Trend Analysis – Small Scale Agricultural Processing

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0 Agricultural Processing Overview

Agricultural processing is defined as the transformation of products originating from agriculture, fisheries and forestry1 into products used as raw materials in a variety of manufacturing sectors, such as food, beverages, textiles, furniture, paper or rubber. Over 50% of the global agricultural processing market (in terms of value added) focuses on food & beverages (including tobacco). The global share of value addition for food, beverages and textiles generated by developing countries has almost doubled over the last 25 years2.

Processing technologies for food and beverages do not differ extensively across product categories, whereas for non-food agricultural processing, there is a much bigger variety in processes. In the non-food sector, the value added is generally higher than in the food-sector. Production volumes of crops differ strongly per region based on many factors, such as climate, local production capabilities, or access to markets, meaning that the demand for agricultural processing also differs strongly per region3.

Agricultural processing equipment is specifically designed for a specific transformation of a specific crop into a specific end product, at a specific scale. This leads to a wide variety of highly specialized equipment.

The focus of this overview is on small scale agricultural processing in low and lower middle income countries, specifically on equipment being used by or producing for those living in poverty 4. Small scale processing is defined as processing taking place directly at small scale farmers premises, at farmer cooperatives, or at small, local processing companies. Processing at large farms, at local industrial organizations or at multinationals is excluded. Small scale processing does not mean that these producers only produce for the local market, some export crops (such as coffee, cacao, cotton) are often produced by small scale farmers, and consequently some steps in the processing also happen at a small scale.

This document is based on information being available in 2013.

1 http://www.fao.org/docrep/w5800e/w5800e12.htm
3 http://www.fao.org/docrep/014/mb060e/mb060e00.pdf
4 See appendix 5

1 Agricultural processing is used to increase shelf life, or for transformations into higher value added products.
2 Small scale processing is done at various locations: at processing facilities, farmers’ cooperatives or directly at small holder farms.
There are 2 main types of customer segments for small scale processing equipment for developing countries, based on the scale of processing:

- Small and medium processing organizations: organizations who source raw input material from agricultural producers and transform the input into processed products. Examples are:
  - a small factory purchasing ripe pineapples and pressing, pasteurizing and packaging it into bottled pineapple juice\(^5\)
  - a cooperative mill where coffee beans of participating coffee farmers are depulped, fermented, washed and dried to be sold on the international market\(^6\)
- Small holder farmers who do various types of home state processing with very basic equipment.

85% of the world’s 525 million farmers cultivate an area smaller than 2 hectares\(^7\).

The main needs of smallholder farmers are preserving food for own consumption or creating access to local or export market (e.g. small coffee farmers).

Globally, over 1 billion people are members of some sort of agricultural cooperative\(^8\).

For established cooperatives or SME’s, acquiring new processing equipment can create a new market (new products, new clients)

In both the food and non-food agro-processing sectors, there is a trend towards greater levels of transformation and value addition, and the employment of more advanced technologies.

- The average upper-middle income country agricultural worker adds 7-10 times more value than his lower-middle or low income country counterpart.
- In upper- and lower-middle income countries, the added value per agricultural worker has grown over 70% within 25 years, while the added value of low income farmers is growing much slower at 30%.
- This makes it increasingly difficult for low-income farmers to compete on the global export market\(^9\).

Experts indicated the fruit and vegetable market is becoming more locally focused, since a lot of products from small scale farmers are rejected for export due to increasing quality and standardization requirements.

### 1.2 Impact description

\(^5\) http://untappedmarkets.ca/2011/05/sustainable-business-part-2/
\(^6\) http://coopcoffees.com/what/trading-partners/rio-azul-guatemala/
\(^7\) http://www.globalagriculture.org/report-topics/industrial-agriculture-and-small-scale-farming.html
\(^8\) http://www.fao.org/docrep/016/ap431e/ap431e.pdf
\(^9\) http://www.econstats.com/wdi/wdiv_338.htm
The impact of agricultural processing can be grouped around food security, food safety and health, economical and environmental issues.

- **Food security**
  - 870 million people, 12.5% of the population, are chronically undernourished. 850 million of those live in developing countries.
  - About 1.3 billion ton food, one-third of global production, gets lost or wasted globally.
  - In low-income countries, almost all of the losses related to agricultural outputs occur before the product reaches the consumer, while in Western markets, much food is wasted at the consumers. Efficient agricultural processing technologies (such as preservation, cooling, packaging) can reduce food losses within the supply chain, improving BoP food security.

