International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 5 Issue 12, December - 2021, Pages:185-203

The Contribution of Technological Innovations in enhancing Agro-processing Industry in Tanzania: A Case of Sunflower Oil Processing Technology in Dodoma City

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Abstract: *There are dynamics in how technological innovations occur in one country after another, and more or less from one business enterprise to the next. This study was carried out to examine the contribution of technological innovations in the advancement of sunflower oil processing industry in Dodoma City. Data collection methods were triangulated, and both quantitative and qualitative designs were used in the cross-section research design modality, making the methodology pragmatic in nature. Using questionnaires, data was collected from 98 respondents, including 49 owners and 49 technicians from sunflower oil processing enterprises in Dodoma City's Kikuyu, Chamwino, and Majengo wards. The sample size of 98 respondents was determined through probability sampling, which included cluster sampling, stratified sampling, and simple random sampling. Non-probability sampling through purposive sampling was used to collect data from organizations such as Small Industries Development Organization (SIDO), United Nations Industrial Organization (UNIDO), Tanzania Food and Drugs Authority (TFDA), and local dealers supplying imported machines. One representative from each of these institutions was selected as a key informant. According to the findings of the study, there are no regular technological innovations in terms of process and product innovations in the enterprises surveyed, as well as in research and technology organizations (RTOs) such as SIDO, TIRDO, and CAMERTECH. This study's findings also show that technician employees gained technical knowledge primarily through learning by doing and reverse engineering processes, rather than through workshops and training at technical colleges. The findings of this study, obtained through various methods, including observation, show that all enterprises surveyed use imported machines and spare parts from China and India. According to the study, a number of arrangements should be made to make local technology intermediaries the source of technology transfer to sunflower oil processing enterprises, while making machine tools required by sunflower oil processing enterprises available, accessible, and preferred. (i) Identifying and policy articulating local public and private sector agencies and organizations that will be involved in the value chain of technological innovation. (ii) Consider activity separation when assigning roles to each actor to avoid duplication of activities and resource waste. (iii) Because local actors are interdependent, they should make decisions in concert. (iv) A local needs assessment must be carried out to ensure that resources are allocated and action is taken that reflects the perceived needs in terms of machine operating efficiency and the level of skill required by both local technology intermediaries and enterprises involved in sunflower processing activities in order for technological innovations to occur.*

Keywords: Technology, process innovation, product innovation, SMEs

1.0 Background of the study

Countries' agendas for joining the Middle Income Economy have been set in the global business environment. As a result, countries are caught in a middle-income trap (MIT). The so-called middle-income trap (MIT) describes a situation in which middle-income economies experience slowing growth and thus fail to join the ranks of high-income economies. Uncertainty, stiff competition, and rapid technological change characterize the business environment of the twenty-first century (AlJinini et al., 2019). Global economic trends, according to Korsakiene et al. (2017), have compelled SMEs in various countries to increase their productivity, expand into new markets, and adopt new technologies. Various studies have attempted to investigate the key factors responsible for the MIT, such as demographic conditions, institutions, industry and trade structures, diversification, physical infrastructure, and macroeconomic developments (Aiyar et al. 2013). According to studies by Eichengreen et al. (2012, 2013) and Lee (2013), innovation capabilities are the key binding constraint for the MIT.

Small and medium-sized enterprises (SMEs) are poised to account for a larger share of economic activity in developing countries. Several factors have contributed to the prolonged and increased interest in launching SMEs, including revitalizing stagnant economies, stimulating developing economies, and addressing unemployment issues by creating new job opportunities (Tende & Nimfa, 2015). In order to respond to the growing scale of agro-processing activities, efforts have been made to improve technological innovations, machine manufacturing, and subsequent machine supply. Several initiatives have already been put in place to support and encourage agro-processing activities. Among the efforts is the launch of technological innovation learning. Learning and innovation processes stem from formal and informal knowledge (Egbetokun et al. 2017). In Nigeria, experience suggests that formal training is pivotal to knowledge build-up, which is, in turn, positively linked to innovation performance. Robson and Obeng (2008) found that in Ghana, formal training in firms had a greater probability of combating business impediments. Informal knowledge sharing, which entails mostly "off the record" interactions, is prevalent among SMEs in developing countries (Ajao, Oyebisi, and Aderemi 2019).

In Ghana, the government has renewed its commitment to using agro-industrialization to transform the economy, with a critical emphasis on policy strategies that promote and sustain micro- and small-scale agro-industries. To achieve this goal, the government has launched a number of flagship initiatives, including "one district, one factory" and "agric-processing parks" (GoG 2015). Private entrepreneurs are also given business assistance in order to establish new agro-enterprises and revitalize existing ones. The majority of policy strategies have also centered on incentives for firm competitiveness. Fruit juice processing businesses, for example, will benefit from zero input duties, value-added tax, and national health levy on inputs; low corporate income tax; and zero import duties on machinery imports, among other things (GoG 2015).

Despite efforts, a number of challenges have been identified in the establishment and operation of SMEs in developing countries. According to the Department of Trade and Industry (2018), agro-processing has been hampered by a lack of adequate investment in processing facilities, particularly in technological innovation at the firm level. Several studies in Kenya have substantiated a number of challenges to technological innovation in agro processing. Due to the high cost of doing business, the use of outdated technology, and a lack of appropriate skills to carry out innovative activities, the sector may fail to achieve the desired level of competitiveness (FAO, 2013; Pokhariyal & Yalla, 2011; RoK, 2013; World Bank, 2008).

Agro-processing SMEs can be supported in a variety of ways to adopt technological innovations. One of the methods used in Tanzania is the establishment of research and technology organizations (RTOs). RTOs are known as "public technology intermediaries" or "R&D parastatals" in Tanzania. These parastatals proliferated in the 1970s in order to boost technological innovation and capacity building for agro-processing SMEs, particularly in the area of technological innovation. According to Tanzania's industrial competitiveness report 2015, most RTOs are still in operation, albeit with low productivity and numerous challenges (URT 2015a; Diyamett and Risha 2015). More than 70% of Tanzania's private sector is informal, with lower skills and limited access to finance and technology transfer through the RTOs-to-SMEs technology transfer modality (URT 2015b), implying that RTO support has yet to be delivered to SMEs. Tanzanian SMEs and their clusters do not yet have the requisite industrial capacity to carry out, among other undertakings, technological innovations at firm level. (Musonda 2007).

Since there is insufficient information regarding the contribution of technological innovations in enhancing agro-processing activities, particularly sunflower oil processing. The study is intended to examine the contribution of technological innovations in enhancing sunflower oil processing activities.

2.0 Theory and Concepts

2.1 Definitions of concepts

2.1.1 Agro-processing technology

Agro-processing technology can be defined as the transformation of products originating from agriculture into final products. Such products include maize, fruits and vegetables, woods, sugarcane, cotton, oilseeds, sunflower seeds, wheat, rice, tea, coffee, etc. (Swai, 2017).

