Optimization of Time and Temperature for Smoking of *Nile Tilapia* for a Better Preservation of Protein and Gross Energy Value

Conference place  Desalegn Hotel
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Introduction

Fish Vs Nutrition

- 25% animal protein - cheapest
- Ethiopia <248g/person/annum
- Regular and sufficient supply - >10kg/person/annum
- 1 billion people
• Omega-3 fatty acid
  - reduce blood cholesterol
  - enrich brain of developing fetus
• Vehicle for iodine (Demeke, 2014)

Fish Vs Economy
• Employment 38 million
• Revenue
Fish Vs Agriculture

- Fertilizer 10-6-2
- Feed for poultry, small ruminants, mice, crocodile & fish itself
- Reserve of food against drought & hunger
Smoking

- Cooking, drying, acidic & alcoholic preservative value
- More than 200 cpds (formaldehyde, carboxylic acid and phenols) contribute to …
- Combined effect of dehydration, antimicrobial & antioxidant activity
Objectives

- To optimize time and temperature for hot smoking in order to get the most nutritive and sensory quality
Materials and Methods

Sample collection and preparation

• A total of fresh 204 *Oreochromis niloticus* - 144 for proximate composition analysis & 60 for sensory evaluation.

• The fish was washed, cleaned, gutted and kept in brine solution for 40 minutes.
Smoking process

- Fish were divided into two groups:
  G1 - smoked directly after brining
  G2 - dried using solar tent dryer for 2hrs
- Smoking temperature 70 ± 3 °C, 80± 3°C, 90± 3°C and 100± 3°C
- Smoking time 2:00 hrs, 2:30 hrs, 3:00 hrs and 3:30 hrs
Mate...

Proximate composition analysis

Moisture content

\[
\text{Moisture content} = \frac{\text{Weight of wet sample} - \text{weight of dried sample}}{\text{weight of wet sample}} \times 100
\]

Crude protein

\[
\% N = N\text{HCl} \times \frac{(\text{Volume of sample} - \text{volume of blank})L}{\text{gram of sample}} \times \frac{14\text{ g}}{\text{mole}} \times 100
\]

Crude fat

\[
\text{Fat content} = \frac{\text{Weight of diethly ether extracted fat}}{\text{weight of sample}} \times 100
\]
• Eventually protein and fat content in wet base was recalculated from dry base using the formula:

\[
\text{% proximate in wet} = \frac{\text{% proximate in dry} \times (100 - \text{moisture content})}{100}
\]

• Gross energy value was calculated using Atwater’s conversion factor

\[
\text{Gross energy value} = 4 \times \text{protein content} + 9 \times \text{fat content}
\]
Sensory evaluation

• Organoleptic characteristics was evaluated using nine point hedonic scale

• Degree of liking was expressed ranging from “like extremely” to “dislike extremely”

• Coded samples were presented randomly for 10 consumer panels

• Taste neutral water was provided for oral rinsing between samples
STEPS FOR PROCESS MODEL BUILDING

1. Objective identification and definition
2. Factor identification and screening
3. Selection of suitable model
4. Design of statistical experimental plans
5. Execution/realization of the Experiment
6. Model Building, Prediction and Optimization
Mate...

Step 3 Selection of suitable models

• Second degree quadratic polynomials

$$y(x) = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{j=2}^{k} \sum_{i=1}^{j-1} \beta_{ij} x_i x_j + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \varepsilon$$

Step 4 Design of statistical experimental plans

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Symbol</th>
<th>Coded level</th>
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</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>X1</td>
<td>-1 0 1</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>X1</td>
<td>80±3°C 90±°C 100±°C</td>
</tr>
<tr>
<td>Time (hr)</td>
<td>X2</td>
<td>2:00 2:30 3:00</td>
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</table>
• Central Composite Design (CCD) was selected as experimental design

Step 5 Execution/realization of the Experiment
## Result and Discussion

<table>
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<tr>
<th>Experimental run</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>0</td>
<td>-1</td>
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<td>1</td>
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<td>1</td>
<td>0</td>
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<tr>
<td>GEV(Kcal) Pre-dried</td>
<td>313.77</td>
<td>296.25</td>
<td>314.02</td>
<td>278.24</td>
<td>277.76</td>
<td>349.53</td>
<td>301.63</td>
<td>301.63</td>
<td>296.25</td>
<td>320.45</td>
<td>349.58</td>
<td>315.06</td>
<td></td>
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<tr>
<td>GEV (Kcal) Non-dried</td>
<td>277.38</td>
<td>283.13</td>
<td>284.18</td>
<td>258.66</td>
<td>262.64</td>
<td>260.86</td>
<td>294.52</td>
<td>263.36</td>
<td>268.29</td>
<td>259.3</td>
<td>279.47</td>
<td>259.47</td>
<td>280.37</td>
</tr>
</tbody>
</table>

Table 1: Arrangement of face centered CCD of experiments for gross energy value
Table 2: Arrangement of face centered CCD of experiments for overall sensory acceptability
Step 6  Model Building, Prediction and Optimization

- Mathematical relationships were generated using multiple linear regression analysis using design expert

- $\text{GEV (non-dried)} = 275.10 - 6.39X_1 + 4.15X_2 + 7.25X_1X_2 + 2.42X_1^2 - 3.97X_2^2$

- $\text{GEV (pre-dried)} = 311.55 - 6.36X_1 + 6.80X_2 + 2.70X_1X_2 + 2.34X_1^2 - 5.62X_2^2$
Overall sensory acceptability (non-dried) = 7.73 + 0.216X1 - 0.66X2 + 0.125X1X2 + 0.913X1^2 + 0.141X2^2

Overall sensory acceptability (pre-dried) = 7.7 + 0.033X1 + 0.11X2 - 0.125X1X2 - 0.262X1^2 + 0.287X2^2
Fig 1. Response surface 3D plot of smoking time and temperature level against gross energy value smoked Nile Tilapia (non-dried)
Fig 2. Response surface 3D plot of smoking time and temperature level against gross energy value smoked Nile Tilapia (pre-dried)
Fig 3. Response surface 3D plot of smoking time and temperature level against overall sensory acceptability non-dried smoked Nile Tilapia
Fig 4. Response surface 3D plot of smoking time and temperature level against overall sensory acceptability non-dried smoked Nile Tilapia
Conclusion and Recommendation

• Smoking T₀ & T’ have a great impact on organoleptic values and proximate composition.

• The better preservation method is therefore one that produces a final product that retains its nutritional properties to a level that is beneficial to consumers at the time of consumption.
With this regards,

- Fish smoked at $80 \pm 3^\circ C$ for a duration of 2:00hrs for non-dried & 3:00hrs for pre-dried smoked fish possessed the highest gross energy value/calorie

- Fish smoked at $100 \pm 3^\circ C$ for 2 & 3 hrs for non-dried and $90 \pm 3^\circ C$ for 2 and 3 hours for pre dried smoked fish possessed the highest overall sensory acceptability.
Acknowledgement

- OARI for funding the project
- EPHI for analyzing proximate composition