- **Food safety and quality / health**
  - In low income countries, food safety and health are dominant issues related to small scale agricultural processing.
  - Foodborne illnesses very often reflect poor handling, preparation, storage and transportation of food.
    - Appropriate food preservation and processing increases food safety and quality, thereby decreasing diseases and mortalities resulting from food poisoning.

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11 http://www.fao.org/docrep/v2890t/v2890t0b.htm
However, it is only when countries have relatively adequate food supplies that food safety and quality become major concerns.\(^\text{11}\) Next to consumer health and safety, worker health and safety is a major concern. Processing workers face a series of job-related hazards, such as:

- Unsafe machinery, cutting and piercing tools
- Hazardous toxins or chemicals in the processed product, such as pesticides, plant-borne allergens, transmittable infections from handling animal material.
- Ergonomic issues such as noise, vibration, prolonged unnatural body positions, extreme temperatures, confined spaces, etc.\(^\text{12}\)

### Economical

- Processing creates access to higher value-added markets for small holder farmers in two ways:
  - Increasing shell life and quality of products increases attractiveness to the local market
  - Complying to international standards for processed products opens up the possibility to enter the export market.
- Processing creates new job opportunities not only in the processing business but also with its forward and backward linkages, such as in collection, distribution, or input supply.\(^2\)
- According to experts, food processing is often seen as women’s job. Therefore, there are many women’s cooperatives getting into processing, which results in empowering women. In some cases men are known to take over from women when the business becomes profitable.
- The main reason why processors are investing in energy efficient equipment is not environmental, but economic in nature. As fossil fuel and firewood prices are increasing, energy efficiency and using renewable energy sources becomes economically more viable.

### Environmental

- In lower-middle income countries, where food safety and health issues are generally less dominant, (energy) efficiency is becoming a dominant factor.
- Decreasing food losses by efficient processing and storage can have a significant positive impact on the environment, considering the negative environmental impacts of agriculture, such as deforestation, habitat loss, soil quality loss, extreme climate events, water use (70% of global fresh water is used for agriculture\(^2\)), and pollution due to fertilizer and pesticide use.
- Experts indicated that many smallholder farmers processing devices are inefficient both in (non-renewable) energy consumption and waste production, as well as in terms of quality of the end-product, compared to solutions at community or processing factory scale. For example, consider a smallholder shea butter nut farmer parboiling and drying

her own nuts on a traditional wood fire versus a larger scale, better designed communal cookstove and solar dryer at a shea butter cooperative\textsuperscript{13}.

1.3 End-user behavior trends

- Urbanization increases the need for processed food
- Mobile phone technology increases transparency in the agricultural value chain, for producers and consumers alike.

The trends below lead to changes in demand and supply of processed food and processing technology.

- Urbanization:
  - Increases in per capita incomes due to a shift from subsistence farming to industrial or service jobs lead to higher demand for processed foods and animal proteins\textsuperscript{2}
  - Increasing share of women in the workforce lead to higher family incomes, but also to less time for women to prepare traditional, non-processed foods
  - The slow but steady introduction of supermarkets makes processed foods available to more people, and makes it easier for processors to sell their products, increasing both supply and demand simultaneously.

- Biofuels:
  - The increasing demand for agricultural products as biofuel production feedstock leads to an increased pressure on agricultural lands otherwise used for food crops
  - The production of biofuel crops require processing, and creates new jobs and income\textsuperscript{2}

- The rise of the mobile phone and mass media:
  - Mobile phone communication and information systems create more transparency in the market
    - Mobile communication allows farmers to get organized easier for joint processing activities.
    - Mobile market information systems match demand and supply, allowing more fresh product to be sold, leading to less need for preservation technologies.
  - Increase access to (social and mass) media increases the demand for higher quality, “Western” products
    - Consumers aspire a “Western” lifestyle of more processed (fast)food, leading to a rapid increase of previously-though Western afflictions such as diabetes, obesity and high blood pressure\textsuperscript{14}.
    - Processing equipment that has a “Western” look gives a certain status to farmers

\textsuperscript{13} http://scialert.net/abstract/?doi=ajft.2012.73.81
\textsuperscript{14} http://www.fao.org/docrep/007/y5736e/y5736e00.HTM
- Food safety scandals go ‘viral’ quickly, and lead to mass consumer boycotts. A recent example is Chinese customers refusing to buy locally produced milk powder after 6 Chinese babies died and 300,000 fell ill from consuming contaminated milk powder.\(^{15}\)

## 2 Market Supply

### 2.1 Equipment landscape

- Agricultural processing equipment comes in literally thousands of shapes and sizes, each specialized for a certain crop, process, scale and end-product.
- The dominant view is that the issue is not the (un)availability of appropriate technology, but the (dis)organization of the value chain.
- Opportunities for product innovation can be found in off-grid cooling and storage, multipurpose processing equipment, autarkic energy or waste-to-energy conversion.

