Innovation Support Voucher Technical Report

ISV ID ISV 143

Project title **SmartTomato**

Period covered by the report: from 12/12/2020 to 12/04/2021

Company name

Project beneficiary (SME)	**Profyta B.V.**

Contact person (responsible for reporting)

Family name	**Schurink**
First name	**Ewout**
Phone number	**+31624655534**
Email address	**ewout@profyta.com**

By signing the document the beneficiary confirms that the provided information concerning this report is correct and complete.

Signature	
Name	Ewout Schurink
Position	CEO Profyta
Date	13/04/2021

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The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.

1. Summary for publication

The study, project was to compare the current system to process tomato till an end product like paste or an product like ketchup. Special in Africa there is several isue's to process it in a economic way, to control the usage of water and energy. Also the have issue's that they can not porocess/produce year round, and/or at least 75% of the year. We learn also in the study that in the case by RedGold (producer in Tanzania) the input of the tomato, special on the quality was dramatic (low % of dry stuff), and we learn by our self that the producer of tomato's are not aware of the MRL's (Maximum Residue Level's) of pesticide.

Composting was done's but not direct for energy, but to create compost, which they can use in the fertigation of the production of new crops.

Water and energy reduction: we learn that the biggest improvements needs tob e done in the production of the raw product.

2. Technical report / Activity report

2.1. Explanation of the work carried out

Profyta: main point is that processing of tomato's to paste or other products is consuming enormous energy, it's also depend on the inputs (products which will be used for the production, in thus case fresh tomato products).

This product can contains less dry stuff or have an low brix, this is depend on:
• Variety's, when they use an variety with less dry stuff it's consume' s more energy.
• Irrigation and fertigation management: when the producent is using too much water by irrigation, product will contains more water, when he use very less fertilizers (an-organic or organic), there are less minerals in the tomato.
• When the producent use too much water, there is an risk he use more pesticide's.
• Bush management, open crop is better for a higher dry-stuff.

Of course the goal is to control it in the process in the factory, but we are also working to connect the information of the "field" together with the factory.
At the factory level: as describe the raw material is coming in, at the current system is less controllable the inputs, this is one of the "building criteria" to know the inputs.
Current the inputs will be treated to reach the goals (dry-stuff and brix), when the dry-stuff is extreme low, it will consume much more energy.

In the process it's difficult to control the process, see also the ISVInnovation Support Voucher Technical

Report of 19 April 2021
Profyta: After the study we learn that we need to:

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• Ensure the inputs have the specs to reduce and control the inputs like energy (means fixed specs like % dry-stuff, Brix).
• Ensure that when the products enter the process room, information like DS, Brix etc. is in the system.
• Track and trace the flow of the product, see also Technical Report of 19 April 2021.
• Calculating the inputs on the different batches, to learn which effect the inputs have on the energy inputs (means raw product with an high % dry-stuff and high brix reduce the energy costs.
• Water consumption: learn with the sensors and flow meters exact the input of water/fertilizers and the effect of precise irrigation on the raw product for the factory.
• Same as above, effect on the health of the crop (precise irrigation have an impact on the health of the crop, over irrigation and special fertigation have an negative effect on the health of the crop, and give "wasser bombs".

