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A NEW CREATIVITY TOOL TO ASSIST FOOD PROCESSING EQUIPMENT DESIGN

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ABSTRACT

A knowledge-based tool was implemented in order to assist in the design of food processing equipment. It was developed and suggested for the use of professionals who are seeking creative solutions for processing principles in a given context and under specific constraints, especially in the context of weak knowledge of food engineering and material properties, poor economic conditions, and impossibility of efficient use of existing design methodologies. This is usually the case in many developing countries where equipment supply is mostly limited to copies and adaptations of a few models despite the big size of small scale food processing sector, which results in the use of unsuitable equipment, lack of efficiency, and bad quality. This new tool uses knowledge-based methodology starting with the identification of the most useful function (MUF) to be achieved in order to identify the main product property change, hence leading to the implementation of the targeted product. MUFs are linked to scientific effects that can achieve them in order to suggest designers a wide range of potential solutions. To facilitate and orient access to useful knowledge for a given problem of food processing principles, this tool is designed using a database program and links to related and existing web-based sites. Selection of optimal equipment types is finally carried out by combining users' manufacturing skills and specifications in terms of cost, maintenance and current use scheme.

Keywords: food processing equipment design, creativity, food raw material classification and properties, innovation, problem solving method, TRIZ methodology.

INTRODUCTION

Since the beginning of the year 2008, food crisis in most Sub-Saharan countries shows the drawback of an agricultural system that tends to produce for exports rather than local consumption. In order to boost small scale local food production in this part of the world, a particular attention is required for the entire supply chain, from the field all the way down to the consumer, including pos-harvest handling, storage, preservation, processing, packaging, and marketing. In this supply chain, a bottle-neck was observed at the processing level where a severe lack of equipment supply suiting social and economic requirement of users was noticed. This supply is unbalanced with regard to the supply chain and given product type (whole, particular, liquid, etc.) [1].

In West Africa in general, and in Burkina Faso particularly, where this work was undertaken, small scale food processing is a strategic economic sector. This sector depends on the supply of equipment designed and manufactured locally. The equipment supply is achieved by a group of actors such as artisans, mechanic SMEs more or less equipped with modern tools [2], technical professional schools, research centres and NGOs. These actors are not organized professionally and there is a considerable distrust among them, each one suspecting the others of stealing his ideas [3] even though the items to be designed are not of high technological complexity. Besides, previous studies have shown that the design activity is not organized and most of the time, leads to many failures [4]. The analysis of the design chain from an idea that comes from an unclear need to the final equipment, has outlined two major weaknesses leading to this fact that even though it works, it does not spread very well among users : i) designer's knowledge of biological products is very approximate since they are mostly of mechanical background and more familiar with the processing of inert materials ; ii) the creativity phase (search for potential solutions, alternative evaluation, selection of optimal solutions according to given conditions) is mostly reduced to adopt existing solutions and using them for other food products than the one for which they were intended. The design approach is more often empirical. This involves long adaptations through the well-known trial and error method to find out the equipment that responds best to the expected technical, social and economical functions. When there is a need for a true innovation for a new product or a new process, such a traditional approach of design is particularly unproductive.

The objective of this work was to develop a tool that is more appropriate for food equipment principle research in the conditions that the use of conventional design methods such as the Pahl et Beitz method [5], Value analysis [6], User-centered design [7], reverse engineering [8] etc. cannot be conducted efficiently in this context where access to available knowledge is quite impossible [9, 10]. The efficient use of these methodologies requires indeed a good knowledge of the elements of the problem in order to accurately define it and facilitate the search for potential solutions. The attempt to gather the required knowledge explains the differences and the complexity of these methodology approaches (multidisciplinary team, a particular functional formulation, questions to be asked to help understand the problem, patent analysis to sort out problem models and solution models that can guide users to specific solutions, etc.). A vast knowledge of possible solutions is required to enable suggestion of feasible ones [11].

In light of these observations and given the limitations of the target actors, this new tool called APSETA (French acronym for a tool to assist production for food equipment solutions) was created. Its methodology aims at assisting in accurately defining the function of any equipment to be designed, and in searching for an appropriate solution by facilitating the access to knowledge of food properties and scientific effects that can fulfil the required functions. This structured and opened tool guides the user and allows the gradual introduction of new food products (raw materials, partly and completely processed products, and products' components) and their properties [12], as well as scientific effects that can be used to achieve all desired product property changes. The tool originality is its approach of the search for potential scientific effects through the identification of its most useful function (MUF) which is the main property change to be performed on an initial product in order to obtain a desired product. This formulation is inspired by the concept of abstraction of a specific problem into a model of problem to enlarge the field for solution search [13, 14]. It allows taking advantage of divergent thinking at this stage before converging to the feasible one by an evaluation method that takes into account technical and socio-economic criteria from the designers and the potential users' point of view.