Agricultural processing equipment is used in many different ways to transform raw materials into products for end-consumers. The main transformations are: water activity control (e.g. drying), heating/cooling/freezing, separation, transformation, structuring and preservation. Subsequently, the products can be packaged, stored, and distributed. The type of equipment for these processes is very diverse, as it is often specialized equipment for a single type of transformation from a single raw material into a single end-product. This leads to a product landscape with literally thousands of processing equipment variations.
There are two different lines of expert opinion about the need for a focus on processing equipment.

- The more dominant view is that the issue is not the availability of equipment, but the (dis)organization of the supply chain where this equipment can be used.
- Another view is that there is a need for appropriate equipment which is low-tech and small enough for small scale processors.

The availability of equipment depends on the region as well. The type of equipment differs a lot from region to region.

- For example, in Central Asia equipment from Soviet times is abundant. These are outdated and very large equipment which need big volumes to process.
- Whereas in Africa there is a lack of machines, funds to purchase them and skills to operate or maintain. Equipment that can be found in African villages is often donated by charity organizations or NGO’s. In many cases, such equipment is left idle, because of reasons such as lack of operating skills, lack of maintenance, lack of spare parts or a too high volume requirement. It is often argued that donated equipment disturbs the market for local equipment sales, and creates the image that equipment is free.

Experts indicated that there are enough suppliers for large scale processors but not enough for low-tech and small scale equipment for small producers. In some cases it is possible to find very simple local equipment. However, these usually don’t supply the necessary functions.

Transport of fresh produce is a big issue. Equipment which can be used close to the harvest can be a solution. In that case, the equipment has to be simple and robust enough for use by non-skilled farmers, and transportation over very bumpy roads.

Storage with little technology and little or no use of electricity involved is one of the main needs, since the largest market is for fresh products.

Small scale, off grid cooling solutions are lacking. Similar to storage, there seems to be a high demand for these solutions, especially for fresh products such as milk, meat, fruits and vegetables.

Multipurpose processing units that can process various produce lack in the sector. Such products could have higher utilisation rates because they are not dependent on only one season

The level of automation is an important criterion for the equipment. The choice depends on the skills for operation and maintenance. Even a limited level of automation results in more stable quality, which increases the market for the processed product.

The type of the equipment to be used depends also on the availability of electricity. Generic processing equipment typically fails in areas without electricity infrastructure, or with unstable energy supply.

A trend is to see agricultural waste as a possible source of energy, using for example biogas digesters to transform coffee pulp into biogas to heat coffee bean cooking vessels.16

There are many traditional alternatives to conserve or to process the produce that hardly involve technology (such as hanging milk in an earthenware pot on a tree in the night to

16 http://www.appropedia.org/Biogas_from_Coffee_Wastes
preserve it). Generally speaking, these methods result in poor and unstable quality, which limits the market potential for these products.

2.2 Supply chain

- Lack of skilled personnel, training, maintenance, and access to spare parts are blocking issues in the supply chain.
- Development projects in agriculture are becoming more business oriented, with the role of NGO’s shifting towards organizing local value chains.

The supply chain for agricultural processing equipment intersects with the general agricultural supply chain, which consists of all activities related to field preparation, seeding, fertilizing and harvesting, to processing, packaging, storage and distribution, up to the final product reaching its end customer. Below, the supply chain for agricultural processing equipment is described.

- R&D
  - R&D on food processing is mainly done in the West, or at recently industrialized countries such as China, India or Brazil. Multinational food processing companies play an important role in advanced R&D.
  - Local food research institutes perform a variety of applied research on adapting processing technologies to a local context, as well as testing and standardization work.
- Design
  - Designs of more advanced products for small scale use are usually done in cooperation with Western NGO’s or social businesses. Mainstream actors in developing countries often focus more on equipment for the export market.
  - In development projects, the designs are often a co-creation between the processors and the producers of equipment.
  - Local, very basic, traditional product designs are of widespread use.
- Production & assembly:
  - Although the sector focusing on small scale products is mainly driven by NGO’s, the equipment production is done by Western or Asian companies.
  - In most of the Western products, components are produced and assembled in China.
- Distribution:
  - Small scale equipment is generally sold at local agricultural business support points, where processing equipment is sold next to fertilizer, seeds and other agricultural products. as seeds are sold.
  - The distribution of mid to larger scale equipment is done via producing companies since the installation would require technical background, but in this stage as well the organization is done by NGO’s.
  - Charitable organizations will distribute equipment in hard-to-reach areas.
- Training:
Training is mainly done on the use of the equipment and by the suppliers since it requires technical knowledge. Usually the cost of the training is included in the price of the equipment.