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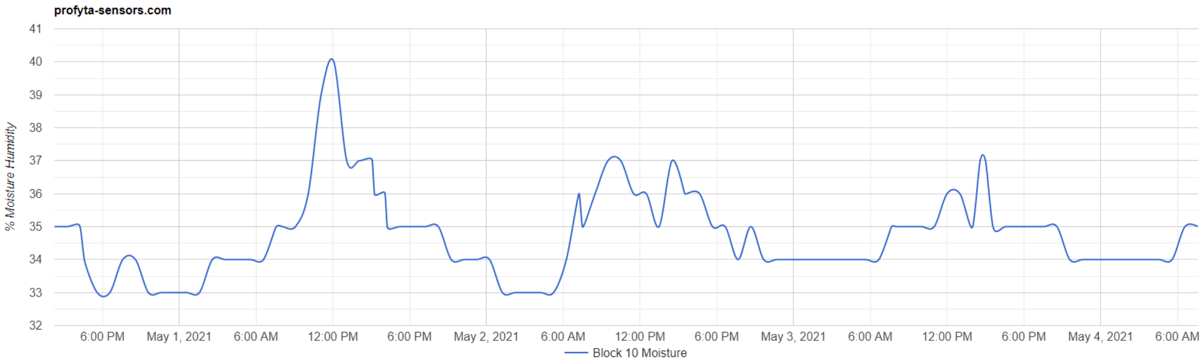
For the society: at the farm and factory this system/program will ensure that a factory/open field create jobs year round, at the current systems, the factory can run only several months per year. When we control the production on the open field and factory we are able to produce more than 8 months per year.
Impact on the environment and on the health of the production employee's is positive, when the growth on the yield is controlled (by irrigation, fertigation, bush management), the usage of the chemical inputs can be reduced significant.
Reducing the energy inputs, will have an direct effect on the cost price, so the products are more available for the low income's population.
Controlling the process as describe above,, the MRL (maximum residue levels) will be easier respected, less diseases pressure make's it even possible to produce more biological.
See below an summary of an current situation in processing of tomato:

The distribution of nine pesticides between the juice and pulp of tomatoes during home culinary practices was investigated. Tomato and carrot pulp contained a higher percentage of all pesticide residues, except for mancozeb in tomatoes.
Although there was a difference in the relative distribution of the pesticides between the commodities with greater amounts present in the pulp of tomatoes, the pesticides followed a similar trend in both. A relationship between the pulp/juice distribution and water solubility of the pesticide was apparent. Pesticides with the highest water solubility were present to a greater extent in the juice. An exception was noted in the case of diazinon and parathion, which were present in higher amounts in the pulp than their water solubility would suggest. The percent residue in the pulp ranged from 49.7 to 95.4% for tomatoes. Residues in the juice prepared from washed commodities ranged from not detected to 0.83 microgram/g. Washing of the produce removed more residue from carrots (carrots we can wash) than from tomatoes, but it did not affect the relative distribution of the residues. The behaviour and fate of the chemical varied with the pesticide as well as the crop.
Special Mancozeb is sprayed "heavily" in tomato's to control "late blight", late blight can be controlled to select the right variety (with an good resistance), and to control the irrigation, when irrigation is "over done" crops will be easily sensitive for blights, and even be wet in the morning hours (guttation), this means spore's can germinate and infect the crop.For the society: at the farm and factory this system/program will ensure that a factory/open



Graph below: the moisture of the soil is measured by an simple sensor, data can be collected by BLE or LORA, this can be an decision tool to irrigate, goal is to reduce the “over irrigation” situation, and to check this together with the crop.
At our trials (to learn how to use an application like this), we learn that the crop can be 100% dry in the morning hours, which means the spore’s can not penetrated the leaves/fruits/stems.
Also we can read the light levels in the crop, means when we found more light in the middle of the crop, there is more thermal circulation in this crop, means the pressure to have an fungal/bacterial infection will be much lower.
Water reducing, special at the cropping site, will easily reduce the inputs of this with more than 25-50%, this have also an effect on the raw material for the factory (high dry-stuff means less inputs of energy).
Re-using the waste of the rest product of the factory and open field production:
Collecting all material, and special the liquid material of the factory can help to produce compost of this, this material can be an excellent input for an new production of tomato’s. As describe by composting will also produce warm water, which can be used at the processing of tomato.

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2.2. Impacts

Energy reduction: at point 2, we can learn that we can reduce the inputs of electricity, oil for increase the brix and/or the dry stuff can be reduced extremely to control the production of the raw product, when we increase already the DS and Brix of the raw product with 2-4%, the energy cost can be reduce with 10-25%.

Water usage: reduction can be at the cropping period more than 50%, today growers use a lot of water to produce tomato's, the same for fertilizers. By reduction, crops will be also more strong, means lesser usage of chemicals.

To start with processing tomato, we need to produce tomato's, this process consume's already several MJ/ton (Joules for 1.000 kg product of tomato), so this needs also a part of the SmartTomato.

Energy utilization and carbon dioxide emission during the growth of fresh tomatoes.

