Application of Risk Analysis / HACCP:
Case of Milk-Borne Public Health Risks Analysis in Milk Markets in Kenya

Presentation at Workshop on Impacts of Urban and Peri-urban Livestock Systems on Public and Ecosystem Health in Nigeria

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ILRI-Kenya
Major issues in regulation for food safety in dairy markets in Kenya

Limited information base for policy formulation, therefore reliance on Western models

However, raw milk markets dominate mainly because most consumers refuse to pay higher costs that pasteurisation and packaging incurs

Need for risk information to balance trade-offs between food safety and economics

Risk analysis is the right approach
## Percent milk marketed informally in selected countries in Africa & elsewhere

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sub-Saharan Africa</strong></td>
<td>Kenya</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Tanzania</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Uganda</td>
<td>90</td>
</tr>
<tr>
<td><strong>Central America</strong></td>
<td>Nicaragua</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Costa Rica</td>
<td>44</td>
</tr>
<tr>
<td><strong>South Asia</strong></td>
<td>India</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Sri Lanka</td>
<td>40</td>
</tr>
</tbody>
</table>

*Typical Small milk trader in Kenya*
Assessment of risks
Study sites and Dairy Density

Nakuru/Narok:
- Extensive production
- Medium market access
- Exotic & Zebu cattle

Nairobi/Kiambu:
- Intensive production
- High market access
- Exotic cattle

Sites differentiated between levels of market access and production system
Study methods

Participatory research and structured data collected between 1999 and 2001

Data included milk pathways, handling practices by market agents and consumers, laboratory hazard assessments, economic & GIS
Analytical approaches

Health Risk Analysis for each hazard using HACCP as a tool/guideline

What is Risk analysis?

What is HACCP?
Analytical approaches (cont’d)
Definitions: Risk and Hazard

Risk = Fn of both probability (likelihood) & magnitude (impact) of an adverse effect from a hazard

Hazard = A biological, chemical or physical agent in food that may have adverse health effect
Analytical approaches (cont’d)
Definitions: Risk Analysis Components

Risk Analysis is a process consisting of three components:

1. Risk Assessment
2. Risk Management
3. Risk Communication
Analytical approaches (cont’d)

Definitions: Risk Assessment

1. Risk Assessment = The scientific evaluation of adverse health effects from exposure to a food-borne hazard. It involves these steps:

   a) Hazard identification
   b) Hazard characterisation: qualitative / quantitative / dose-response
   c) Exposure assessment: evaluation of degree of intake
   d) Risk characterisation: integration of above and reference to a population and uncertainties
2. Risk Management: The process of weighing policy alternatives to accept, minimise or reduce assessed risks and to select and implement appropriate options.

3. Risk Communication: An interactive process of productive exchange of information with stakeholders.
Analytical approaches (cont’d)

Definitions: HACCP

Hazard Analysis Critical Control Points (HACCP) is a tool/guideline for risk analysis.

Originally applied to food for astronauts

HACCP is designed to prevent problems before they occur and to correct deviations as soon as they are detected. Such preventive control systems with documentation and verification are widely recognized as the most effective approach for ensuring food safety.

HACCP reduces regulatory enforcement costs
Analytical approaches (cont’d)
Definitions: HACCP Steps/principles

1. Assessment of risks in the food chain (use conceptual flow-diagrams)
2. Determination of critical control points (CCPs): Points for remedial action
3. Determination of Critical Limits (CL)
4. Development of monitoring systems
5. Implementation of monitoring procedures
   - Corrective action, Documentation & Verification

Challenge: Adapting HACCP concept to informal food market situations
Analytical approaches (cont’d)
Laboratory Hazard Assessment in Kenya

- Total & Coliforms Bacteria: SPC
- Butter-fat: Gerber Method
- Added water: Specific gravity
- *Brucella abortus*: MRT, ELISA
- *E. coli 0157:H7*: Culture & typing
- Antibiotics & antibacterials: Charm tests
- Bovine TB (*M. bovis*) in humans: Culture and PCR

Hazards to be investigated were identified at the initial stakeholder consultation.
Analytical approaches (cont’d)