- There is a lack of training on maintenance or end of life of the product.

**Maintenance:**
- Maintenance is an issue because of the lack of local skill and equipment.
- Since the suppliers are usually from Western countries, US or China, their maintenance service is not available locally.
- Because of the lack of maintenance, Western companies hesitate to enter BoP markets. Since the machinery is left idle in the case of failure, it causes a negative image for the company.

**End of Life:**
- There is almost no consideration on end-of-life of products. Sometimes reuse can be seen (e.g. truck motors which are not good enough for a truck anymore can be used for fishing boats or electricity generation).

**Trends:**
- Supply chains become more business oriented. There are more business stakeholders involved, while charity giveaways are being more and more seen as market disturbing.
- The role of NGO’s changes from being donors to service suppliers to connect the farmers with the companies and to organize the local market. Many NGO’s offer business services focused on a certain niche, such as the Sustainable Food Lab.\(^{17}\)

### 2.3 Revenue models

- New financing models are emerging, such as micro-finance, equipment leasing or resource pooling. NGO’s often play a role in connecting farmers and processing companies to capital.
- Autonomous mobile processing units are a way for multinational companies to source local products on a low-cost basis when regular distribution channels are non-existent.

- Small scale processors or farmer cooperatives who buy the equipment usually require (micro)finance from banks or MFI’s. NGO’s increasingly play a supporting role in micro-financing agricultural equipment. (e.g. NGO ICCO gives 50% guaranty on agricultural processing equipment loans)
- The revenue model of NGO’s is traditionally based on subsidies and grants but especially in Europe there is a significant decrease in these resources. Therefore NGO’s are trying to move towards more sustainable models like development of services.

\(^{17}\) [http://www.sustainablefoodlab.org/](http://www.sustainablefoodlab.org/)
- Companies (suppliers of the equipment) get their revenue streams from direct sales, usually via NGO’s to farmer cooperatives or small scale processors.
- Experts indicate that there is a limited number of social enterprises involved in the sector.
- New revenue models are emerging:
  - Leasing models are emerging; where processors buy the equipment and either rent it to farmers for short periods of time (e.g. plowing equipment) or do the process and let the farmers pay for the service (e.g. rice husking)
  - Pooling resources; where the farmers jointly purchase shared equipment.
  - Autonomous Mobile Processing Units, owned by multinationals are able to do on-the-spot processing, significantly lowering the cost for local farmers, and creating an international market for products for which this was previously impossible due to the absence of distribution channels. “If the farmer cannot come to the factory, let the factory come to the farmer”. An example is on-the-farm and on-the-factory cassava processing by Dadtco.\(^\text{18}\)

## 2.4 Industry structure / market leaders

The processing equipment industry can be segmented into four types of players:

- Commercial Western medium scale equipment producers
- Social business small scale equipment producers
- Equipment donating charities
- Traditional solutions (often home-made)

The industry for agricultural processing equipment can be divided into 4 segments:

- Western medium scale processing equipment, typically from the USA, Germany, Italy, Japan, the Netherlands etc. which is purchased by more advanced processing companies
- Fit-for-purpose small scale processing equipment manufacturers, which specifically target small scale producers. Typically, these tend to be social enterprises or NGO’s. Solar dryers are an example.\(^\text{19}\). Some products are both sold to small scale hobbyist in the West, and small scale farmers in developing countries, such as the Piteba oil press.\(^\text{20}\). NGO’s often create their own design for certain small scale solutions, such as the Zeer Pot Fridge by Practical Action.\(^\text{21}\).
- Donated equipment by charities.
- Homemade, traditional solutions.

- For the three bottom segments, market leaders cannot be named, because of the small scale of operations and often informal character of the industry.

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\(^\text{18}\) [http://www.dadtco.nl/what-are-we-doing](http://www.dadtco.nl/what-are-we-doing)
\(^\text{19}\) [http://www.solarfooddryer.com/](http://www.solarfooddryer.com/)
\(^\text{20}\) [http://www.piteba.com/eng/company%20profile.html](http://www.piteba.com/eng/company%20profile.html)
\(^\text{21}\) [http://practicalaction.org/zeerpots](http://practicalaction.org/zeerpots)
3 Knowledge State

3.1 R&D intensity

- Tropical agriculture is a specialized field of research that focuses on agriculture in (the climate of) developing countries. Its main focus is more on agricultural practices, and only second on post-harvest activities such as processing.
- The export markets of developing countries can be heavily influenced by global shifts in preferred crop variety which is the result of Western, high-tech cultivar improvement.