Activity	Energy utilization/ton of fresh tomatoes (MJ/t)	CO_2 emission/ton of fresh tomatoes (kg/t)
Chemical fertilizers	302.2	57.3
Chemicals (pesticides, etc.)	23.5	0.7
Diesel consumption for transportation and machine work	420.2	5.8
Water for irrigation	19.4	2.7
Recycling waste tomatoes	164.7	22.8
Total	930	89.3

Goal is with the smart farming to reduce already an big part of this.
Water usage is this example is 2990m2/hectare for a cycle of 45 ton tomato means 66 liter of water per kilogram tomato.

On average, for preserved tomatoes, thermal energy consumption is 1,200-1,500 kJ/kg (0.333-0.417 kWh/kg) and the one of electricity is 0.009-0.0012 kWh/kg; for tomato concentrates, thermal energy consumption is 8,500-12,000 kJ/kg (2.361-3.333 kWh/kg) and the one of electricity is 0,050-0,085 kWh/kg (data from ENEA, ENEL, ENI, IASM).

Introduction:
Industrial tomato processing primarily involves concentration of tomato juice into paste or production of non-concentrated products such as peeled or diced tomatoes. Concentrated paste may be rehydrated to produce purées, sauces, or juices in subsequent processing. For all processed tomato products, energy inputs are required at each step of the processing pipeline. These inputs may be broadly classified as thermal or electrical energy requirements at the unit operation level. Thermal energy is derived from combustion of fuels, often natural gas, to generate hot water or steam in boiler systems. Thermal energy is delivered to hot or cold break heat exchangers to control tomato enzyme activity, evaporators to concentrate product, and direct and indirect heat exchangers to sterilize product. Electrical energy is primarily used to power pumps that convey product or deliver water used for fruit transportation and washing, steam generation, facility cleaning, and cooling. Electricity also powers fan motors in boiler furnaces or cooling towers along with compressors to provide compressed air for pumping, valve control, and other uses.
Elucidating energy use in tomato processing is crucial for assessing the environmental impact of this industry and for revealing opportunities to implement more efficient technologies and practices.

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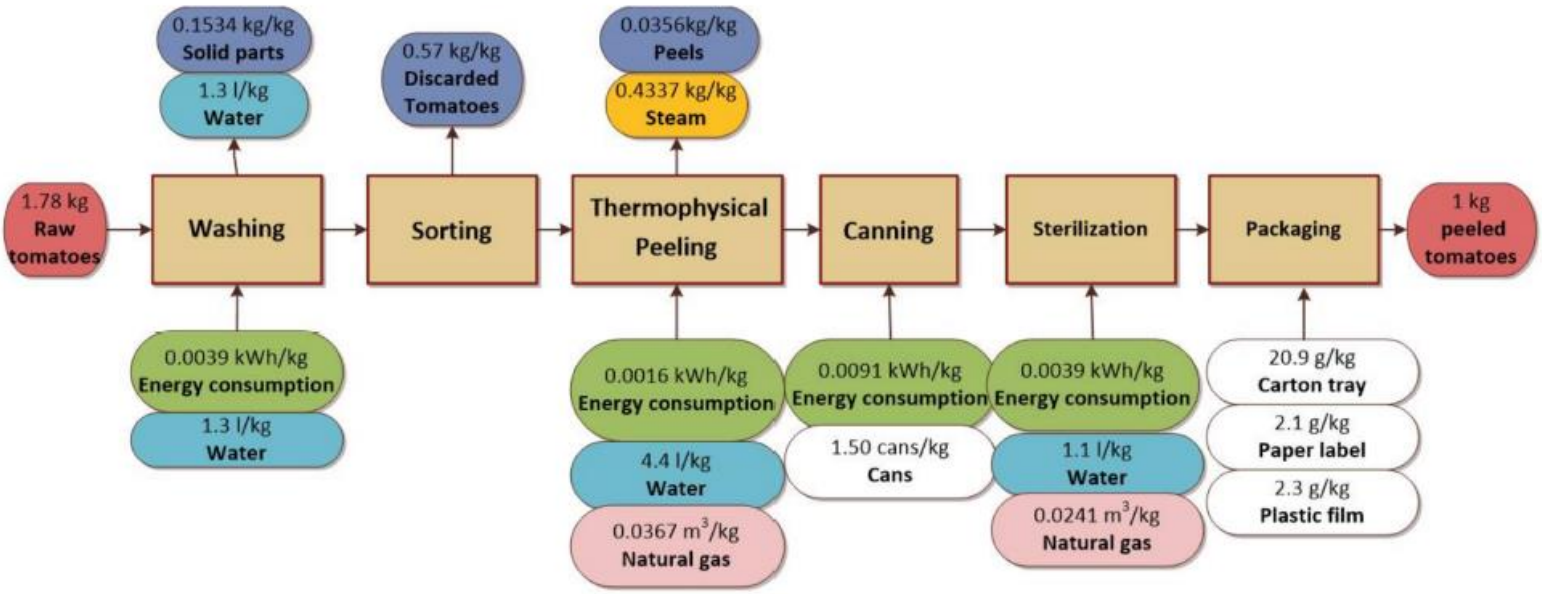
Researchers have characterized the energy footprint of tomato processing for various products. Studies have also investigated new processing technologies to conserve energy. More broadly, guidelines exist for energy efficiency in common industrial processes. All of this information must be considered together to develop a holistic understanding of energy use and possible efficiency measures in tomato processing.
Process step by step (Peeled product)