Development of the APSETA tool

The proposed tool was developed mainly for local food processing equipment designers and manufacturers, particularly those who do not have food engineering background and have difficulties accessing knowledge sources. Previous studies carried out in West African countries showed that this target group included actors that can be classified in the following categories according to their qualifications and production capacity [2]:

a) Industrial manufacturers: This category represents a small part of the actors involved in small scale food equipment design and manufacturing. They have a team made up of engineers and technicians mostly of mechanical background. This category manufactures mills, dehullers, etc. Its production capacity goes from hundreds to a thousand of units per year. It uses conventional manufacturing machinery and can import materials for its production. Many of these manufacturers have been created in the 1980s in the context of agricultural development projects.

b) **Semi-industrial manufacturers:** This group is usually led by an engineer or a technician who is most of the time trained in the domain of mechanics. Actors in this category purchase materials locally or use recycled parts. They manufacture small scale equipment and spare parts and they do repairs. Their production capacity is less important than industrial manufacturers'.

c) Artisans: This group is led by trained artisans. It manufactures metal items and food equipment of low complexity and spare parts, and it does repairs.

d) Blacksmith: Actors in this category have an empirical knowledge and practical know-how passed down from generation to generation or acquired in the field. They have very few tools. They produce on order equipment of low complexity, and spare parts.

Most of these actors have the following constraints:

- lack of knowledge of food properties and scientific effects applicable to food equipment design,
- empirical approach of design based on trial and error method,
- lack of creativity and a limited problem solving approach that is mostly based on internal discussions,
- difficult access to knowledge sources,
- lack of collaboration due to distrust (Any created or adapted equipment is a market opportunity that is to be protected from other manufacturers in the same sector)
- severe economic constraints.

Other actors involved in food equipment design in these countries include national and international research centres, technical institutes, and NGOs.

Several institutions have been set up more than a decade ago in order to promote innovation and equipment design but they have had a limited effect on the development of this sector given the few innovative equipment designed locally on the market. Among these institutions, are the following in Burkina Faso: the FRSIT which is the national forum for scientific research and technological innovation [15] that gathers actors from different countries every two years, including industrialized countries; and the ANVAR which is the national agency for the valorisation of research results in Burkina Faso [16]? The OAPI which is the African organization for intellectual property is also present to assist actors in patenting procedures and prototype development. However, given the cost of these procedures, actors are rarely ready to pay for them.

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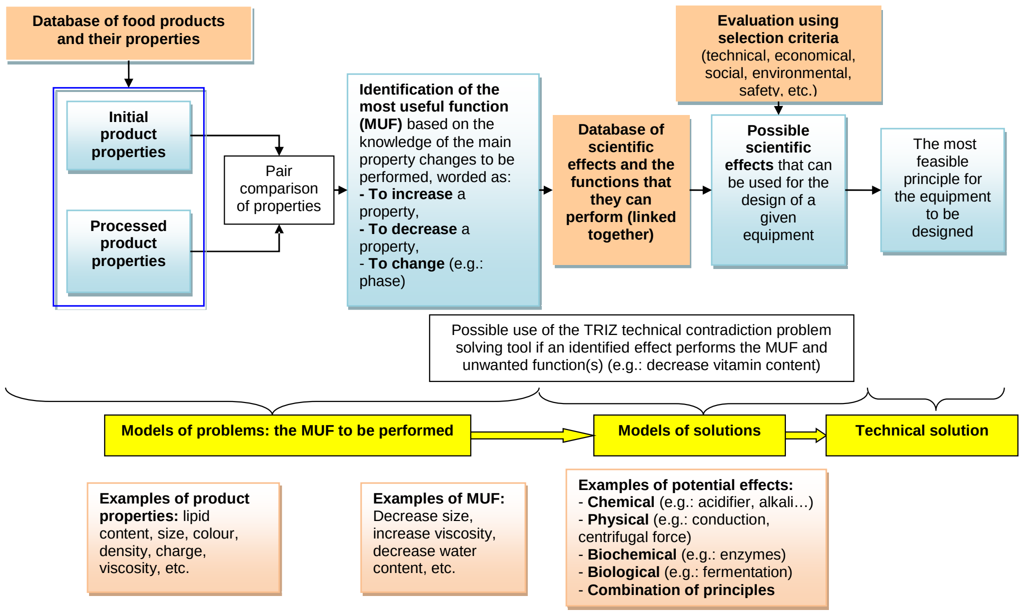

Figure-1. Steps and components of the tool for food equipment principle search.