Having analyzed the annual amount of scholarly and popular articles published in the Scopus database that focus on agricultural processing technologies for developing countries, the following conclusions can be drawn from the data:

![Peer reviewed articles published per year](chart.png)

- Yearly, around 12,000 scientific articles are published that cover a topic on Agricultural Processing. Out of those, roughly 800 (7%) focus specifically on developing countries.
- Tropical agriculture is an established research field that deals with the specificities of agriculture and processing in tropical areas, which are often BoP markets. This is similar to the field of Medicine, but for none of the other BoP research topics (e.g. water, energy). The focus is more on agricultural practices than on post-harvest processing.
- Experts indicated the majority of R&D in agricultural processing for developing countries is applied R&D, there is almost no fundamental research as most basic processing technology

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22 See appendix, paragraph 5 for detailed description of search database and keywords.
are considered to be fully developed. The main issue is to adapt the existing technology according to the needs of BoP (low-tech, easy maintenance, etc.)

- Conservation techniques such as drying, cooling or freezing are one of the most heavily researched topics, especially with a focus on centralized solutions. Small scale, decentralized solutions which are more suited for BoP markets because of poor transport and energy infrastructure are less researched.

- Global trends in food processing R&D are:
  - Food processing focusing on making food healthier, meaning less salt, less sugar and less fat. In developing countries, these are emerging issues.
  - New proteins to replace meat, such as soy-based or insect-based proteins. Both soy and insect based protein have links to production and consumption in developing countries.
  - Varieties of specific products suitable for processing. (e.g. only specific varieties of pineapples are suitable for juice production.). Developing countries are often vulnerable to global shifts in preferred crop variety when a new, improved production variety has been developed in high-tech R&D in the West. An example is the shift in global demand for pineapples from Smooth Cayenne to the engineered pineapple cultivar MD2 which is better suited for long haul sea transport, and later back again to Smooth Cayenne as air freight became more popular\(^2\).

### 3.2 R&D centers, journals and conferences

- Newly industrialized countries such as India, Brazil and Malaysia, are upcoming R&D centers on fundamental research into agricultural processing solutions.
- Much practical research is being conducted at national food research institutes, who often have strong links with Western Universities or NGO’s.

The following universities and R&D centers have published the highest number of scientific articles on agricultural processing specifically focused on developing countries (2011 – 2013).

- Central Food Technological Research Institute India(36)
- Punjab Agricultural University, Ludhiana, India
- University of Agriculture, Faisalabad, Pakistan
- University of Ibadan, Ibadan, Nigeria
- Universität Hohenheim, Hohenheim, Germany
- Central Institute of Post Harvest Engineering and Technology, Ludhiana, India
- University of Nigeria, Nsukka, Nigeria
- Universidade de Sao Paulo, Sao Paulo, Brazil
- UC Davis, Davis (California), United States of America
- Universiti Sains Malaysia, Penang, Malaysia
- University of Agriculture, Abeokuta, Nigeria
- National Dairy Research Institute, Karnal, India
- Council of Scientific and Industrial Research India, New Delhi, India

\(^2\) http://www.acdivoca.org/site/ID/success-Ghana-Renewing-Smooth-Cayenne-Pineapple-Production
Universidade Estadual de Campinas, Campinas, Brazil
Wageningen University and Research Centre, Wageningen, The Netherlands
G. B. Pant University of Agriculture & Technology, Pantnagar, India
Indian Agricultural Research Institute, Delhi, India
Universiti Putra Malaysia, Kuala Lumpur, Malaysia
CIRAD Centre de Recherche de Montpellier, Montpellier, France
Michigan State University, East Lansing (Michigan), United States of America

Expert indicated the following applied research institutes as important practical R&D players