Washing 1 kg/tomato:

- Electra 0,003 kWh
- Water 1,3 l/kg

Peeling 1 kg/tomato:

- Electra 0,0016 kWh
- Water 4,4 l/kg
- Gas 0,0367m3

Peeling: mostly by hot steaming (high pressure), the lowest input on energy, also more friendly than using sodium or potasiumbicarbonate.

Highest reduction of energy for peeling needs to find in the right variety.

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3. Description of deviations from project plan (if applicable)

Project was planned to executed in Netherlands and partly in Nigeria. Because lack of tomato's in the autumn (because the weather, too much rain), so we did the most of this in Tanzania.
We have there an crushinh machine, production area and sensors to deepdive in the study (so we use already more sensors, even we buy several for this project (not planned), like the handhold sensor, see the description of this, and the measuring even from a raw tomato:
Team was in this case different that we planned:

- Anna Mbodze, senior, research on the cropping of tomato, sensoring the moisture, EC and others, how we can change the dry stuff and brix of the raw material. Anna was also the lead in the processing of the tomato's.
- Anna Mrosa, specialized in the sensoring and the platvorm, to check the results.
- Ewout Schurink: in the plan, but did more work on the total planning, and collect all kind of data together.

4. Description of further planned activities (if applicable)

What we learn is that we can change the quality of the inputs (tomato for paste) extreme, higher dry-stuff % with 1-2 points is already a big change in the energy cost for a process factory. Also the evaporation sensor above the product of above the pipe which remove the vapor/moisture of the product (pre-paste) can give the right information. The sensor in the product moisture) inform us about the status of the product.
We will continue measure the inputs in the cropping period, this we need to learn more, one of the biggest reduction in producing paste, is to ensure the inputs have the right specs (high dry stuff, and high brix).

Composting is also one of the goals to deepdive more, now we learn that the compost is a excellent "fertilizers" for the new crop, it's even ensure that the waterholding capacity of the soil is much better, which safe's water and fertilizers in the cropping.

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Goals of this study: saving water, nutrients, energy (electricity, gas, oil):

1: water usage, see also the remarks above, the biggest reduction of water (and minerals) we need to find in the production of raw material (tomato). Reduction and smart farming helps even to increase the brix and the dry stuff (over irrigation give's luxury consumption of water, and even cracking of the fruits).

Water usage in the process period, can be reduced by using semi-det tomato (which needs to be staked), so less particle's of soil and others on the fruit.

Smart irrigation, also reduce the pesticide, so less washing to reduce by example the residu of Mancozeb (fungicide on the skill of the fruit).

2: reduction of energy (electricity, petrol or gaz or others), by increasing in the production of the dry stuff and brix, we need already less energy. The evaporation sensor (not tested) can measure the output of the vapor of the drying process. This can be used to "dry" the product as less as possible.