Risk factors (Risk characterisation) in Kenya

Consumer preference, market structure, conduct and performance

Market margins

Spatial factors affecting marketing behaviour and performance

Regression, principal component and clustering of milk quality indicators & profit parameters
Highlights of Results of Risk Characterisation

Percent of Households Buying Raw and Pasteurised Milk in Kenya

<table>
<thead>
<tr>
<th>Location</th>
<th>Raw</th>
<th>Pasteurised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi</td>
<td>29%</td>
<td>78%</td>
</tr>
<tr>
<td>Nakuru urban</td>
<td>80%</td>
<td>34%</td>
</tr>
<tr>
<td>Nakuru rural</td>
<td>93%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Raw milk preferred due to its low price

Milk prices (1999)

<table>
<thead>
<tr>
<th>Area</th>
<th>Mean Price (KSh/Litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw milk</td>
</tr>
<tr>
<td>Nairobi</td>
<td>31.5</td>
</tr>
<tr>
<td>Nakuru urban</td>
<td>25.3</td>
</tr>
<tr>
<td>Nakuru rural</td>
<td>18.4</td>
</tr>
</tbody>
</table>

Lower prices for raw milk in rural areas and as distance from Nairobi increases.
Higher quantities consumed as income increases

Price is not the only determinant of raw milk consumption. Tastes and preferences also count.
Overview of lab. results

Adulteration

KEBS standards for specific gravity <1.026kg/l (added water) & >1.032kg/l (added solids) applied

<table>
<thead>
<tr>
<th>Added Water %</th>
<th>Added solids %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer hh</td>
<td>5</td>
</tr>
<tr>
<td>Mkt agents</td>
<td>10</td>
</tr>
</tbody>
</table>

- Adulteration highly variable by season & area
- All traders had some adulterated milk
- Tendency to add water during periods of low milk supply and high milk prices
Bacterial counts (cfu/ml): % bad/very bad (KEBS)

Raw: TC>2M, CC>50,000; Pasteurised: TC>30,000, CC>10

- High counts in urban; low counts in rural areas
- Lack of effective preservation e.g., cooling. Standards?
- Significant deterioration before first transaction
• Bulking of raw milk → higher risk of brucellosis
• 6% of rural hh consume home-made fermented milk
• *E. coli* 0157:H7 2 out of 264 (<1%)
• No *M. bovis*
Nearly all households boiled marketed milk prior to consumption but some naturally fermented milk was also consumed.
• All common antibiotics & antibacterials tested (penicillins, tetracyclines, sulphonamides, aminoglycosides & macrolides)
• The major health risk found.
• An average Kenyan consumer is exposed to milk with unacceptable residue levels twice every month!
# Antibiotics & antibacterials (Charm AIM-96 Test)

Detection levels of Charm-AIM test, MRLs and ADI

<table>
<thead>
<tr>
<th>Drug</th>
<th>Min. test Range µg/kg</th>
<th>EU/Codex MRLs µg/kg</th>
<th>Codex ADI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penicillin G</td>
<td>3-4</td>
<td>4</td>
<td>30 µg/day</td>
</tr>
<tr>
<td>Oxytetracycline</td>
<td>150-300</td>
<td>100</td>
<td>30 µg/kg bwt</td>
</tr>
</tbody>
</table>
## Factors associated with milk quality (OLS)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total bacteria</th>
<th>Coliforms</th>
<th>SNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nairobi/Kiambu</td>
<td>Strong (+++)</td>
<td></td>
<td>Strong (+++)</td>
</tr>
<tr>
<td>Wet season</td>
<td>Strong (+++)</td>
<td>Medium(--)</td>
<td>Medium (--)</td>
</tr>
<tr>
<td>SNF</td>
<td>Medium(++)</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Market Pathways (relative to Farm-coop)

<table>
<thead>
<tr>
<th>Market Pathway</th>
<th>Total bacteria</th>
<th>Coliforms</th>
<th>SNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm-Shops/kiosk</td>
<td>Weak (+)</td>
<td>Medium (--)</td>
<td>Weak (+)</td>
</tr>
<tr>
<td>Coop-Shop/kiosk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile trader-Milk bar</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### Milk handling