- KIRDI, the Kenya Industrial Research and Development Institute, Nairobi, Kenya
- AVRDC - the World Vegetable Center (11 offices in Africa and Asia, headquartered in Tainan, Taiwan)
- CGIAR, the Consultative Group on International Agricultural Research, an alliance of 15 research centers worldwide:
  - Africa Rice Center (West Africa Rice Development Association, WARDA), Bouaké, Côte d’Ivoire
  - Bioversity International Maccarese, Rome, Italy
  - Center for International Forestry Research (CIFOR), Bogor, Indonesia
  - International Center for Tropical Agriculture (CIAT), Cali, Colombia
  - International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon
  - International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad (Patancheru), India
  - International Food Policy Research Institute (IFPRI), Washington, D.C., United States of America
  - International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
  - International Livestock Research Institute (ILRI), Nairobi, Kenya
  - International Maize and Wheat Improvement Center (CIMMYT), El Batán, Mexico
  - International Potato Center (CIP), Lima, Peru
  - International Rice Research Institute (IRRI), Los Baños, Philippines
  - International Water Management Institute (IWMI), Battaramulla, Sri Lanka
  - World Agroforestry Centre (International Centre for Research in Agroforestry, ICRAF), Nairobi, Kenya
  - World Fish Center (International Center for Living Aquatic Resources Management, ICLARM), Penang, Malaysia

The following journals contain the highest number of articles on agricultural processing technologies for developing countries (2011 – 2013):

- Journal of Food Science and Technology
- Acta Horticulturae
- Pakistan Journal of Nutrition
- Plos One
- International Food Research Journal
- Livestock Research for Rural Development
• Journal of the Science of Food and Agriculture
• Food and Nutrition Bulletin
• Journal of Food Science
• Tropical Animal Health and Production
• Food Chemistry
• International Journal of Food Microbiology
• African Journal of Biotechnology
• International Journal of Food Microbiology
• Food Research International
• Advanced Materials Research
• Pakistan Journal of Agricultural Sciences
• Journal of Food Agriculture and Environment
• Environmental Monitoring and Assessment
• Agricultural Engineering International Cigr Journal
• Field Crops Research

The following conferences are selected based on the amount of relevant articles published, or were indicated by experts. Usually they focus on a single topic, and solutions dedicated to developing countries make up a small niche.

• Association for Computing Machinery International Conference
• American Society of Agricultural and Biological Engineers Annual International Meeting
• American Institute for Chemical Engineers AIChE Annual Meeting
• International CIGR Technical Symposium Towards A Sustainable Food Chain Food Process
• Bioprocessing and Food Quality Management
• Engineering for Rural Development
• International Technical Symposium on Food Processing Monitoring Technology in Bioprocesses and Food Quality Management
• American Society of Agricultural and Biological Engineers ASABE Annual International Meeting
• American Society of Agricultural and Biological Engineers ASABE Agricultural Equipment Technology Conference
• Computers in Agriculture and Natural Resources
• Agricultural Mechanization in Asia Africa and Latin America
• International Mineral Processing Congress IMPC
• Agricultural Equipment Technology Conference
• Future Beverage Innovation
• Food Ingredients Global
• Health Ingredients
• Bakery Innovation Europe
• European Federation of Food Science and Technology

Key take-aways:
Local universities in developing countries such as India, Brazil and Malaysia are publishing an increasing share of research on agricultural processing for developing countries. Measured in the amount of scientific articles produced, ‘Western’ universities seem to be losing their previous dominance on this subject.

There is ongoing debate about the general scientific quality of articles published in developing countries. Vanity publication and plagiarism are often mentioned occurrences in underdeveloped academic ecosystems. (The above list is created using the Scopus scientific index by Elsevier, which imposes certain quality controls). Other aspects that impact perceived quality can be a poor command of the English language, or unfamiliarity with the ‘Western’ scientific culture and traditions.

Local, practical institutes affiliated to global consortia such as CGIAR or AVRDC are mentioned as important innovation centers.

Most of the universities have dedicated food processing departments, although not specifically focusing on developing countries. Tropical agriculture departments generally focus less on processing.

European applied research institutes such as TNO(Netherlands), Fraunhofer(Germany), VTT(Finland), CNRS(France), all have food processing departments, which mainly specialize in the products produced in their country: in the Netherlands horticulture and dairy processing, pasta in Italy, rice in Spain, dairy in Denmark, etc.

Conferences tend to be very specialized, either focusing on a specific technology (thermal processing) a specific product (milk), or a specific topic (biohazards, microbes, hygiene).

3.3 Technological trends

- Three technology trends that are relevant to developing countries are:
  - Increasing quality requirements for export are a driver for local markets
  - Focus on frugal, human-centered design
  - Focus on off-grid energy

- Global R&D for agricultural processing focuses on high tech topics such as the isolation of specific food components (antioxidants, specialized lipids), which are generally not relevant for small scale solutions.