Sensors (vorks) can be use to measure the moisture of the product, this can be used at several points, so with the measuring of the inputs (energy) we learn the consumption per % dry stuff).

3: re-use of the compost and/or use the warm water which is produced in this process can safe reduce the water consumption (compost give a better water holding capacity of the soil).

4: reduction of pesticide, perhaps not the right place to remark, but we learn that by the smarttomato/smartfarming reduce the need for chemicals extreme (less stress in the crop, less guttation).

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5. Summary of dissemination and communication activities

Specify the total number of conducted dissemination and communication activities linked to the project:

Communication and Dissemination Activities	Nº
Organisation of a Conference	1
Organisation of a Workshop	1
Press release	
Non-scientific and non-peer-reviewed publication (popularised publication)	
Exhibition	
Flyer	
Training	
Social Media	
Website	
Communication Campaign (e.g. Radio, TV)	
Participation to a Conference	
Participation to a Workshop	
Participation to an Event other than a Conference or a Workshop	
Video/Film	
Brokerage Event	
Pitch Event	
Trade Fair	
Participation in activities organized jointly with other EU project(s)	
Other	

February 2021: Profyta organised that the TVET's visit 8 day's our project, to learn "Smarttomat – Smart Farming", how to reduce the inputs for tomato/processing.

Specify the estimated number of persons reached, in the context of all dissemination and communication activities:

Stakeholders' groups	Nº
Scientific Community (Higher Education, Research)	
Industry	
Civil Society	
General Public	
Policy Makers	4
Media	
Investors	
Customers	12
Other	

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Thursday 20 May 2021: work shop with the SAGCOT on the project, to discuss and learn about tomato cropping in a way, to reduce the usage of water, and to deliver the best product to the market and to the process compagny's (REDGOLD).

6: Annex (if applicable)

What we learn an like to share, and we give the permission to publice the data, picture's below:

To produce 1 kg pulp/paste:

- We use 3,93 kg raw product, per kg raw tomato 14,9 l/kg raw product.
- By an yield of 4,5 kg/m2 (which is already very high), water consumption is 66.4 l/m2.

Calculated to an 1 kg raw and 1 kg pulp (3,93 kg raw = 1 kg pulp)

Water consumption	Liter/1 kg/raw	Liter/1 kg/pulp
Irrigation	7,4	29,0
Processing	14,9	58,6
Total	**22,3**	**87,6**

Calculated to an 1 kg raw and 1 kg peeled (1,78 kg raw = 1 kg peeled)

Water consumption	Liter/1 kg/raw	Liter/1 kg peeled
Irrigation	7,4	13,2
Processing	14,9	26,5
Total	**22,3**	**39,7**

See also:
http://www.fao.org/fileadmin/user_upload/inpho/docs/Technical_coefficients.pdf

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Field observation and sensoring:

To study on which sensors and how to combine those, to calculate and reduce the cost of energy, we did a desktop study, to come to a advice which sensors can be interesting in this case, to ensure this is the right direction we also used them in this experience and use them in the farm and processing area of Iringa Tanzania,

Just to study and to learn or this can be an tool fort he SmartTomato.

Water contains was in this case 68% (semidet process tomato), and the most soft tomato we measured was 94% water contains.

The juice after processing of this same variety (68%), after crushing so more measurable water give's the result of 74% water contains.

Also we measure the pH of both, on the fruit 5.3 after crushing 5,6.

Fixed points:

- After crushing
- At the evaporator process

Paste tomato production	Dry matter	water	raw produc to produce 1kg paste	Kg water to evaporate	kJ/total	K/gasoil
Raw product	8%	92%				
Paste single concentrated	13%	87%	1,6	0,6	1410	0,035
Paste double concentrated	29%	71%	3,6	2,6	5922	0,147
Energy input kJ/kg	2256					
Kg gasoil	0,0561					

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Processing of tomato: we measured the water contains of block 4, which we also measure with the Planthub sensors (moisture of the soil, EC, light and temperature).

This handhold (JXCT) store the data as a CSV file and have the possibility to send the data by GSM.
Also it measure the N (nitrate) P (phospate) K (potassium), and EC.

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