2.1.2 Technological innovations

Innovation is the most contemporary management orientation; it refers to the ability of organizations to create and develop new ideas and transform these ideas into a processes, products and services. According to Şimşit et al. (2014), innovation is a continuous process for developing productive resources which are then employed to manufacture existing products with superior quality at lower cost. Along the same line, Ilori et al. (2017) defined innovation as implementing new knowledge into processes, products, and services. The authors categorised innovation according to technological development, marketing activities, and organizational characteristics. Based on the definitions given, innovation is a sequential process which begins with recognition of a problem or discovery of a novel idea and is followed by problem-solving and the creation of productive ability to introduce creative products and services in the market.

2.2 Theoretical review

This study is guided by the theory of Networking Capability (NWC). The theory concerns the sharing of resources, capabilities, and technologies between the source and recipients (Dickson & Weaver, 2011; Welter & Smallbone, 2011; Nieto & Santamaria, 2010). This theory is used in this study because the sunflower oil processing enterprises run by SMEs are resource constrained and in need of support. The support can be machines, spare parts, and consultancy. Networking allows sunflower oil processing enterprises to access resources they do not own or control, but are necessary for enterprises' processing activities and technological innovations (Song et al., 2010; Gronum, Verreynne, & Kastelle, 2012). Networking is crucial in sharing risk and resources in capital-intensive ventures or in an environment with weak regulatory frameworks, as found in Tanzania, where entrepreneurs feel less protected (Tang & Murphy, 2012). However, this theory has some limitations since SMEs may rely on incompatible partners. In order to address these limitations, sunflower oil processing enterprises must have knowledge about partners in advance in order to ensure they get the right kind of support in terms of machines, spare parts, consultancy, training and finance. Partners' knowledge enables the sunflower oil processing enterprises to identify potential partners with relevant resources and capabilities that are highly needed. Knowledge about partners is necessary in ensuring the proper allocation of resources for the most productive intervention.

SMEs that are in need of technical support can opt to seek support from technology sources available locally or internationally. Technology sources concern institutions (public and private) which deal with technological innovations and the manufacturing of machines, generally termed "technology intermediaries." Technology intermediaries have been characterized as organizations that generate value for other actors within a system of innovation (Arnold et al., 2010; Tran et al., 2011). Technology intermediaries enable their clients to leverage external technologies (Howells, 2006) and offer existing design solutions (Lichtenthaler and Ernst, 2008). Nevertheless, in order for technology intermediaries to successfully perform these tasks, they need to generate internal value for themselves from such engagement with clients. "Internal value" is defined as the sum of both financial and non-financial values generated by technology intermediaries. The internal value generated by intermediaries during collaborative projects will be multi-dimensional, comprising both (a) financial and (b) non-financial gains (Huizingh, 2011; Tran et al., 2011; Verona et al., 2006).

2.3 Empirical literature review

2.3.1 Technology sources

The organizations and firms that manufacture and sell machines are the available sources of technology both locally and globally. These businesses are known as "technology hubs." They are found in African countries such as Nigeria, South Africa, Kenya, and Uganda. According to Atiase et al. (2020), hubs are at the forefront of generating new knowledge. In fact, unlike universities, where large proportions of large volumes of knowledge produced are not transferred to local communities for use, the hubs appear to ensure knowledge usage. This distinction stems from the fact that innovation hubs primarily contribute to the generation of new knowledge and innovative solutions, particularly for those at the bottom of the pyramid, by providing alternative channels of local knowledge production and transfer. Cherunya and Ahlborg (2020) specify channels like business ideation, incubation, technical training, and mentoring as the ones mainly used in the production, exchange, and transfer of knowledge.

Innovation hubs are altering the landscape of knowledge production by allowing non-university actors to establish new spaces for knowledge co-creation and transfer (Atiase et al., 2020). De Propris and Hamdouch (2013) observed that knowledge and innovation hubs strengthen the generation of technological externalities, which has a positive impact on the innovation capacities of various sectors. Furthermore, the authors claim that the hubs facilitate the development of complex, globally competitive innovation systems. Pancholi et al. (2014) report that in an attempt to understand the best practices of innovation hubs across Europe, namely Cambridge Science Park (UK), 22@Barcelona (Spain), Arabianranta (Finland), Strijp-S (Netherlands), and Digital Hub (Ireland), the hubs foster creativity and an interactive culture of innovation and commercialization of various products. Jiménez and Zheng (2018) discover that surveyed innovation hubs boost the diffusion of diverse innovations and creative thinking in their investigation of the role of Zambian innovation hubs in the nation's development. This is consistent with the findings of Loorbach et al. (2020), who discovered that innovation hubs facilitate the diffusion of innovation.

The Small Industries Development Organization (SIDO) was established by the Government of Tanzania (GOT) with the goal of creating and sustaining an entrepreneurial base through the promotion and support of the development of SMEs, including agro-processing enterprises, by providing them with business development services. SIDO's services to SMEs include technology development. However, the expansion of small agro-processing firms in Tanzania has been hampered by a lack of technological innovation. The value of processed products for domestic and export use has not yet increased significantly in the sub-sector. In fact, some processing firms are collapsing, while others are not growing as expected. TIRDO and CAMERTECH, the counterpart RTOs, have not yet been of assistance in enhancing innovation by serving as a source of agro processing technology. Noting from a study by Friederici (2016), scarcity of capital investment, weak infrastructure, and inadequately skilled and knowledgeable human resources constrain the operation of innovation hubs in Tanzania.

2.3.2 Technology recipients

Several studies have been carried out to investigate the dynamics of technology availability and accessibility, particularly in agro-processing technology. A common method used by SMEs involved in agro-processing activities to acquire technology is to purchase from technology manufacturers, some of whom are local and others who are international. Access to equipment is a common problem for small agro-processing enterprises in many African countries, according to experience. (Mukantwali and colleagues, 2012) Because these businesses cannot afford modern equipment and packaging materials, some of them resort to using recycled materials (Mukantwali et al, 2012). According to Nichter and Goldmark (2009), the ability to acquire appropriate processing technology has proven to be a significant problem for SMEs in Tanzania. In spite of available advanced technologies around the world, most food processors (especially small and medium enterprises) in the country still use poor and labour intensive technologies" (Ruteri&Xu, 2009).

Technological innovations undertaken by agro processing enterprises can lead to the acquisition of technology for processing activities. Pursuing technological innovations at the enterprise level necessitates the acquisition of relevant technical knowledge and skills. Support for education and training for entrepreneurs and small businesses will help lay the groundwork for technological innovation within businesses (Biggs and Shah, 2006). According to a Training Needs Analysis (TNA) conducted in Albania, technological innovations and problem-solving skills are regarded as important areas to develop. Furthermore, the report stated that the process of acquiring and consolidating technological innovations necessitates a wide range of skills and knowledge pertaining to the changing characteristics of SMEs' businesses. In practice, this means that SME training and other business support services should be a significant source of leverage.