In order to face all these problems the methodology and the components of the APSETA tool are shown in Figure-1. The main steps of the methodology are the following:

- Identification and collection of the properties of the initial and desired products, and identification of the most useful function (MUF) as the main change in property that have to be accomplished to obtain the desired products;
- Suggestion of scientific effects that can be used to carry out the desired property changes and proposal of examples of existing equipment that use them ;
- Suggestion of evaluation method to select the most feasible scientific effect in the context of the designer/manufacturer and the equipment final user.

The APSETA tool was developed on Microsoft Access as it is the most common database in West Africa. Data on food properties, functions, effects, and equipment are captured on different Tables and linked to each other in a structure that supports the user in the application of the proposed methodology.

Identification and collection of product properties and identification of the most useful function to be accomplished

As mentioned, the APSETA tool proposes in its early stage the identification of the MUF of the equipment to be designed as the main change in food property that has to be accomplished on a given product to obtain a desired product. It is the main objective of the equipment.

It is proposed as a formulation of the MUFs into only three possible types of functions: increase, decrease, and change a given property (e.g.: lipid content, state, etc.). This formulation allows the standardization of description of the function to be achieved as proposed in the TRIZ method [13] to open the search for solutions to a large scientific and technical field. It facilitates the access and the transfer of solutions that already exist and new solutions that can be adopted for the same functions. Converging to the most feasible specific technical solution is done afterwards through an evaluation phase. This knowledge-based approach allows increasing creativity as supported by researchers who have worked on the Concept-Knowledge or C-K unified design theory [17].

The APSETA structure was therefore developed to allows i) a progressive storage of relevant food properties and related data by food science experts, ii) links to facilitate access to existing databases and other Internet sites that are specialized in food science and technologies where users can seek for more information when needed; and iii) property comparison between the initial product and a target processed product, and identification of MUFs. Figure-2 presents the structure of the main form of the APSETA tool as developed on Microsoft Access.