- Three main trends that are relevant for developing countries are:
  - Increasing quality requirements for export results in developing new processes (e.g. juice production) for small scale processors to achieve the desired quality. Although this doesn’t require fundamental R&D, it requires the implementation of existing technology in new (smaller scale) circumstances. The export market is a strong driver for local markets.
  - When local markets are considered, the key issue is to adapt technology in such a way that it becomes appropriate and affordable for small processors with limited technical knowledge or access to spare parts. Research into these products tends to be human-centered design oriented, and when a main design criteria is low cost, it is often called ‘frugal design’.
Energy dependency:
- For remote areas, equipment which can work off-grid, e.g. via solar energy, or using processing waste as input for a biogas digester
- For lower-middle income countries: equipment that runs on renewable energy (e.g. biogas from agricultural waste) or is very energy-efficient.

3.4 Standardization and Test Centers

- In international standardization, country specific organizations such as ASABE\(^{25}\) guide international developments on agricultural processing standards
  - Working group “FPE-703 Food Processing” deals with engineering design, modeling, optimization and control of process operations; including heating and cooling, pasteurization, sterilization, freezing, dehydration and concentration.
- In most developing countries, a National Bureau for Standards sets safety and hygiene standards for agricultural processing and processed food products\(^{26}\). Generalizing, these standards are based on ISO and WHO guidelines, but not formulated as tight as EU or US standards.
- Developing countries face a large number of difficulties in formulating, implementing and enforcing process and product standards\(^ {27}\). Reasons are:
  - Inadequate institutional infrastructure and capabilities
  - Insufficient knowhow in standards development processes
  - Little awareness and little access to information on standardization
  - Limited participation in international standard setting
  - Poor coordination among agencies responsible for technical regulations
  - Inadequate funding
  - Inadequate stakeholder participation
  - Corruption
- Especially electrical and mechanical safety standards are not much applied.
- Illegal labelling of food products is becoming an issue, due to a lack of test centers and test equipment, and due to a lack of enforcing or corruption.
- If Western companies import from or export to low-income markets, they typically fulfill the standard from their home markets, which are generally higher than local standards.
- A trend is for Western consumers to demand transparency of the entire production process, forcing multinationals to apply higher safety (and payment) standards in developing countries. In export value chains that involve small scale processors, such as coffee or cacao, pressure from Western certification agencies\(^ {28}\) and consumers has resulted in improved conditions even for the smallest farmers.

\(^{26}\) http://www.bioline.org.br/request?nd10118
\(^{27}\) http://ageconsearch.umn.edu/bitstream/93814/2/op29.pdf
\(^{28}\) https://www.utzcertified.org/
4 Support ecosystem

4.1 Funding and Financing

- Funding for R&D is available via various international agricultural funding organizations.
- Multinational organisations are funding projects to include small holder farmers into their supply chain
- Impact investing and micro-finance are growing financiers of agri-businesses.

The following trends can be observed in 3 types of funding that are relevant for agricultural processing equipment in developing countries:

R&D funding: fundamental and applied scientific research

- The global agricultural R&D agenda focuses on topics such as food security, high-quality foods and other bio-based products, and competitive, resource efficient production systems. Given the global nature of the agriculture import/export market, topics which are relevant to developing countries will generally fit within Western research agenda’s.
- The FAO has published a comprehensive online guide\(^\text{29}\) that directs users to sources of funding available for agricultural research that also includes small scale solutions, for various regions. Funders include international agriculture research programs such as CGIAR\(^\text{30}\) and the CGIAR Fund\(^\text{31}\), CIAT\(^\text{32}\), or IFAD\(^\text{33}\), or regional ones such as ASARECA for Eastern and Central Africa\(^\text{34}\).
- Donors and NGO’s typically sponsor a certain niche in agricultural research, such as the Bill & Melinda Gates Foundation\(^\text{35}\) who funds R&D into countering food losses and increasing nutrition

Project funding: projects aiming for impact via implementation without commercial objectives.

- Implementation projects are typically funded by:
  - Government agencies such as SDC, GIZ, DFID, USAID, DGIS, SIDA.
    - Some agencies set up bilateral agricultural innovation programs, such as the AgInnovation US India program\(^\text{36}\).
    - The Devex portal\(^\text{37}\) gives an overview of USAID Agriculture programs.
  - Investment banks such as World Bank, European Investment Bank, Asian Investment Bank