In Tanzania, the growth of agro-processing enterprises is affected by the adoption of poor technology and is not competitive. According to Ruteri & Xu (2009), the problem is not that high-quality equipment is unavailable in Tanzania, but that the SMEs lack enough capital to acquire it. Poor technology has been pointed out as a business constraint in other studies as well (Mukantwali et al., 2012). According to Eshetu and Zeleke (2008), the constraints to the survival of small and medium enterprises are technology, level of education, managerial skill, and the ability of SMEs to convert a portion of their profit to invest in technological innovations' work force with a higher level of education always performs better than those with a low level of education. Tanzania's agro-processing enterprises are run by a labor force with low technical knowledge and skills, joining other countries in the trap of technological innovations. According to Zikusoka (2015), technological innovations are compromised because of a low level of education as far as Tanzania is concerned.

3.0 Study Location and Methodology

This research was carried out in Dodoma, specifically in the Kikuyu, Majengo, and Chamwino wards. These locations were chosen because sunflower oil processing businesses are located there. In order to ensure the validity and reliability of the data collected, both quantitative and qualitative research designs were used. According to Sekaran and Bougie (2010), quantitative research is based on deductive reasoning or deduction and employs a variety of quantitative analysis techniques ranging from providing a simple description of the variables involved to establishing statistical relationships among variables through complex statistical modeling. On the other hand, the qualitative research design enabled the capture of expressive information about beliefs, values, feelings, and motivations that underpin technological processes in sunflower oil processing that is not conveyed in quantitative data. It includes textual descriptions of how respondents felt about the research topic. According to Sekaran and Bougie (2010), qualitative research employs inductive reasoning and seeks to gain a comprehensive understanding of human behavior and the reasons for its occurrence.

Questionnaires were used to collect data from respondents in a quantitative research design. In contrast, for qualitative data, an interview guide was created to collect information from key informants (Sekaran and Bougie 2010). Other methods of data collection included observation and documentary reviews. The purpose of combining data collection methods is to maintain internal consistency and correlation between responses from various sources. The adoption of technological innovations taking place at the enterprise level was measured in this study using a Likert scale of five levels (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) and at the other extreme, 1 = very good, 2 = good, 3 = moderate, 4 = poor, 5 = very poor).

The population was sampled using 49 owners of sunflower oil processing businesses and 49 technician employees from those businesses, for a total of 98 respondents. The sample was drawn using both probability and non-probability sampling methods. Prior to simple random sampling, multi-stage sampling was used in probability sampling. The first stage involved identifying the locations of sunflower oil processing enterprises. This method is known as cluster sampling. Cluster sampling is used to ensure that potential locations with sunflower oil processing enterprises are included in the sample. Stratified sampling was used in the second stage based on the size of the enterprise. The use of stratified sampling allows enterprises with various types of machines to be included in the sample. Sunflower oil processing businesses in the study area used a variety of imported machines, including the XY95A, XY105, XY115, and XY118. For the need to triangulate data from different methods and sources for the sake of validity and reliability of the data, it was necessary to accommodate non-probability sampling.

Purposive sampling was used in non-probability sampling to select key informants from institutions such as the Small Industries Development Organization (SIDO), the Tanzania Food and Drug Authority (TFDA), the United Nations Industrial Development Organization (UNIDO-Dodoma representative), and local dealers in supplying imported sunflower oil processing machines (Burns and George 2003). In this study, quantitative data analyzed with the Statistical Package for Social Scientists (SPSS Version 24) and presented in the form of tables, pie charts, and graphs show the current state of technological innovation at the enterprise and local technology intermediary levels.

Primary data were obtained from owners of enterprises, technicians employed in these enterprises, and key informants from SIDO, UNIDO, RLDC, and TFDA. Primary data were gathered through field surveys in which questionnaires were used to collect information from enterprise owners and technicians. Interview method was used to gather information from the key informants, using an interview guide as a tool. The method used to collect secondary data was documentary review. The data were also collected from documents containing technological innovations and practices taking place across different countries.

The survey method was used to collect information from respondents who were owners (49) and technical employees (49) of sunflower oil processing businesses. The survey method was chosen for this study because it allowed for the quantification of data. The method allowed for the structured collection of the opinions of such a large number of respondents (Silverman, 2019). By ensuring internal consistency, all potential errors must be kept to a minimum. The instrument was validated using content and constructs validity, while the reliability or internal consistency of the items within the structure of this study was assessed by an indication of Cronbachs alpha and yielded an average value of 0.83, which is significantly higher than the minimum average value of 0.7 depending on the nature of the instrument. An interview method was used to collect data from officials who were from SIDO, RLDC, TFDA, and UNIDO, as well as from local suppliers of machines.

Data collected in the field was cleaned, coded, and key punched into a computer before being analyzed. The collected data was quantitatively analyzed using the IBM SPSS Statistics Version 24. The study's data was analyzed using descriptive analytical techniques. To analyze data from the questionnaire, analytical techniques such as factor analysis and simple percentage frequency distribution tables were used. Descriptive statistics were used to describe the distribution of results based on the variables in the study and the measurement scale used. Instruments such as tables, pie charts, and graphs were used to present quantitative data.