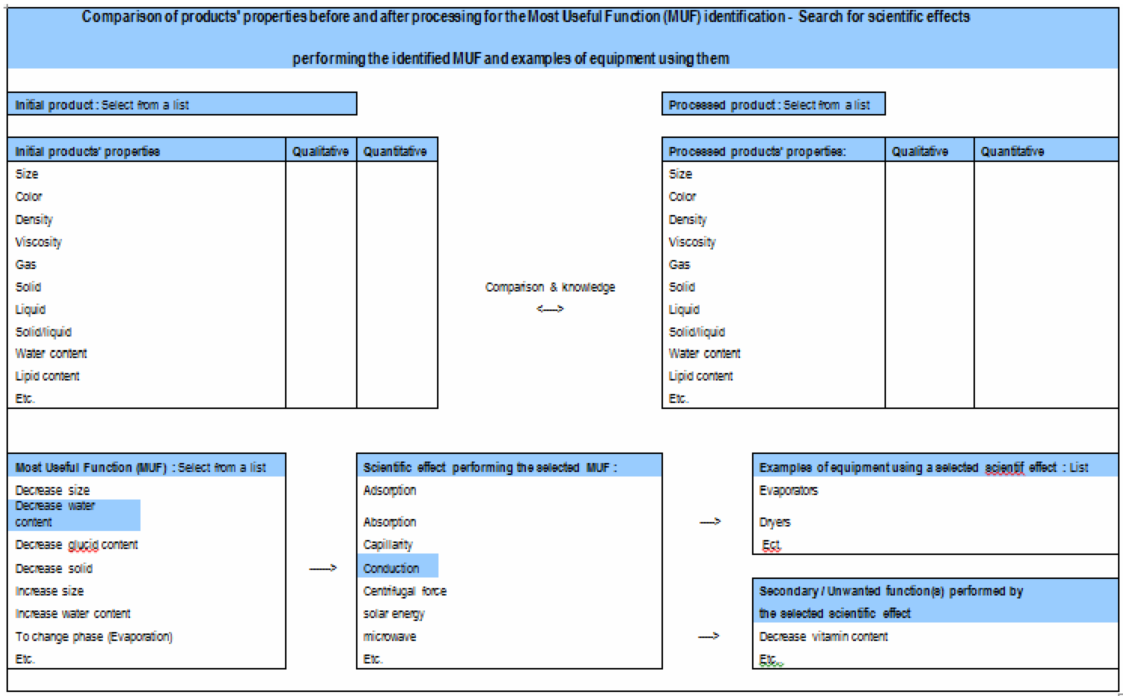

Figure-2. Structure of the APSETA main form for food properties comparison for the most useful function (MUF) and potential scientific effects identification.

For the purpose of developing the APSETA tool, properties used for food characterization and classification and databases were reviewed (plant and animal physiology, food material structure, microstructure, texture, physicochemical and biological properties, etc.), [18, 19, 20, 21] and the most relevant were retained and included progressively in the APSETA tool.

The tool can already be used by following the proposed methodology despite the lack of data on engineering properties of food materials and their phases or components, as already observed in previous studies aiming at proposing a systematic approach to food systems of many researchers working in this field [12, 22, 23, 24, 25]. The knowledge of these properties is capital to the understanding of their behaviour, inter-relations, importance and effects in food process engineering [26], and therefore to the search for food equipment solutions (e.g. for food component extraction, preservation, mixing, etc.). Only food biochemical composition is widely available for most common products. Food compositions have been indeed studied to determine products nutritional values and for labelling purposes. Very few data can be found on tropical product properties and their components. Some data may exist but they are dispersed in publications that are not accessible to all. For the APSETA use, when these data are missing, it is necessary to undertake measurements when possible or use estimated values available for similar products. APSETA proposes to collect gradually these data and links to Internet sites where they can be found in order to facilitate their use.

Some food property notions may be difficult to understand for actors who do not have sufficient scientific and technical knowledge (e.g.: diffusivity, enzyme, etc.) and/or lack database technical skills. In this case, assistance from the organization that has to manage this tool development and diffusion is necessary to manipulate it and explain its use results. This service must be provided free or at minimum charge and must respect confidentiality when requested. In the case of Burkina Faso, it is recommended that this role be ensured by the previously mentioned ANVAR.

Proposal of exploitable scientific effects

In the present tool, as it is done for data on food products and their properties, scientific effects that can be used in food engineering are also listed and linked to the functions that they can accomplish. Several scientific effects can be used to achieve the same function, and one scientific effect can achieve different functions. This fact may cause a situation of contradicting functions. For example, heating, using conduction process or microwaves, achieves the function of decreasing micro organisms but it also decreases vitamin contents and other properties such as colour, texture, etc., that are to be preserved in general. The TRIZ method proposes a matrix of 40 principles identified from the study of more than 100 000 patents to help solve such contradictions [27]. The APSETA tool also provides links to existing function databases [28, 29] to facilitate knowledge transfer from other scientific and technical fields.

The difference between these existing function/effects data bases and the APSETA rely on the fact that the latter is a knowledge-based methodology developed for the purpose of principle search for food

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equipment design. Data that are stored in this tool are related to food engineering and linked to each other in such way to guide potential users towards equipment solutions. The structure of scientific effects and equipment data capturing forms are shown in Figures 3 and 4. Examples of collected scientific effects are given in Table-1.

