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Letter to Editor

Foldscope, the Frugal Innovation and its Application in Food Microscopy - A Review

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Microbiologists often claim that "microorganisms are omnipresent", i.e. microorganisms presence is detected everywhere in our surrounding environment, i.e. land, water and air. Microorganisms are found in the deepest point of the sea or in the topmost peak of the world. The food that humans consume usually comes from land or water, get contaminated with microorganisms from the surrounding environment. For making the food safer, different food-processing operations are carried out of which thermal processing is the most commonly used process to reduce or deactivate the microbial load. The best example of thermal processing is sterilization, which ensures elimination of microbial load including the spores and enzymes. For this reason, sterilized products are safer for consumption with the highest shelf life [1-3].

Microorganisms, as the name suggests, are microscopic organisms, which may exist as single cellular or multi-cellular form. Food microbiology generally deals with the study of beneficial and harmful effects of microorganisms, which are present in food, their effects on food quality and safety of raw and processed foods. The concept of microorganisms was predicted by few in past, but Antonie van Leeuwenhoek (1676) was the first to observed bacteria under his own developed microscope, for which he is known as "Father of Microbiology". The invention of the microscope and its developments helped the researcher community to understand the microscopic world around us and opened up a new dimension of research and study. Microscopic techniques are very helpful not only for viewing microorganisms but also for other areas of studies like viewing cells, crystalline structures and as an important diagnostic tool for medical examination [1,3]. Disadvantages of a regular microscope are it is expensive, heavyweight, bulky, fragile, need to be operated by an expert only and high maintenance, makes the applications of the microscope are limited in underdeveloped and poor countries [4].

Dr Manu Prakash, Assistant Professor from Stanford University, and his PhD student Jim Cybulski realized this problem during their field visits to a poorer country, he found that microscope was limitedly available, fragile and are not been used properly. For overcoming these limitations of the conventional microscope, Dr Prakash and team came up with the idea of making affordable and easy to use microscope, by using folded papers, and hence named as "Foldscope". This frugal innovation, the Foldscope, is the inexpensive microscope, which is sufficient for viewing the microscopic world around us, and with time become a significant microscopy tool for medical and other scientific research, round the globe [4-6].

This foldscope is origami based printed and fold paper microscope, which can magnify up to 2000 X, would be sufficient to identify harmful microorganisms like *E. coli* and *Giardia* [7]. Waliullah (2018) reported about the application of mobile-based microscopy, Foldscope, for investigating clinical non-human histopathology, where microscopic images of the samples were acquired and compared with conventional light microscopic images. From the study, it was concluded that foldscope is feasible for human histopathological sample investigation and with developments of the methods; it can be made more accurate for its application in economically challenged regions. Department of Biotechnology (under Ministry of Science and Technology, Government of India) has collaborated with Prakash Lab, Stanford University to bring the low-cost microscopy to India and is distributing the foldscope to different schools, colleges, research institutes and individual researchers. Application of this low-cost microscopy technology to a different domain of microscopic study would help people to better understand the microscopic world around us including microorganisms and microstructures. Aim of this DBT funded program of technology around the country including the twinning partners in the Northern Eastern Regions (NER) of India. Distributed foldscope has micro-lens, with the capability of 140x magnification and 1.9 µm resolution, would be useful for viewing and video recording microscopic data (with a smart phone - optional) in bright field, dark field and oblique phase illumination [8].

The food that we eat comes from various sources like the plant, animal or even microbial origin. Composition, sources and types of foods vary widely from one other, but in few aspects, they fall in one category, i.e. they are all organic in nature and they are susceptible to spoilage. Spoilages of foods can occur due to chemical changes or by microbial metabolic activities. There are many opportunities to apply the low-cost frugal innovation of microscopy, to have a better understanding of the foods. Usually, the methods for estimation of microbial loads in foods are time-consuming, requires expensive laboratory set up with a quality analyst expert to run the lab. Introduction of low cost microscopy would reduce the quality analysis costing and also one can have a better understanding about the surface microstructure of foods using this foldscope. Future scope lies in development of rapid and simple methods for common people, who could also get used to foldscope as a microscopic tool to rapidly determine the microscopic quality of food before consumption.

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Parameters	HIV-TB	HIV
	Coinfected	Infected
Nutritional adequacy: Energy %	78.42	84.25
Nutritional adequacy: Protein %	72.58	80.18
Energy rich food frequency (times a month)	115	124
Protein rich food frequency time (times a month)	83	98

Table 2: Dietary parameters of patients.

The data on food related symptoms also suggest the same, figure 2 portrays the data and it is remarkable to see that 86% patients with co-infection suffer from anorexia. Co-infected patients suffer from more food related problems except for dryness of mouth. This hinders in proper dietary pattern and directly affects the quantity and frequency of food ingested by these patients. This is in the same line of thought with Swaminathan., *et al.* [6].

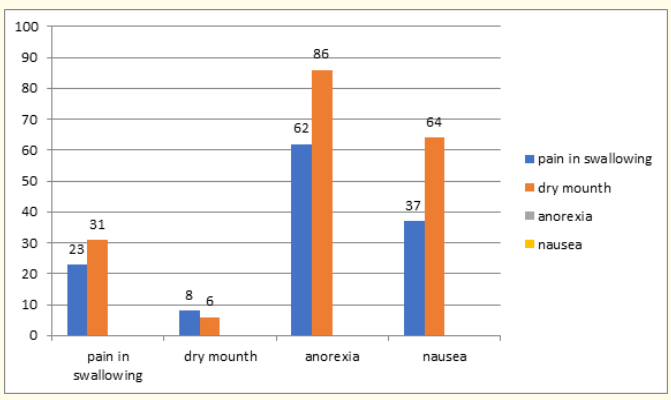

Figure 1: Percentage of patients experiencing dietary problem.

T test was done to comparing all the test parameters between HIV infected and co-infected patients and the result are represented in table 3. All the anthropometric and immunological parameters show a statistically significant difference between the two groups and the value indicates that the nutritional status of the patient with HIV infection only are significantly better than that of co-infected patients. A study in Africa shows that low BMI and low Haemoglobin are a strong predictor of Tuberculosis [12]. It should be noted that Haemoglobin is also significantly less in case of HIV -TB coinfected patients. On the other hand, it should be noted that the dietary profile does not show significant difference, this may be due to the small sample size of the study.

Parameters	P value
Body Mass Index (kg/m^2)	0.00**
Grip Strength (kg force)	0.04*
Tricep Skin Fold (mm)	0.00**
Mid Upper Arm Circumference (cm)	0.00**
Absolute CD4 Count (Cells/mm^3)	0.01**
Haemoglobin (gm/dl)	0.01**
Albumin (gm/l)	0.00**
Nutritional Adequacy: Energy %	0.32
Nutritional Adequacy: Protein %	0.38

Table 3: T test comparing different parameters in presence and absence of Tuberculosis.

*: significant at the 0.05 level (1- tailed)

**: significant at the 0.01 level (1- tailed)

To summarize, this study has found HIV-TB coinfected patients of eastern India to be more malnourished, anemic, and hypo-albuminemic than are socioeconomically matched HIV infected individuals, despite almost similar calorie and protein intake. This study has a limitation and that is the sample size is small and the data collected may not be enough to generalize. Nevertheless, in a resource poor setting with a high background level of malnutrition, HIV infection has an adverse effect on the nutritional status of the individual, which is further worsened by TB. This forms a vicious cycle which will go on. It can be assumed that both nutritional counseling in combination with supplementation and preventive therapy for TB could help to maintain ideal nutritional status among these patients.

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