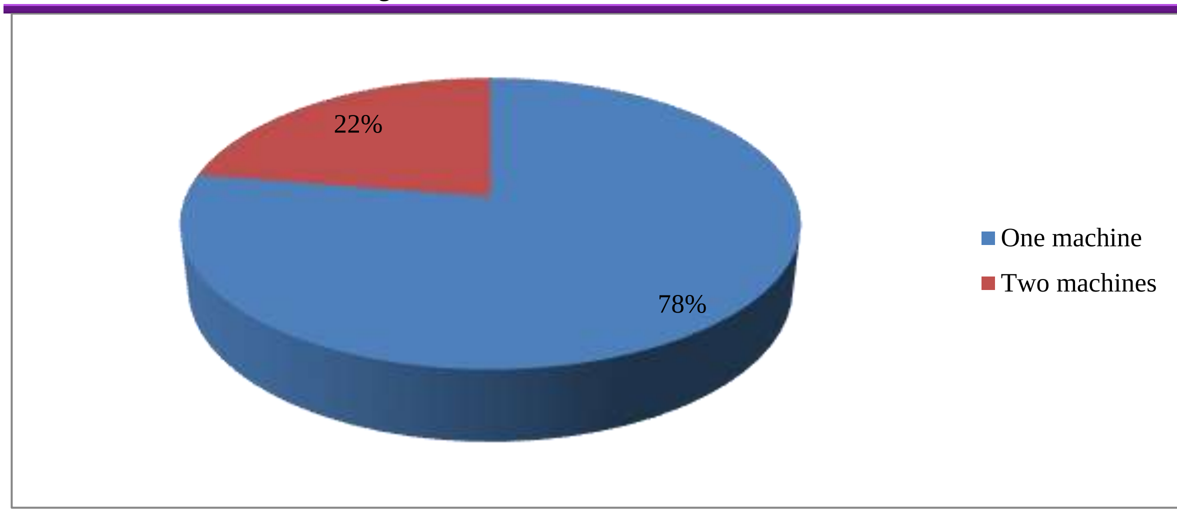
4.0 Findings and Discussions

4.1 Number of machines per enterprise

The size and quality of an enterprise's machinery infrastructure are determined by its financial position and the technical knowledge of its workforce. The majority of the surveyed enterprises (38) have only one processing machine (78%) installed, indicating limited machinery infrastructure and less competitive financial capacity in undertaking sunflower oil processing. As shown in Figure 1, the remaining 11 businesses (22 percent) have installed two processing machines. According to the technician respondents, this is the case. It is possible that local oilseed processing enterprises will open and pave the way for increased processing capacity in a favorable business environment, allowing the enterprises to acquire or build appropriate processing technology and capture the local and international cooking oil markets. The size of the enterprise was used to calculate these results. The size index of an enterprise is calculated by dividing the productivity index by the number of machines installed per enterprise. Because of the number of machines, the average enterprise's mean index was less than one, according to the survey results. This demonstrated that the infrastructure of sunflower oil processing enterprises is lacking. This is due to the fact that the majority of businesses are technologically and financially constrained, and their output level can only meet local demand rather than distant markets.

These findings are consistent with the findings of Ampadu-Ameyaw and Omari (2015) in Ghana. Their research revealed that technological deficiencies, inadequate infrastructure, and insufficient financial resources are impeding the development of the agro-processing sector. Furthermore, Owoo and Quayefio (2018) discovered that a lack of agro-processing facilities and modern equipment has a negative impact on the growth of agro-processing firms in Ghana. Rahim and Bakar (2014) investigated the impact of financial resource management on SME performance and investigated the potential of financial capabilities. It was discovered that financial resources enable the process of launching new products in both the context of young and small enterprises, which will eventually have an impact on SME performance.

Figure 1: Number of installed machines per enterprise



Source: Field survey, 2021

4.2 Types of machines installed for processing Sunflower oil

A motorized screw expeller is used to extract sunflower oil mechanically. Local sunflower oil processing businesses rely on imported Chinese machinery that is widely available in the local market. Table 1 shows the number of businesses that use various machine types. Machines of various types were used by the businesses polled. Based on these findings, the machine types XY95 and XY105 appear to be preferred by the enterprises surveyed in sunflower oil processing. According to the research, various types of machines used in the processing of sunflower oil are imported. Local dealers such as Hombolo Investment, Sokoni Auto Parts, Agro Machinery Limited, and Kisheni Auto Parts supply the machines to sunflower oil processing companies. During an interview with one of the machines' local suppliers, he acknowledged the fact by saying:

> *"The imported machines are of different types. The machine types commonly purchased by our clients are 6XY 95A and 6XY 105 because some of their spare parts are used interchangeably. The capacity of 6XY 95A is to process 3 to 4 tons of sunflower in 24hours, as the smallest capacity. There is an increased demand for oilseeds processing machines in the local market. Since locally manufactured machines are not available, the imported machines are highly demanded and widely used. The imported machines and their spare parts are easily available and more accessible to local enterprises than a few locally manufactured machines".*

The findings are consistent with the studies conducted in Chile. According to Bravo-Ortega and Muoz (2015) and Pietrobelli et al. (2018), most local suppliers operate in a context of marginal improvements in production management and adaptations of available technologies, with no major technological advances. Technological innovations are insufficient not only among Tanzania's technology intermediaries such as SIDO, TIRDO, and CAMTECH, but also at the enterprise level. Because sunflower oil processing SMEs are typically small and medium-sized, they are unlikely to adopt technological innovations. Firm size is an important determinant of firm technological innovations, according to studies conducted by Salerno, M.S., de Vasconcelos Gomes, L.A., da Silva, D.O., and Bagno, R.B. (2015). Furthermore, research by Liu, F., Park, K., and Whang, U. (2019) revealed that large enterprises have the resources to invest in technological innovations. Reichert and Zawislak (2014), on the other hand, discovered that firms in lower technological (locally manufactured technology) intensity industries performed above average in economic performance indicator systems over the years they were employed in local production and agricultural processing in Nigeria.

Table 1: Types of machines used in processing Sunflower oil

Machine type	Frequency	Percentage
XY 95A	18	37
XY 105	25	51
XY 115	2	4
XY 118	4	8
TOTAL	**49**	**100**

Source: Field Data, 2021

Figure 2: Typical Sunflower oil expeller

Source: Field Survey, 2021

4.3 Perception of respondents on local manufacturers' efforts to promote local technology

The technological innovation index was investigated in relation to efforts by local technology intermediaries to promote local technology by using parameters I availability (ii) accessibility (iii) durability and (iv) commercialization of locally manufactured agro-processing machines. The owners of sunflower oil processing businesses were asked to rate the technology intermediaries' various efforts. The overwhelming majority of respondents (33 respondents, or 67 percent) believe that efforts to promote local technology are very poor, while 12 respondents, or 24 percent, believe that the effort is poor. The results of the other parameters also show that efforts to promote local technology are not impressive, as shown in Table 2 below, based on how respondents rated accessibility, durability, and commercialization of locally manufactured machines. According to the findings, there is a mismatch between rising demand for the machine in the local market and the availability of locally manufactured machines. As a result, purchasing imported machines has become a viable option for meeting and fulfilling the demand for sunflower oil processing machines.

Developing and strengthening technological capabilities in emerging economies has frequently been difficult due to the presence of not only market failures but also system and learning failures (Lee 2019). However, there are dynamics in the scope of national efforts to promote technological innovation. According to a Kenyan innovation survey conducted in 2012, 89.9 percent of the firms surveyed reported innovation activity. Product and process innovations were reported by 50% and 75% of the firms surveyed, respectively. This indicates that local firms have made some technical progress in addressing issues related to the availability of appropriate technology (European Commission, 2009). Organizational innovation was reported by 65 percent of the firms in a survey of technological innovation in selected indigenous oilfield servicing firms in Nigeria from 2001 to 2010; diffusion-based innovations were reported by 41 percent of the firms, and product and process innovation were reported by 15 and 28 percent of the firms, respectively. According to the Nigerian survey, process innovation occurred primarily through the purchase and mastery of new machinery, whereas product innovation occurred through the introduction of a new service. According to the survey, the level of innovation intensity is very low (Jonas, 2013).

Previous research has revealed dynamics when the national effort to promote technological innovations is measured in terms of Gross Domestic Expenditure on Research and Development (GERD). Although GERD remains low in Uganda, at around 0.3–0.4% of GDP, all government R&D expenditure is used for civil purposes (Uganda National Council for Science and Technology, 2009). In South Africa, GERD increased from 0.7 percent to 0.9 percent in 2006, with the business sector funding 44.8 percent of GERD (government of South Africa 2009).