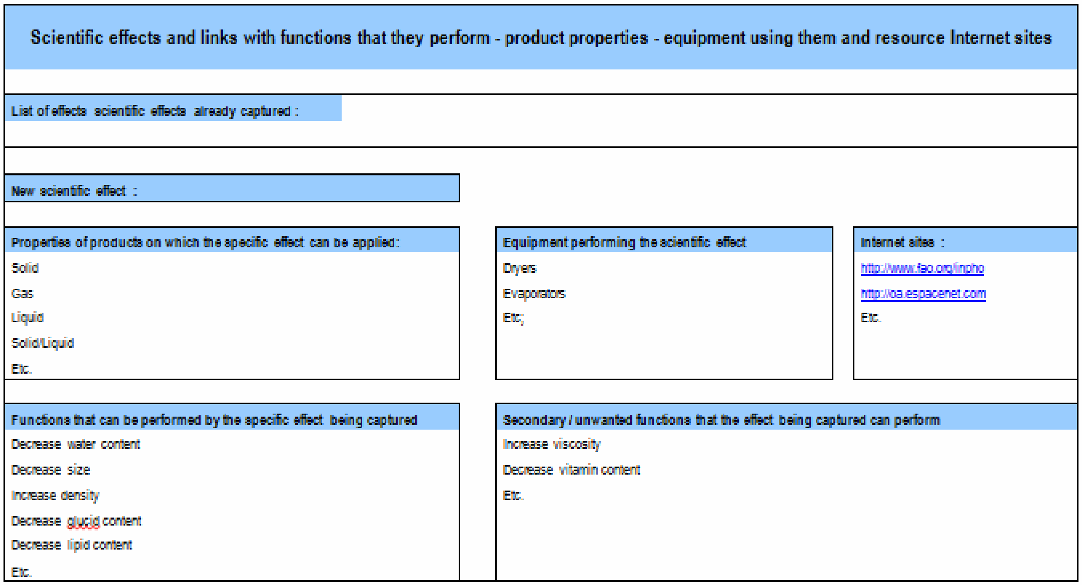
Scientific effects and links with functions that they perform - product properties - equipment using them and resource Internet sites
List of effects scientific effects already captured :
New scientific effect :
Properties of products on which the specific effect can be applied:
Solid
Gas
Liquid
Solid/Liquid
Etc.
Equipment performing the scientific effect
Dryers
Evaporators
Etc;
Internet sites :
http://www.fao.org/inpho
http://oa.espacenet.com
Etc.
Functions that can be performed by the specific effect being captured
Decrease water content
Decrease size
Increase density
Decrease glucid content
Decrease lipid content
Etc.
Secondary / unwanted functions that the effect being captured can perform
Increase viscosity
Decrease vitamin content
Etc.

Figure-3. Structure of scientific effect data capturing form.

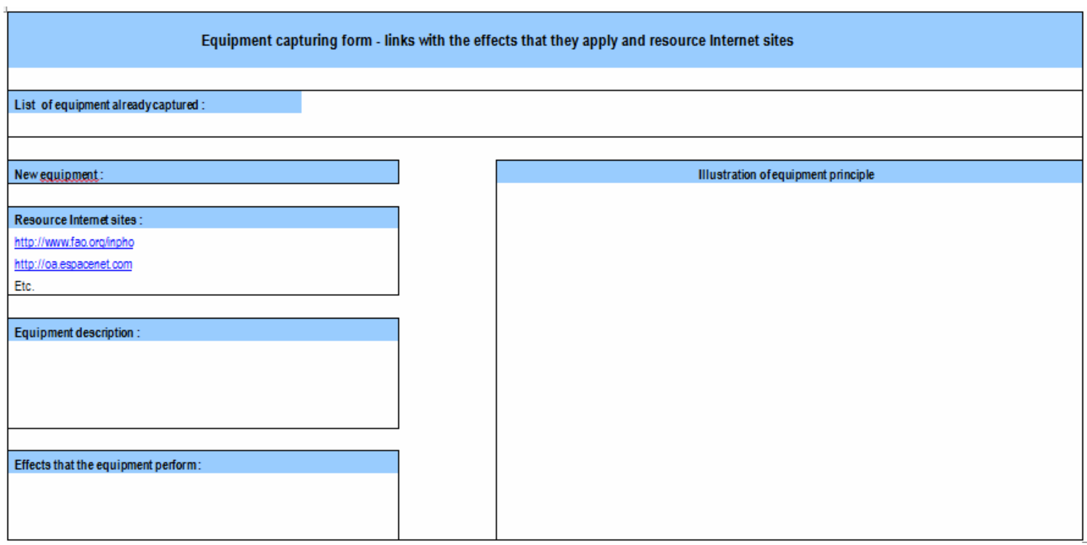
Equipment capturing form - links with the effects that they apply and resource Internet sites
List of equipment already captured :
New equipment :
Resource Internet sites :
http://www.fao.org/inpho
http://oa.espacenet.com
Etc.
Equipment description :
Effects that the equipment perform :
Illustration of equipment principle

Figure-4. Structure of equipment data capturing form.

Table-1. Examples of collected effects.