<table>
<thead>
<tr>
<th>Milk handling</th>
<th>Total bacteria</th>
<th>Coliforms</th>
<th>SNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk preservation</td>
<td>Weak (-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic container</td>
<td>Medium (++)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scooping vs pouring</td>
<td>Medium (++)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piped water</td>
<td>Medium (++)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Other covariates

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Total bacteria</th>
<th>SNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time since collection</td>
<td>Strong (+++)</td>
<td></td>
</tr>
<tr>
<td>Profit Margin/Lt</td>
<td></td>
<td>Strong (---)</td>
</tr>
</tbody>
</table>
Major risk factors (CCPs) in milk handling and critical points

**Antibiotics & antibacterials**

Major risk that heat treatment cannot address
Long term issue to be addressed mainly at farm level

**Bacterial risks:** Can be addressed by boiling/pasteurization

- **Total Bacteria**
  - Wet season, Time before and after first transaction,
  - Pathways from farms to shops/kiosks and milk bars

- **Coliform Bacteria**
  - Lack of training, Scooping vs. pouring, Plastic containers

- **Zoonoses**
  - Fermented milk is a potential source; No Bovine TB
Current licensing requirements do not promote good milk quality in Kenya

Summary of means of new variables & major clusters
(principal component and cluster analysis)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Large scale</th>
<th>Low</th>
<th>High</th>
<th>Long</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq.</td>
<td>/Experience</td>
<td>quality</td>
<td>margin</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>-0.31</td>
<td>0.29</td>
<td>-1.47</td>
<td>0.48</td>
<td>Small: 44 l/d</td>
</tr>
<tr>
<td>158</td>
<td>-0.25</td>
<td>-0.06</td>
<td>-0.19</td>
<td>0.06</td>
<td>Small: 126 l/d</td>
</tr>
<tr>
<td>120</td>
<td>-0.37</td>
<td>-0.01</td>
<td>0.58</td>
<td>0.08</td>
<td>Small: 108 l/d</td>
</tr>
<tr>
<td>25</td>
<td>2.74</td>
<td>-0.29</td>
<td>0.11</td>
<td>0.07</td>
<td>Large: 5,536 l/d</td>
</tr>
<tr>
<td>22</td>
<td>0.89</td>
<td>-0.36</td>
<td>-0.21</td>
<td>-0.03</td>
<td>Medium: 367 l/d</td>
</tr>
</tbody>
</table>

- Small traders grouped together irrespective of licensing
- Quality is not a problem for majority of small traders (relatively)
- Training/experience helps to significantly improve milk quality
- Can target specific groups and market pathways
Conclusions (risk assessment)

Consumers generally prefer whole raw milk but this fact is currently ignored by policy makers.

More than 50% of samples exceed current hygiene standards.

Nearly all consumers who purchase milk boil it before consumption.

Antimicrobials are the major public health risk. Some risk from consumption of naturally fermented milk.

Small traders use cheap and poor quality containers mainly due to policies that exclude them.
Conclusions (risk management)

Policy is ineffective since the quality of traded but unlicensed milk does not differ significantly from licensed milk.

Tradeoffs should consider actual risks, consumer preference and ‘safety’ as perceived by them.

Appropriate public intervention should be through consumer education.

Alternative approach of training and certification of market agents should result in better milk quality and better service to consumer preferences.

Role for self-regulation?
Communicating the risk information has largely been productive with some positive changes in mindsets.

Policy was/is important and policy-makers were therefore directly included in research and testing of interventions.

Private sector and NGOs also included.

Stakeholders gathered in early 2001 mandated policy makers to form a committee to refine recommendations and oversee their implementation.
Conclusions (risk communication cont’d)

Engage in public debate

Contribution to changing policy environment: Drafts of Policy & Bill explicitly recognize the predominance of small scale raw milk markets and are supportive

However, additional changes in legislation and institutions will be required to realize the desired changes in the new DDP
## Acknowledgements

### Co-investigators and Institutional Collaborators

<table>
<thead>
<tr>
<th>University</th>
<th>Contributors</th>
</tr>
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<tbody>
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<tr>
<td>MoARD</td>
<td>H. Muriuki</td>
</tr>
<tr>
<td>DFID bilateral</td>
<td>Support to SDP</td>
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