Table 2: Perception of respondents on local manufacturers' efforts to promote local technology

Parameter	Very good	Good	Moderate	Poor	Very poor
Availability of locally manufactured machines	0 (0%)	0 (0%)	4 (8%)	12 (24%)	33 (67%)

Accessibility of locally manufactured machines	0 (0%)	0 (0%)	6 (12%)	15 (30%)	28 (57%)
Durability of locally manufactured machines	0 (0%)	0 (0%)	5 (10%)	14 (29%)	30 (61%)
Commercialization of locally manufactured machines	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Source: Field Data, 2021

4.4 Factors contributing to limited availability of locally manufactured machines

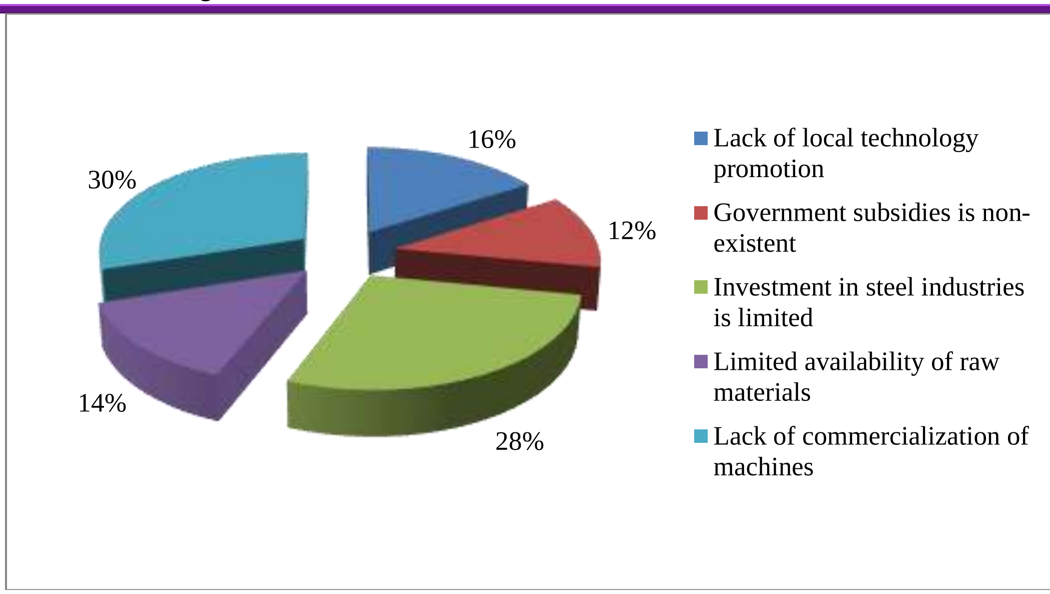
Local organizations dealing with technological innovations are key players in manufacturing of machines and their parts. Government can provide support in promoting technological innovations by facilitating organizations dealing with technological innovations. Government support can be in form of subsidies to organizations for the aim of reducing cost of raw materials, also the government can grant intellectual property rights, provision of training to upgrade skills. These efforts would enable technological innovations be taking place in organizations which are mandated to promote local technology. The results in this study show that number owners of enterprises surveyed equivalent to 28% were of the view that limited investment in steel industries contributes to limited availability of locally manufactured machines. Whereas 30% of owners of enterprises said that lack of commercialization of machines contributes to limited availability of machines. Some other respondents' equivalent to 12% of the sample size was of the opinion that government does not provide subsidies to organizations mandated to manufacture machines, as illustrated in the figure 4.

Shaping innovation efforts requires an enabling policy environment in which the government plays a significant role (Egbetokun et al. 2017). The weak growth of locally-owned firms has to do with the absence of explicit industrial policies providing incentives for local suppliers to innovate, as well as the high level of competition from foreign suppliers, which constitutes an entry barrier and a disincentive for local suppliers' upgrading and innovation (Pietrobelli et al. 2018). R & D requires a great deal of raw materials. The high cost of securing raw materials poses a detrimental effect on R & D efforts, particularly with steel materials. The experience in Tanzania shows that technological innovations often exhibit oligopolistic industrial structures that are prone to the formation of cartels. In turn, this undermines industrialization by raising costs, reducing investment, and limiting entry and competitive rivalry between steel firms (Vilakazi and Roberts, 2017). Yet, in other circumstances, local private-sector arrangements may lead to a form of developmental cartelism by ensuring the viability of steel in the face of intense competition from low-cost producers in foreign countries.

These responses matched with SIDO key informant opinion on the factors limiting the availability of locally manufactured machines:

> *"We are undertaking technology prototyping and upgrading. However, we have not attained the capacity to commercialize the processing technology. The reasons behind this are high cost and inadequate budget to support R & D projects, particularly technological innovations. Meanwhile, existing infrastructure and skill level are not favourable for carrying out R & D activities."*

Figure 4: Factors contributing to limited availability of locally manufactured machines



Source: Field Data, 2021

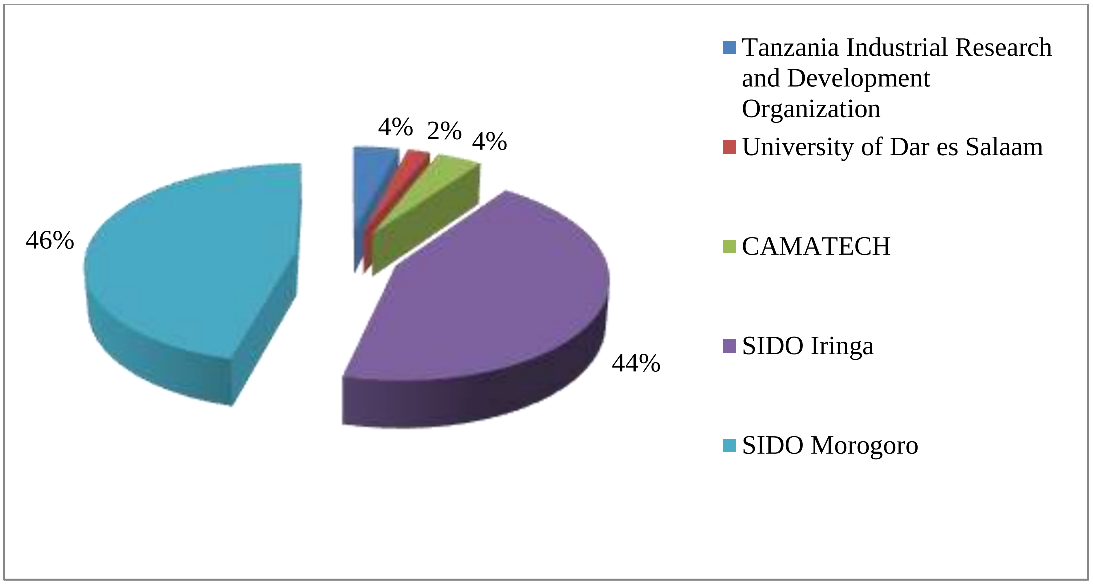
4.5 Respondents' awareness about local technology intermediaries

According to the survey, local technology intermediaries are producing machines. Figure 4 depicts the number of business owners who are aware of the existing local technology intermediaries. SIDO Morogoro was mentioned by the majority of the owners (23) (46 percent), while SIDO Iringa was mentioned by 22 owners (44 percent). The survey indicated that Tanzania Industrial Research and Development Organization (TIRDO), University of Dar es Salaam, and the Center for Agricultural Mechanization and Rural Technology (CAMARTECH) carried out limited activities, so little is known about the activities and products manufactured by these technology intermediaries. One respondent, accounting for 2% of the total, mentioned the University of Dar es Salaam. Whereas 2 respondents (4%) are aware of CAMATECH's activities, 2 respondents (4%) mentioned TIRDO. The results suggest there is inadequate effort to promote technological innovations. The few local technology intermediaries have insufficient capacity to meet country's demand for machines.