Categories of effects	Effects
Physical and mechanical effects	Abrasion, absorption, capillarity, cavitation, electrical fields, magnetic fields, phase changing, mechanical force, conduction, convection, difference in size, difference in density, gravity, difference in concentration, centrifugal force, friction, microwave, solar energy, ultrasound, UV, etc.
Chemical effects	Chemical reactions, difference in charges
Biological effects	Microbial metabolism, enzymes

Evaluation method of possible solutions

To evaluate ideas of possible effects of any equipment to be designed, an adoption index (Ia) is proposed based on criteria related to technical, economic, and social feasibility with regards to standards (e.g.: environmental and safety standards). Equipment designers/manufacturers and potential users have to evaluate potential solutions. Therefore, Ia is the result of equipment designers/manufacturers' adoption index (Iad) multiplied by potential user index (Iau):

$$Ia = Iad * Iau \quad (1)$$

For any equipment solution that is to be evaluated, Iad and Iau are the results of multiplication of marks given on a scale of 0 to 3 to each category of criteria as shown in Tables 2 and 3. The awarded index allows classifying the possible solutions in decreasing order of feasibility. The same index can be obtained either by high level of Iad and low level of Iau, or low level of Iad and high level of Iau, in any cases, priority must be given to potential users' evaluation results to avoid designing equipment that will not be adopted by them.

Table-2. Proposition of designer's adoption Index (Iad) to assist solution evaluation.

Categories of criteria	Scale of 0 to 3	Meaning
Technical feasibility Possibility of local Manufacturing , availability of required skills, Machinery, and materials	0	**Unfeasible:** None of the feasibility requirements is met by the solution
	1	**Low feasibility:** Most of the feasibility requirements are not met
	2	**Fairly feasible:** some feasibility requirements are not met but alternatives exist.
	3	**Feasible:** All feasibility requirements are met
Economic feasibility Manufacturing costs; Profitability	0	**Unfeasible:** Manufacturing costs are too high for manufacturers, sales price are also too high for potential buyers
	1	**Low feasibility:** Manufacturing costs are high but accessible to manufacturers; however, sales prices do not guarantee profitability
	2	**Fairly feasible:** Manufacturing cost are high and there is a possibility of a certain profitability can be
	3	**Feasible:** manufacturing costs is not limiting and sales prices allows a good profitability
Social feasibility Ability to gather the required skills, and to materialize the idea into an equipment; Notoriety	0	**Unfeasible:** no ability to innovate, no notoriety
	1	**Low feasibility:** low ability to innovate but a certain notoriety
	2	**Fairly feasible:** some capacity to innovate but no notoriety
	3	**Feasible:** a good capacity to innovate, and a good notoriety
Feasibility regarding standards (e.g.: environmental and safety standards)	0	**Unfeasible:** Measures and devices required to meet the standards are not technically and economically feasible
	1	**Low feasibility:** Measures and devices required to meet the standards are technically feasible but their costs are too high
	2	**Fairly feasible:** Measures and devices required to meet the standards are technically and economically feasible but affect the solution's profitability
	3	**Feasible:** There are no constraints related to standards

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Table-3. Proposition of users' adoption Index (Iau) to assist solution evaluation

Categories of criteria	Scale of 0 to 3	Meaning
1. Technical feasibility: Appropriate technology level, output, sturdiness, flexibility, maintenance ability, type of energy, possible integration with existing equipment	0	**Unfeasible:** None of the feasibility requirements is met by the solution
	1	**Low feasibility:** Most of the feasibility requirements are not met
	2	**Fairly feasible:** some feasibility requirements are not met but solutions can be found
	3	**Feasible:** All feasibility requirements are met
2. Economic feasibility Acceptable investment, operating, maintenance and repair costs; profitability	0	**Unfeasible:** costs are too high for potential users
	1	**Low feasibility:** low profitability , high costs
	2	**Fairly feasible:** profitability but high costs
	3	**Feasible:** acceptable costs and profitability
3. Social feasibility Ability to adopt an equipment that works differently or innovating	0	**Unfeasible:** Resistance to adopt an equipment that works differently or is innovating
	1	**Low feasibility:** Weak ability to adopt an equipment that works differently or innovating
	2	**Fairly feasible:** Some ability to adopt an equipment that works differently or innovating
	3	**Feasible:** Good ability to adopt an equipment that works differently or innovating
4. Feasibility regarding standards (e.g.: environmental and safety standards)	0	**Unfeasible:** Measures and devices required to meet the standards are not technically and economically feasible
	1	**Low feasibility:** Measures and devices required to meet the standards are technically feasible but their costs are too high
	2	**Fairly feasible:** Measures and devices required to meet the standards are technically and economically feasible but affect the solution's profitability
	3	**Feasible:** There are no constraints related to standards

