

Application of Genetic Algorithms in the Optimization of a Solar Tunnel Fish
Dryer Design and Performance

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ABSTRACT

The fish industry in Kenya, with a production of over 350,000 metric tonnes earns USD 105 million which accounts for about 5% of the national Gross Domestic Product, provides 3% of skilled and unskilled employment. However, this industry is threatened as the fish is harvested at high moisture content of about 5kg/kg, dry basis, and at this moisture content, if not preserved, fish undergoes spontaneous spoilage in 24 hours. At the artisanal fishermen level, the most viable preservation option is solar drying, in which fish is enclosed in a solar dryer, shielding it from contamination, and destruction. Depending on the conditions in the dryer, fish can either be over-dried or under-dried, resulting in heavy losses at household and national level, and therefore, a conducive environment must be provided within the dryer to avoid destruction of fish during drying.

Based on the above observations, studies were conducted with the objective of optimising the design parameters and performance of a solar tunnel dryer, using genetic algorithms. This involved, initially, developing computer simulation models for prediction of global solar radiation incident on the dryer, the amount of solar energy harnessed and the drying of fish. The models were then validated, based on actual data, and thereafter were used in the optimisation process. The original (non-optimised) solar dryer was then modified based on the obtained optimised design parameters. The optimised solar tunnel dryer was then tested to evaluate its performance in the harnessing of solar energy and the drying of tilapia fish.

The results of a two-way Student's t-test at 5% level of significance, show that there were no significant differences between simulated and actual data for global solar radiation ($t_{stat} = 0.17$,

$t_{crit} = 1.65$), plenum chamber temperature ($t_{stat} = 0.55$, $t_{crit} = 1.72$) and for moisture ratio of the drying fish ($t_{stat} = 0.96$, $t_{crit} = 2.06$). The subsequent performances of the models in the prediction of the above parameters were 78.4, 83.3 and 81%, respectively, at 10% absolute residual error interval. This implies that the developed models can be used to predict the global solar radiation, the harnessed energy and the drying of fish in a solar tunnel dryer.

The optimization process resulted in the heating chamber dimensions of 2.44m long, 1.22m wide and 0.11m high as compared with the non-optimised of 2.44m long, 1.22m wide and 0.54m high. Higher temperatures (14.2 to 57.6°C) in the plenum chamber were obtained for the optimised solar tunnel dryer (*OSTD*) as compared with those (12.1 to 42.5°C) for the non-optimised solar tunnel dryer (*NOSTD*). This indicates that the *OSTD* harnessed more energy than the *NOSTD*. The results further show that the *OSTD* took 15 hours as compared to 28 hours for the *NOSTD* to dry fish to equilibrium moisture. A two-factor Analysis of Variance at 5% level of significance confirmed the existence of significant difference in plenum temperatures developed by the two dryers ($F=36.83$, $F_{crit,\alpha=0.95} = 3.26$).

The mean values of protein, fat, carbohydrates and ash content of fish dried under *NOSTD* and *OSTD* were 69.60%, 8.00%, 1.01µg/g and 8.41% (for *OSTD* only), respectively, 69.70%, 5.92%, 1.00 µg/g and 17.6%, (for *NOSTD* only), respectively, and 71.10%, 7.3%, 0.73 µg/g and 18.11% (for open sun drying, *Osd*), respectively. This indicates that the drying process had no significant influence on the nutritive value of fish dried in both the *OSTD* and *NOSTD* solar dryers. In addition, based on TBARS analysis, the quality of fish dried in the *OSTD* was found to be acceptable at 2.3µg(MA)/kg, while that for *NOSTD* (5.3µg(MA)/kg) was close to the

unacceptable level of 6 $\mu\text{g(MA)/kg}$, though within the acceptable range. Finally, the TVB-N results show “very good” putrefaction values (11.14–12.74mg/100g) and these were not significantly different for the two treatments.

Based on these results, it is recommended that appropriate designs and optimisation principles and models for solar dryers should always be developed and adopted as has been established in this study. This would result in effective and efficient energy harnessing and quality enhancement of solar dried food material, with the possibility of reducing food losses, improving food security and raising the level of income at farm level.