There are various sources through which local technology intermediaries can use to make themselves well known to the public, specifically users of their products. Knowledge of existing technology intermediaries can be obtained from a variety of sources, including advertisements, trade shows, and commercialization. Technology intermediaries in Tanzania can be termed as training or R & D organizations. They are mostly known to the owners of the businesses through exhibition, either "Nanenane" as indicated by 40 owners (82%), or "SIDO showroom" as indicated by 9 owners, rather than commercialization of their machines. In relation to this particular finding, there are limited sources of information that are used to inform the public about existing local technology intermediaries and their products.

Other research indicates that local technology intermediaries have yet to complete their basic responsibilities. According to Howells (2006), technological innovation intermediaries are organizations that support collaboration between two or more parties at various stages of the innovation process. As a result, they are regarded as critical to the establishment and maintenance of a successful innovation ecosystem (Sieg et al., 2010). Technological innovation intermediaries have emerged as key players in the innovation landscape, helping firms improve their innovative speed and performance (Knockaert et al., 2014; Lin et al., 2016).

Figure 5: Awareness about local manufacturers of machines



Source: Field Data, 2021

4.6 Activities undertaken by local technology intermediaries

The common technology intermediaries in Tanzania are TIRDO, the University of Dar es Salaam, CAMATECH, and SIDO. The scope of activities undertaken by these technology intermediaries is limited. In this study, the results reveal activities like training and making of machines for pilot studies are predominant activities, whereas activities like R&D, prototype innovations, and reverse engineering processes are not considered. When respondents were asked to provide their view on the activities of local technology intermediaries, different views were given. In relation to R&D activities, 35 respondents, equivalent to 71%, disagree that R&D activities are undertaken by technology intermediaries. Activity like undertaking prototype innovations was investigated where 15 respondents disagreed and 14 respondents strongly disagreed with the view that technology intermediaries do undertake prototype innovations. Regarding making machines for pilot studies, 27 respondents agree and 11 respondents strongly agree with the view that the local technology intermediaries do make machines for pilot studies. In light of these findings, the interplay between technological innovation taking place in local workshops run by the technology intermediaries, manufacturing, distribution, availability and assessment of local demand for agro processing machines proves to be lacking in coordinated efforts toward technological innovation in terms of both process innovations and product innovations.

The limited scope of activities undertaken by local technology intermediaries was also acknowledged during an interview with one of the suppliers of machines;

> *"Tanzania does not have any research and technology organizations that are competitive, whereby they have not been able to manufacture machines to meet local demand for machines used in sunflower oil processing. The country is importing the machines from foreign countries to fill the gap. There are a few local manufacturers, such as SIDO, TIRDO, University of Dar es Salaam, and VETA, but with no capacity to manufacture machines on a large scale. This has made them less competitive in comparison with the imported machines. These institutions are public organizations that operate as training and research organizations."*

According to Anderson (2019), Business Process Reengineering (BPR) is an important tool that agro-processing firms can use to improve their processes and, as a result, their performance. Business Process Reengineering (BPR) is hailed as one of the current major drivers of change and performance in all types of organizations, including agro-processing firms. BPR enables such businesses to thrive in today's more competitive, customer-focused commercial environment.

Industrial, research, and technology organizations have various names and classifications across countries, but a consensus has been reached in referring to them as RTOs. Some RTOs around the world have been key contributors to national industrialization and in shaping their industrial policies (United Nations' Economic Commission for Africa, 2016). The European Association of Research and Technology Organizations [European Association of Research and Technology Organizations (EARTO)] considers RTOs' core mission to be "to harness science and technology in the service of innovation, to improve quality of life and build economic competitiveness" (2015). Giannopoulou et al. (2019) found that RTOs play different (but complimentary) roles in national innovation systems than academic institutions (universities) and that investing in RTOs yields different outcomes as well. In Chile, public R & D agencies have been instrumental in enhancing the capabilities of local firms to start developing their own technologies to meet their unique challenges and environment (Hosono, 2016).

Comparing innovation hubs in Zambia and the United Kingdom (UK), Jimenez and Zheng (2019; 2017) reveal that some innovation hubs in Zambia were not directly linked to market-based products. One of the explanations is that the main focus of some of the hubs was on capacity. Building and training, thereby indirectly linked to market-based products, In contrast, some of the innovation hubs in London were found to generate revenue and introduce social enterprises. This implies that some of the hubs were directly linked to market-based products.

Table 3: Views of respondents on activities undertaking by local technology intermediaries

Activities	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Training	14(29%)	16(33%)	2(4%)	12(24%)	5(10%)
Undertaking R&D	0(0%)	2(4%)	7(14%)	35(71%)	5(10%)
Making machines for pilot study	11(22%)	27(55%)	3(6%)	5(10%)	3(6%)
Undertaking reverse engineering	2(4%)	4(8%)	3(3%)	10(20%)	28(57%)
Undertaking prototype innovations	7(14%)	8(16%)	6(12%)	15(30%)	14(28%)

Source: Field Data, 2021

4.7 Skill adequacy

The presence of education-based skills such as literacy and numeracy skills in an enterprise provides insights on the workforce's skills content. Literacy skills are the ability to read and write. They facilitate understanding of instructions given on how to operate machines and impart new knowledge through training. Numeracy skills involve simple arithmetic skills. They facilitate the use of equipment and modern machines. As for the availability of higher skills, they might or might not match enterprises' expectations. Further, they might or might not be adequate for performing certain production functions (skills adequacy). Lack of numeracy skills at the shop floor level makes the introduction and effective use of modern machines and equipment extremely difficult.