CONCLUSIONS

Former studies have shown that West-African equipment designers/manufacturers' conception practices are not organised and often lead to failure. These actors are mainly from mechanic background and hence lack of knowledge on food properties and scientific effects that can be used in food processing. Their context also limits access to that knowledge. In this condition, traditional design practices can hardly result in innovative equipment and usual design methodology cannot be efficiently applied. The APSETA is developed in light of the need for a more appropriate tool to assist these actors. It proposes a knowledge-based methodology that guides and enlarges the field for potential scientific effects for an equipment to be designed, before converging to the most feasible solution by the use of an evaluation method.

APSETA proposes a methodology organized in three main steps:

a) Identification and wording of the most useful function (MUF)
b) Proposal of potential scientific effects that can achieve the identified MUF.
c) Evaluation of potential scientific effects regarding designers/manufacturers and final users requirements.

A first validation phase of the APSETA tool with Burkinabé designers/manufacturers allowed observing their interest as it assists in defining precisely the function to be achieved and also in searching for potential effects to be adopted outside their own limited knowledge.

The methodology proposed by the APSETA tool can be applied to products for which data on properties are available. The validation phase has given the opportunity to make the following recommendations regarding the improvement of this new tool and its use:

-More data on products and their components are to be gradually collected particularly on tropical products, as well as on effects, food processing equipment, links to Internet sites that provide detailed information on these data;

-Illustrations (including animated illustrations and 3D when possible) of equipment principles are to be added to make the tool more helpful;

-The tool is to be managed by an organization with the following missions:

- Improving it gradually without changing its basic structure. For example, integration of links between effects and patents databases such as the ones of the African organisation for intellectual properties (OAPI) and the World Organisation for Intellectual Properties (OAPI) can be interesting,
- Communicating on its existence, improvement, and on its use results,
- Making it accessible on the Internet or accessible for free for local centres,
- Undertaking a larger validation that includes all categories of potential users,
- Providing support particularly to users who have difficulties using/manipulating it, e.g. those who do not have enough scientific and technical background to understand notions of food properties, functions, and effects. A resource person from the organization can be an intermediary between the user and the tool and provide support in a confidential way when requested,
- Validating the proposed evaluation method of potential solutions of effects with a panel of designers/manufacturers and equipment use on real cases,
- Studying this tool use in developed countries where there are supposedly more data on products properties.

These points will supplement the results presented. They will contribute for a better organized and more efficient design activities based on a better knowledge of product properties, scientific effects in order to improve equipment offer.

The present tool focused mainly on assisting in the search for possible scientific effects for one main useful function at a time, food processing being usually a series of unit operations that aims at obtaining a final processed product from a given raw material. A process design creativity tool can be developed considering that those who ask for new equipment to process a given raw material into a final product do not require a specific series of unit operations to be achieved. They only expect a solution (made of one or more unit operations) that allows obtaining the target product, and that takes into consideration their technical, economic, and other possible evaluation criteria. Such a tool may propose different ways of obtaining the desired product with different equipment. Its approach is less restrictive in terms of innovative possibilities than when the problem is presented at a given stage of an already adopted process diagram.

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Claude Marouzé prematurely passed away on October 19th, 2009, from a long-term illness.

REFERENCES

[1] F. Giroux. 2000. Pour une conception coopérative dans les pays du Sud. Application aux équipements de petite capacité dans le domaine agricole et agroalimentaire. Institut National Polytechnique de Grenoble, HDR Discipline MECANIQUE (60ème section CNU), soutenue le 19 Juin.

[2] F. Bationo. 2007. Prise en compte du réseau socio-économique de maintenance dans la conception d'équipements - Cas des petites unités de transformation agroalimentaires des pays de l'Afrique de l'Ouest. Organisation industrielle et système de production (OISP), Grenoble, Institut National Polytechnique de Grenoble (INPG): 221.

[3] I. Médah. 2008. Activités de conception et processus de production de connaissances: coopération et coordination entre acteurs de métiers différents dans les en développement - Thèse en cours, UPMF, ED OISP, Grenoble. Grenoble.

[4] C. Marouzé. 1999. Proposition d'une méthode pour piloter la trajectoire technologique des équipements dans les pays du Sud. Application au secteur agricole et agroalimentaire, ENSAM Paris, Paris.

