Marketing and Distribution of Shiitake Mushrooms: A Virginia Retail Case Study

Charles W. Coale, Jr., and Andrew G. Hankins
Editors
James R. Nichols, Dean and Director
College of Agriculture and Life Sciences
Virginia Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0402

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MARKETING AND DISTRIBUTION OF SHIITAKE MUSHROOMS: A Virginia Retail Case Study

Charles W. Coale, Jr., and Andrew G. Hankins Editors

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**COVER:** Photograph by Bob Veltri
# TABLE OF CONTENTS

Abstract  
Charles W. Coale, Jr., William F. Wilcke,  
and Andrew G. Hankins ......................... v

Introduction  
Charles W. Coale, Jr. .......................... 1

The Harvest and Assembly of Mushrooms  
Charles W. Coale, Jr. .......................... 2

A Physical Evaluation of the Distribution  
of Shiitake Mushrooms  
Joe Anthony, Mark Warman, Richard Mook,  
Clinton Allen, and William Craig ............... 7

Packing Analysis and Recommendations  
William F. Wilcke, C. Gene Haugh,  
and Kenneth C. Diehl .......................... 15

Microbial Analysis and Recommendations  
Orson K. Miller, Jr. and Moss Baldwin .......... 31

Consumer Attitudes About Shiitake Mushrooms  
Andrew G. Hankins ............................. 35

Cost of Marketing Shiitake Mushrooms  
Charles W. Coale, Jr. and C. Gene Haugh ........ 40

Strengths of the Mushroom Marketing Study  
Charles W. Coale, Jr. .......................... 48

Weaknesses of the Mushroom Marketing Study  
Charles W. Coale, Jr. .......................... 51

Recommendations: A Virginia Shiitake Market  
Research Study  
Charles W. Coale, Jr. .......................... 54

References ................................. 57
LIST OF TABLES

TABLE
1. Virginia Mushroom Production Schedule, 1988 ............... 2
2. Shiitake Mushrooms Supplied by Seventeen Virginia
   Growers, 1988 ........................................ 3
3. Shiitake Mushroom Weights and Grades Supplied by
   Seventeen Virginia Mushroom Growers, 1988 ........ 4
4. Shiitake Mushroom Assembly Routes for Four Virginia
   Locations, WEEK 1, May 16 and 17, 1988 ............. 5
5. Shiitake Mushroom Assembly Routes for Four Virginia
   Locations, WEEK 2, May 23 and 24, 1988 ............ 5
6. Shiitake Mushroom Assembly Routes for Four Virginia
   Locations, WEEK 3, May 30 and 31, 1988 .......... 6
7. Fungi Found on Shiitake Mushrooms ...................... 32
8. Shiitake Mushroom Deliveries and Returns
   at Four Farm Fresh Supermarkets, 1988 ............. 36
9. Shiitake Mushroom Packing Cost for a Three-Week
   Marketing Research Period, 1988 .................... 40
10. Estimated Costs Per Pound for Packing Shiitake
    Mushrooms Under Commercial Conditions, 1989 .... 41
11. Shiitake Mushroom Distribution Routes for Four Farm
    Fresh Supermarket Locations, WEEK 1, May 19, 1988 42
12. Shiitake Mushroom Distribution Routes for Four Farm
    Fresh Supermarket Locations, WEEK 2, May 26, 1988 42
13. Shiitake Mushroom Distribution Routes for Four Farm
    Fresh Supermarket Locations, WEEK 3, June 2, 1988 . 43
14. Shiitake Mushroom Assembly and Distribution Costs for
    a Three-Week Test Marketing Period, 1988 ......... 44
15. Estimated Costs for Shiitake Mushroom Assembly and
    Distribution Costs for a Commercial Operation, 1989 . 45
16. Shiitake Mushroom Marketing Cost for a Three-Week
    Marketing Research Period, 1988 ................. 46
17. Estimated Costs for Shiitake Mushroom
    Assembly and Distribution Costs
    for a Commercial Operation, 1989 ............... 47
LIST OF FIGURES