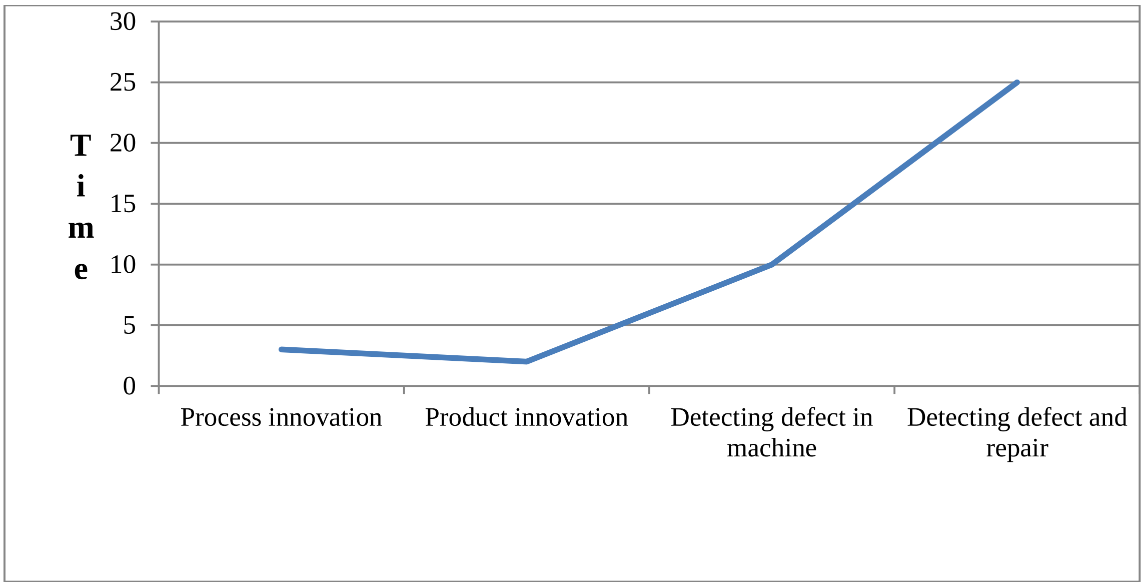
Moreover, a lack of basic skills in the workforce tends to reduce the effectiveness of in-firm training, especially when enterprises seek to move from simple to higher processing functions and standards in terms of process and product innovations. Production processes require workers who also possess experience-based technical skills. Such skills are generally acquired through vocational training and colleges of technical education. "Skills inadequacy" was encountered in local sunflower oilseeds processing enterprises due to a lack of in-firm training to upgrade enterprises' manpower technical knowledge.

Reichert and Zawislak (2014) in a study examined technological capacity and firm performance, aimed at determining the relationship between investments in technological capability and economic performance in Brazilian firms. Through the use of secondary data and key indicators, 133 Brazilian firms were analyzed. Given the economic circumstances of an emerging economy in which the majority of businesses are primarily based on low and medium-low technology industries, it is not possible to affirm the existence of a positive relationship between technological capability and firm performance. There are other elements that allow firms to achieve such results. Negatively, firms of lower technological intensity industries performed above average in the economic performance indicators. However, they invested below average in technological capability. These findings do not diminish the merit of firms' and a country's success. They in fact confirm the historical tradition of a country that concentrates its efforts on basic industries.

Other research, focused on specific analyses of entrepreneurship competencies and innovation activities of SMEs, was conducted by Lara & Salas-Vallina (2017), who discuss the qualifications of graduates necessary for their possible activities in entrepreneurship. The objective of their research was to examine the influence of entrepreneurial competencies on positive attitudes towards work and support the ability to work. A manager should primarily be a professional but also a person with developed innovation thinking skills (Gulhelme & Flavio, 2017). Following the above, it could be stated that it is necessary to support the development of entrepreneurial and managerial competencies at schools and to develop practical skills necessary for possible employability in companies and business sectors, as well as in research and development.

Although the available skills of the workforce were quite low, as experienced in sunflower oil processing enterprises, they might still be sufficient for performing processing activities within enterprises. However, existing skill levels and current processing practices would pose a challenge when enterprises are eager to move into higher processing standards in terms of process innovations and product innovations unless enterprises undertake skill upgrading relevant to new tasks. Process innovations and product innovations critically depend on changing and increasing the work force's skills content. The workforce employed in agro processing enterprises may acquire skills through learning by doing on a daily basis, and as time goes by, activities such as detecting defects in machines and even repairing machines can be handled within an enterprise without necessarily attending any training. Nevertheless, when considering tasks like process innovations and product innovations, the existing work force skills may not be effective for undertaking those tasks that require specialized skills. Figure 5 below shows that enterprises surveyed carry out more activities during the time for repair of defected parts in machines than during the time for process innovations and product innovations.

Figure 6: Number of technical operations against unit of time at an enterprise level



Source: Field Data, 2021

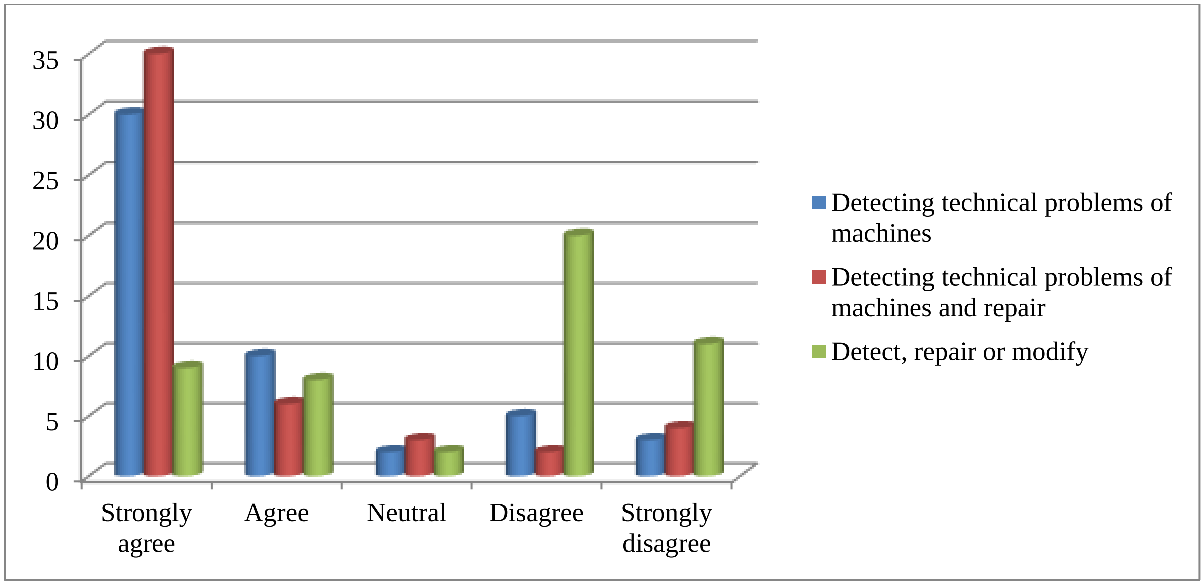
The findings were acknowledged by one of the owners of the enterprises surveyed by saying:

> *"The machines used in sunflower oil processing activities require low-tech workforce skills. Technicians who operate the machines have acquired technical knowledge mainly through learning by doing. In this way, they have been able to detect defects in machines and most of the technical problems causing machine breakdown are detected and solved within the enterprise. We do not recruit our technician employees who have been trained in training institutions. Because the skill base and enterprise infrastructures do not allow for it, there is no regular process and product innovation."*

Figure 6 illustrates the technical knowledge acquired by the workforce in surveyed enterprises. About 96 percent of the respondents who are owners of enterprises said that their technicians' employees are capable of playing multiple roles, such as detecting defects in machines, repairing machine parts, or making modifications to some machine parts. It can be seen that technological capabilities like machine operation, detecting defects in machines, repair and maintenance of machines were built in the enterprises surveyed mainly through learning by doing. However, the existing workforce lacks sufficient skills to perform specialized technical activities like designing new features in machines. The findings indicate that the surveyed enterprises have successfully acquired certain technical knowledge but not related to process innovation nor product innovation.

