into decision-making, ability to save, asset acquisition, freedom of movement, social recognition and improved self-worth, group association and general economic well-being. Groundnut processing using the available (and accessible) processing facilities have provided a valuable source of income for most of the women in the research communities as women who were into groundnut processing, could sell the processed groundnuts and earn profits to meet their household needs.

The findings show that groundnut processing with the aid of processing infrastructure has increased women's bargaining power within households and communities, giving them greater influence and input into decision-making related to groundnut production and processing and decision-making related to income. These findings align with the assertion by Owoo and Lambon-Quayefio (2017) who reported that access to processing infrastructure increases the income of farmers and processors, promotes employment generation, and contributes to enterprise development as well as diversifies rural economies. It further affirms that women's full participation in the economy results in better-performing and more resilient communities and businesses and makes households more economically secure (Young, 2019; De Silva, 2021).

The savings ability of most women improved due to their engagement in groundnut processing as most women were found to be members of VSLA. This confirms the study results by Zakuan and Hassan (2016), and Purnamawati and Utama (2019) that increasing the capacity of women by giving them access to resources like processing infrastructure, not only reduces the time they spend on their work but also increases their savings ability and income.

With respect to access to nutritious diets, it is found that less than half (45.2%) of women of reproductive age (15-49 years) achieved the minimum dietary diversity for adequate micronutrient intake, with an average score of 4.5 (out of 10 food groups). This suggests that most of the women (54.8%) in northern Ghana consume poor-quality diets, that are deficient in essential micronutrients. While the consumption of cereals, vegetables, oil, and fats is widespread, the intake of fruits, meat, milk and milk products and eggs is uncommon. Similar dietary patterns are also observed at the household level. Furthermore, it is found that engagement in groundnut exerts positive and significant impacts on improved individual and household dietary diversity in Northern Ghana. Compared to primary producers, female groundnut processors (aged 15-49 years) are found to be significantly more likely to achieve the minimum dietary diversity for adequate micronutrient intake. Although the quantitative analysis finds no conclusive evidence of a direct impact of processing facilities on access to and consumption of nutritious diets, the qualitative results show that show both direct and indirect impacts of processing infrastructure on women's access to, and consumption of nutritious diets.

5.2 Conclusion and Recommendations for Policy and Practice

Overall, the findings of this study show that access to efficient, cost-effective processing infrastructure has the potential to contribute to women's economic empowerment and access to, and consumption of nutritious diet. Access to processing infrastructure enables women to add value to their produce, earn income, support household expenditure, and enhance free movement, well-being, and social recognition. The women in this study further expressed some sense of empowerment through their perceived positive changes, which they connected to their involvement as processors or access to processing infrastructure. These positive changes included: more respect given by husbands and the community for their wage-earning status; increased household spending on education, foods, education, healthcare, acquisition of assets, and other household investments. However, the study findings also point to diverse challenges which women face in their attempt to build their livelihoods in groundnut processing: limited availability of quality processing infrastructure,

gender norms, and limited access to social resources (e.g., cost of transport, power supply). These findings have important implications for policy seeking to promote women's economic empowerment. In line with this, the following recommendations are put forward.

i) Expand access to processing infrastructure.

Expanding access to groundnut processing infrastructure can serve as a critical enabler of women's economic empowerment. The findings indicate that adequate, affordable, well-designed and gender-sensitive groundnut processing infrastructure can serve as an important first step for poor women to access expanded opportunities. However, processing infrastructure across the northern regions is inadequate. It is therefore recommended that government and development partners team up and join efforts to provide various forms of processing infrastructure (e.g., shellers, oil extractors, millers etc.) to facilitate the processing of groundnut. Intentional investment in infrastructure along the groundnut value chain, is essential for making women economically empowered. There is also the need to develop post-harvest technology and labor-saving equipment to lessen the burden of work on women groundnut producers and processors.

ii) Recognition of importance of groundnut processing as food security measure and cash crop

Access to processing infrastructure for women groundnut processors is both a means of household food security and a poverty reduction strategy. This calls for agricultural and rural development policies that support both groundnut production and processing to optimize women's economic empowerment outcomes. Such policies should recognize that groundnut processing and related micro-enterprises have an important role in increasing income from processing activities and strengthening their capabilities to become economically independent.

iii) Provide training on groundnut processing.

The study found that most women processors had not received training on groundnut processing. Further, they did not know about advances in peanut technology as they commonly use only traditional methods of processing. A training program should be developed to support rural women in areas of peanut production and processing. There was also limited knowledge of the health and safety protocols associated with the processing of groundnut. It is recommended for the Department of Agriculture team up with other actors including the health departments, Business Advisory Centres and Department of Cooperatives to provide training on groundnut processing and ensuring the safety of the products and practices that can also support and improve the well-being of women processors. Training on how to reduce aflatoxin contamination is also recommended to help reduce women's time spent shelling groundnuts presale.

iv) Provision of credit

A key challenge faced by women groundnut processors in northern Ghana is limited capital. This challenge has inadvertently affected the capacity of women to expand the scale of processing. There is a need to ensure women's access to credit facilities through both formal and informal financial institutions and to support and expand the coverage of VSLAs, which have proved effective in enabling women groups acquire sustainable access to credit.

v) Addressing systemic barriers to women's economic participation

Our findings call for the need to ensure essential? to address systemic barriers and create an enabling environment that supports women's full participation in economic activities. This requires a multi-faceted approach that includes policies and programs aimed at improving the nature and conditions of processing infrastructure along the groundnut value chain, infusing capital to boost their economic activities as well as efforts to change social norms and attitudes in favor of women's economic empowerment.

Additionally, policymakers and stakeholders should prioritize gender-transformative policies that address the specific and unique needs and constraints faced by women along the groundnut value chain to ensure

their full participation and benefits from groundnut processing.

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