FIGURE

1. Assembly and distribution points used for mushroom shipments in Virginia ................... 9
2. Locations of thermocouples and relative humidity sensors ........................................... 10
3. Shiitake mushroom packing line used Week 1 ......................................................... 20
4. Shiitake mushroom packing line used Weeks 2 and 3 ............................................... 21
5. Revolving packing table ............................................................................................. 22
6. Suggested 34 kg/h (75 lb/hr) shiitake-mushroom packing line ................................. 29
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This study could not have been completed without the support of the membership of the Virginia Shiitake Mushroom Marketing Cooperative, Inc. (VSMMC) and their leaders -- Ed Dunphy, David Garland, Lester Kodger, and Milt McGrady; J. B. Tatum, Southside Virginia Produce Cooperative; and Susan Mayo and Bobby Wiltshire, Farm Fresh, Inc. Other loyal workers included assembly point managers, employees at Southside Virginia Produce Cooperative, and store and produce managers at Farm Fresh, Inc.
ABSTRACT

A Virginia Shiitake Market Research Study

Edited by Charles W. Coale, Jr.,
William F. Wilcke, and Andrew G. Hankins*

The Virginia shiitake mushroom marketing research study was a comprehensive effort on the part of mushroom growers, food marketers, and public agency personnel to determine the feasibility of marketing Virginia-grown mushrooms in a retail marketing channel.

The overall objective of this research was to specify and evaluate a marketing and distribution system to profitably market Virginia mushrooms. The specific objectives were: 1) to develop and evaluate an assembly and distribution routing system, 2) to develop and evaluate a packing line that would simulate a commercial packing operation, and 3) to demonstrate product handling procedures that would maintain an adequate mushroom quality assurance program.

A three-week shiitake marketing program was developed and conducted. The study began on May 16 and was completed on June 8, 1988. Virginia growers packed out 55.5 percent of the mushrooms supplied for the marketing research in the Grade 1 category, 15.8 percent in Grade 2, and 17.9 percent in Culls. Due to time constraints and logistical problems, about 10.8 percent of the mushrooms did not receive a graded inspection.

The marketing research study showed that the total cost of the mushroom assembly, packing, and distribution was about $5.95 per pound because of the small volume packed. The principal factor increasing the cost of assembly and distribution was the small shipments compared to the capacity of the vehicle. The mushroom cooperative received a wholesale

*Professor, Agricultural Economics Department, Virginia Polytechnic Institute & State University; Assistant Professor, Agricultural Engineering Department, University of Minnesota; Associate Professor, Virginia State University.
price of $7.50 per pound, which left $1.55 for grower returns. Assembly utilized 21.2 percent of the total costs, 34.0 percent of costs were allocated to the experimental packing, and 24.1 percent were associated with product distribution. In total, 79.3 percent of the wholesale price was allocated to marketing. Generally, marketing costs for food products range between 40 and 60 percent of the wholesale price.

In-store mushroom demonstrators served shiitake soup and dip taste samples, asked questions about customer reactions, and answered questions about using the mushrooms. The following is a summary of 306 customer responses:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Have you ever tasted shiitake mushrooms?</td>
<td>32%</td>
<td>68%</td>
</tr>
<tr>
<td>2) Have you ever used shiitake mushrooms?</td>
<td>26%</td>
<td>74%</td>
</tr>
<tr>
<td>3) Does the taste appeal to you?</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>4) Would you purchase Virginia grown shiitake?</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>5) Do you feel the price ($2.59/3 1/2 ounces) is fair?</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>6) Is the packaging attractive?</td>
<td>83%</td>
<td>17%</td>
</tr>
</tbody>
</table>

There were two main causes for the minor amount of quality loss in the shiitake mushrooms used in the marketing research. First, and most important, was infestation of mushrooms by rove beetles. Second was contamination by bacteria fungi, but this was a minor problem, and was easily detected in the grading process. Third was temperatures on the retail shelf that were higher than recommended.
INTRODUCTION

Charles W. Coale, Jr.*

The U.S. Department of Agriculture (USDA) is cooperating with individual states and universities to identify alternative agricultural enterprises for small-scale farmers. The shiitake marketing study is part of federal and state agency initiatives to evaluate and develop alternative agricultural enterprises. This marketing project involved selling Shiitake mushrooms as an alternative to the traditional Virginia agricultural products. Virginia Polytechnic Institute and State University (VPI&SU), Virginia State University (VSU), and the Virginia Department of Agriculture and Consumer Services (VDACS), in cooperation with USDA, conducted the mushroom research and educational program for the benefit of Virginia consumers and producers. The principal private industry cooperators in the project were the Virginia Shiitake Mushroom Marketing Cooperative (VSMMC), the Southside Virginia Produce Cooperative (SVPC), and Farm Fresh, Inc. (FF). This mushroom research was initiated by the VSMMC marketing committee.