Most literature indicates a positive and significant relationship between innovation capabilities and enterprise performance (Al-Ansari, Pervan, and Xu 2012; Figueiredo 2014; Hilman and Kaliappen 2015; Kafetzopoulos and Psomas 2016). Kipene, Lazaro, and Isinika (2013) examined the labor productivity performance of small agro-processing firms in Mbeya and Morogoro, Tanzania, focusing on the effect of human capital factors. A survey of 107 agro-processing firms was conducted in the Mbeya and Morogoro regions of Tanzania. According to calculations by the German Institute for Employment Research (IAB), 45 per cent of the tasks that are currently performed by low-skilled workers are routine tasks that could be substituted by computers or computer-driven machines (Dengler & Matthes, 2019). The study conducted by Gomezel and Smolcic (2016) analyzed correlations between intellectual capital and innovativeness as well as the influence of innovativeness on enterprise growth. The authors claim that "there exists a significant relationship between human capital and innovation." The strong and positive relationship between innovation and growth demonstrates the importance of innovation for enterprise growth. Other studies indicate a positive and significant relationship between innovation capabilities and enterprise performance (Al-Ansari, Pervan, and Xu 2012; Figueiredo 2014; Hilman and Kaliappen 2015; Kafetzopoulos and Psomas 2016).

Figure 7: Technical knowledge acquired by enterprises workforce



Source: Field Data, 2021

4.8 Mode of acquiring technical knowledge

Data collected using multiple responses revealed that there are various modes of acquiring technical knowledge by the workforce in surveyed enterprises. The findings in this study show that there is variation in the levels of prevalence of one mode of acquiring technical knowledge compared to another mode. The results reveal that the majority of technician respondents acquired their technical knowledge through adaptation and reverse engineering processes rather than by attending workshops or training in technical colleges. Results show that the majority of technician employees in surveyed enterprises have acquired technical knowledge, mainly through the adaptation of machines and reverse engineering processes, as illustrated in Table 4 below. Technical knowledge acquired through the adaptation of machines implies that, as machines are operated, simple skills can be acquired. At some point, experience is gained in such a way that problem-solving skills, like detecting defects in machines and carrying out minor repairs, can be demonstrated. On the other hand, reverse engineering processes entail activities like dismantling machine parts and making replacements for those parts during repair.

Previously conducted studies collaborate with the findings of this study. According to Mohammed and Nzelibe (2014), seminars and workshops are recommended to improve SME's technical knowledge base, as well as the enterprise coordination efforts with relevant agencies and organizations, although the prevalence of workshops as a mode of acquiring technical knowledge in enterprises surveyed is low. Other studies have highlighted the reasons behind the low prevalence of seminars and training for enterprise employees: the reluctance of owners of enterprises to offer opportunities for their employees to acquire more technical knowledge. According to Abramovsky et al. (2011); Martin & Rüber, (2016); Ramos & Harris, (2012), in Germany, similar to many European countries, the training participation of low-skilled workers is low as employers are the main providers of continuing training.

Other studies have categorized learning into internal and external. The internal learning mechanisms are mostly related to innovation-related skills; knowledge creation through R & D; intra-firm communication of knowledge; knowledge articulation and assimilation; and various forms of experience acquisition. External learning mechanisms relate to short courses and/or postgraduate programs in overseas organizations for staff; active participation in scientific conferences; access to codified knowledge (research reports, articles, etc.); knowledge from specialized consultants; and hiring university graduates (Bell and Figueiredo 2012). In Europe, learning mechanisms are associated with learning by doing to strengthen technical knowledge acquisition. The mechanisms are termed either dual apprenticeship systems or continuing training. In Germany, learning mechanisms do not only represent a prominent case of the dual apprenticeship system and continuing training (Thelen, 2014); they also stand for the high impact and strong regulation of continuing training activities at the company level (Allaart et al., 2009). Despite an increase in the average participation in further training in Germany, the social structures of inequality in participation in continuing vocational training persist.

Table 4: Mode acquiring technical knowledge

Multiple response	Frequency
Attending workshops	9
Attending vocational training	15
Adaption and reverse engineering process	88
Attending university training	0
Consultancy	10

Source: Field Data, 2021

5.0 Conclusion and Recommendations

This study examined the contribution of technological innovations in enhancing the agro-processing industry, particularly sunflower oil processing in Tanzania. At an enterprise level, no regular technological innovations were revealed in terms of both process and product interventions, thus compromising enterprises' need to advance to higher processing standards. Such a lack of regular technological innovations was evident in local technology intermediaries like SIDO, TIRDO, CAMERTCH, and technical training institutions, implying the local technology intermediaries' support like machine supply to sunflower oil processing enterprises have not come to effect. In the areas related to skills, there was an existence of skill bases at an enterprise level in which technical knowledge was acquired mainly through learning by doing and reverse engineering processes rather than attending seminars and training in technical colleges. Technician employees' technical knowledge is limited to the ability to operate machines, detect defects in machines while they are in operation, and perform minor repair and maintenance services. As they belong to a low-skilled workforce, they are unlikely to master complex technological innovations like process innovations and product innovations. In terms of the type of machines, all the enterprises use imported machines and spare parts from China and India in their sunflower oil processing activities. Lastly, most of the enterprises surveyed operate on a small scale, with one to two employees who deal with the technical operations of the sunflower oil processing machines.

The study recommends that there should be a number of arrangements to make local technology intermediaries the source of technology transfer to sunflower oil processing enterprises, while making machine tools needed by sunflower oil processing enterprises available, accessible, and preferred. (i) Identifying and policy-articulating local public and private sector agencies and organizations involved in the value chain of technological innovation. When assigning roles to each actor, we should consider activity separation to avoid duplication and resource waste. Because there is an interdependence relationship between them, local actors should make coordinated decisions. (v) A local needs assessment should be conducted to ensure resource allocation and action is taken to reflect the perceived needs with respect to machine operating efficiency and the level of skill required by both local technology intermediaries and enterprises dealing with sunflower processing activities so as to allow technological innovations to take place.

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International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 5 Issue 12, December - 2021, Pages:185-203

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