\(^{30}\) http://www.cgiar.org/our-research/cgiar-research-programs/cgiar-research-program-on-integrated-systems-humid-tropics/
\(^{31}\) https://www.cgiarfund.org/
\(^{32}\) http://ciat.cgiar.org/
\(^{33}\) http://www.ifad.org/operations/grants/
\(^{34}\) http://www.asareca.org/about/CGS.htm
\(^{35}\) http://www.gatesfoundation.org/what-we-do/global-development/agricultural-development#AreasofFocus
\(^{36}\) http://aginnovation.org/
\(^{37}\) https://www.devex.com/impact/partnerships?search=agriculture&page=1
- Agricultural funding programs such as IFAD\(^\text{38}\).
- Multinational food companies are increasingly investing in working with small holder farms. Involvement can be from a CSR perspective, although more and more companies are starting to see the BoP as future producers and consumers. Even if food is consumed locally, the export market of these companies is driving local trends and focus.
  - An example is Danone, who is funding smallholder and family farm milk producers to become part of the Danone supply chain\(^\text{39}\).
- A trend is that within non-commercial value chain development projects, commercial micro-finance is made available to small scale farmers to e.g. purchase processing equipment to be able to play a role in the newly established value chain.

(Social) business funding: funding for business that either focus on commercial return, or focus on reaching social or environmental impact while at the same time becoming financially sustainable.
- Impact investors specifically targeting agricultural businesses, such as the Terragua\(^\text{40}\) group of investors or Root Capital\(^\text{41}\), who focuses on medium sized business loans that are too big for microfinance but too small for commercial finance.
- Micro-finance institutions that target small scale farmers, such as Kiva\(^\text{42}\).

### 4.2 Political and institutional support

- National agricultural policies generally include processing.
- National regulations demanding at least a share of local production increase in-country processing.

- Despite advances in reducing hunger\(^\text{43}\), global population expansions means food security is a constant pressing policy issue.
- Political support for appropriate processing equipment innovation in developing countries is limited, although it varies a lot per crop and per region. The governments of developing countries slowly start supporting the local private sector which is the initial phase to get small scale solutions onto the market.
- Most African countries have put processing in their development plans. Social development strategies have a part of agricultural development and there is always a part about processing, because of its added value.
- Some governments bring enforcement regulations to substitute the import. For example Niger forced Friesland Campina to get 10% of its milk from local producers. Similarly, South Africa has legislation for retailers to get 30% of their products from small farmers.

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\(^{38}\) http://www.ifad.org/
\(^{40}\) http://www.thegiin.org/cgi-bin/iowa/council/terragua/index.html
\(^{41}\) http://www.rootcapital.org/
\(^{42}\) http://www.kiva.org/labs/financingagriculture
\(^{43}\) http://www.who.int/topics/millennium_development_goals/hunger/en/
4.3 Awards and recognition

Apart from criteria such as the actual achieved impact, or scientific recognition via publications,

- Industry status is achieved by working with the right partners
- Awards are being pursued for status, the financial gains are often limited

awards and recognition come in many forms.

- Fellowships such as Ashoka: Rural Innovation and Farming\textsuperscript{44}
- Awards, either broad food-related such as the world Food Prize\textsuperscript{45} or specifically for processing equipment such as the Energy for Agriculture Award\textsuperscript{46} by Ashden and USAID
- Working with the right partners: A certain status within the industry can be derived from working with international organisations such as FAO, top funders such as the Bill & Melinda Gates Foundation, renowned universities or large NGO’s.

\textsuperscript{44} http://farming.ashoka.org/fellows
\textsuperscript{45} http://www.worldfoodprize.org
\textsuperscript{46} http://www.ashden.org/wood-stoves
5 Poverty definition

Poverty can be defined economically as those living below a certain income threshold, typically less than 1.25 or 2 USD a day (at 2005 Purchasing Price Parity). Such quantitative definitions are often criticized for not taking into account price differences between regions, excluding non-monetary income (e.g. produce from subsistence farming), or ignoring that poverty is a continuum with different levels of hardship. We follow the qualitative definition of the UN, which describes poverty in broader terms as a “lack of income and productive resources to ensure sustainable livelihoods; hunger and malnutrition; ill health; limited or lack of access to education and other basic services; increased morbidity and mortality from illness, homelessness and inadequate housing; unsafe environments and social discrimination and exclusion”.

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7 Background on R&D state search methodology

7.1 Search Database

The database used for these analytics is Scopus, the world’s largest online database of peer-reviewed articles and abstracts, by Elsevier. Scopus covers over 50 million records from 21,000 journal titles by 5,000 publishers.

Scopus also offers advanced online search tools, covering ‘popular scientific’ publications outside of the Scopus database. Those publications include scientists’ homepages, courseware, patents, institutional repositories as well as selected web content such as reports from World Bank, OECD etc.

7.2 Search Queries

The search queries that have been used to yield the data on which this analysis is built consists of combinations of 3 search terms:

1. A search term describing the field of ‘Energy’

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47 http://go.worldbank.org/77LE4ON4V0
3. A search term describing ‘Developing Countries’