[5] G. Pahl and W. Beitz. 1996. Engineering Design, 2nd edition, Springer-Verlag, New York, USA.

[6] Anon, Analyse de la Valeur, Norme NF X 50-150 à 153 Paris, La Défense, AFNOR, 1991.

[7] C. Abras and D. Maloney-Krichmar *et al*. 2004. User-Centered Design, Bainbridge, W. Thousand Oaks, Sage Publications.

[8] K. Wood and K. Otto. 1995. A reverse engineering design methodology, Austin (Texas), USA.

[9] C. Marouzé and F. Giroux. 2004. Design method in the context of developing countries: Application to small-scale food processing units. CIRP Design Seminar 2004, Design in the Global Village, May 16 - 18, Cairo, Egypt.

[10] D. Retière, Enseigner l'Analyse de la Valeur, Témoignage d'un formateur en Afrique, AFAV, 1995.

[11] J.-C Ferrier, M. Kneubühler, *et al*. 2007. Méthode de développement de concepts innovants. 7ème édition du Congrès international pluridisciplinaire Qualita 2007, Tanger (Maroc).

[12] M. A. Rao and S. S. H. Rizvi, *et al*. 2005. Engineering Properties of Foods, Boca Raton, Florida, CRC Press Taylor and Francis Group, Eds.

[13] G. S. Altshuller. 1984. Creativity as an exact science.

[14] D. Cavallucci and R. De Guio, *et al*. 2005. La Triz: Introduction théorique et éléments fondamentaux. C. CE-5. Strasbourg, Institut National des Sciences Appliquées (INSA) de Strasbourg, France.

[15] Anon. 2008. Forum National de la Recherche Scientifique et des Innovations Technologiques (FRSIT), édition 2008: Impact de la recherche scientifique, des inventions et des innovations sur les sociétés africaines. Du 29 novembre au 06 décembre, Ouagadougou, Burkina Faso, Institut de Recherche pour le Développement (IRD).

[16] I. G. Séguèda. 2008. ANVAR: valorisation, trait d'union entre recherche et développement, FASO-DEV.

[17] A. Hatchuel and B. Weil. 2003. A new approach of innovative design: an introduction to C-K theory. ICED, August, Stockholm, Sweden.

[18] J.-C. Cheftel and H. Cheftel. 1986. Introduction à la biochimie et à la technologie des aliments, Paris, Technique et Documentation.

[19] J.-C. Favier and J. Ireland-Ripert, *et al*. 1995. Répertoire général des aliments - Table de Composition - Composition Tables, Lavoisier Technique and Documentation, INRA, CIQUAL-REGAL.

[20] Anon. 2005. The LANGUAL 2000 Thesaurus, the Danish Institute for Food and Veterinary Research, Euro FIR, http://www.langual.org/.

[21] Anon. 2006. Database of food science and technology research projects relevant to the food needs of developing countries. IUFoST, FAO/AGST. http://www.fao.org/inpho/isma?i=INPhO&m=iufost&p=SimpleSearchForm&lang=en.

[22] J. Scher. 2006. Rhéologie, texture et texturation des produits alimentaires. Techniques de l'Ingénieur, traité de Génie des procédés.

[23] H. This. 2004. Modelling dishes and exploring culinary precisions: the two issues of molecular gastronomy. British Journal of Nutrition 11(58): 1-9.

[24] J. M. Aguilera. 2005. Why food microstructure? Journal of Food Engineering. 67(1-2): 3-11.

[25] Le Maguer, M. and M. Marcotte, *et al*. 2004. A Systematic Approach to Food Systems and the Need for Engineering Data. ASAE Meeting, Ottawa, August. Guelph, St Hyacinthe, Griffiths, ASAE, IRM: Food Systems, Guelph Ontario; AAFC, CRDA, St-Hyacinthe, Quebec;Griffiths Laboratories, Toronto, Canada.

[26] Z. B. Maroulis and G. D. Saravacos. 2006. Food Process Design, New York, Marcel Dekker. http://www.techniquesingenieur.fr/dossier/rheologie_texture_et_texturation_des_produits_alimentaires/F3300.

[27] G. S. Altshuller. 1998. 40 principles: Triz keys to Technical Innovation, Technical Innovation Center, Worcester, USA.

[28] Anon. 2008. CREAX function Database, CREAX.

[29] Anon. 2007. Catalogue of important effects for solving inventive tasks, TriSolver. http://www.triz.it/eng/ebf/pew01.htm.