The VSMMC marketing mission was to provide marketing alternatives for members of the Virginia shiitake mushroom industry. VSMMC defined four marketing channels for development: 1) the restaurant trade, 2) wholesale/retail markets, 3) the military market, and 4) further processed markets. A retail marketing channel was chosen for this study.

The overall objective of this research was to specify and evaluate a marketing system to profitably market Virginia mushrooms. Specific objectives were: 1) to develop and evaluate an assembly and distribution routing system, 2) to develop and evaluate a packing line that would simulate a commercial packing operation, and 3) to demonstrate product handling procedures that would maintain an adequate mushroom quality assurance program.

A three-week marketing program was developed and conducted. The study began on May 16 and was completed on June 8, 1988. The methodology and results of the study are discussed in this report.

*Professor and Extension Economist, Agricultural Economics Department, Virginia Polytechnic Institute & State University.
THE HARVEST AND ASSEMBLY OF MUSHROOMS

Charles W. Coale, Jr.*

The VSMMC steering committee had written a marketing plan for effective marketing of their members' mushrooms. The marketing plan was based on 1987 harvest figures and expected 1988 harvest [Survey conducted by A. G. Hankins]. The mushroom production estimates were based on data provided by 36 Virginia growers who make up the membership of the cooperative.

Shiitake mushroom production for 36 VSMMC growers for 1988 was estimated at about 66,800 pounds over a five-month harvest period (Table 1). Shiitake mushrooms fruit only during specific calendar periods based on an optimum ambient temperature and humidity. The 36 VSMMC member growers provided a sufficient volume of shiitake mushrooms for the marketing research program. Seventeen growers of the 36 volunteered to participate in the study. Two additional sources of mushrooms were located, so that enough mushrooms were available for the research program.

<table>
<thead>
<tr>
<th>Table 1. Virginia Mushroom Production Schedule 1988.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month: Apr May Aug Sep Oct Nov</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>1987: 4,500 2,250 4,500 4,500 2,500</td>
</tr>
<tr>
<td>1988: 6,000 10,700 8,350 16,700 16,700 8,350</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>*Forecast based on thirty-six VSMMC growers, 1987</td>
</tr>
</tbody>
</table>

A production quota was set for the 17 cooperative growers to supply a total of 655 boxes, or about 1,965 pounds, for the three-week market research period. Three cooperative growers did not supply any

*Professor and Extension Economist, Agricultural Economics Department, Virginia Polytechnic Institute & State University.
mushrooms for the marketing research study, although they had been assigned a quota of 115 pounds of mushrooms. Due to limited market demand, growers actually supplied 314 boxes, or about 895 pounds, during the market research period (Table 2).

Table 2. Shiitake Mushrooms Supplied by Seventeen Virginia Growers, 1988*

<table>
<thead>
<tr>
<th>Grower (#)</th>
<th>5/17</th>
<th>5/24</th>
<th>5/31</th>
<th>Delivered Quota</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-----------------</td>
</tr>
<tr>
<td>(1)</td>
<td>09</td>
<td>09</td>
<td>08</td>
<td>26</td>
</tr>
<tr>
<td>(2)</td>
<td>03</td>
<td>01</td>
<td>00</td>
<td>04</td>
</tr>
<tr>
<td>(3)</td>
<td>00</td>
<td>10</td>
<td>00</td>
<td>10</td>
</tr>
<tr>
<td>(4)</td>
<td>03</td>
<td>05</td>
<td>02</td>
<td>10</td>
</tr>
<tr>
<td>(5)</td>
<td>09</td>
<td>08</td>
<td>04</td>
<td>21</td>
</tr>
<tr>
<td>(6)</td>
<td>07</td>
<td>00</td>
<td>03</td>
<td>10</td>
</tr>
<tr>
<td>(7)</td>
<td>19</td>
<td>10</td>
<td>10</td>
<td>39</td>
</tr>
<tr>
<td>(8)</td>
<td>04</td>
<td>06</td>
<td>07</td>
<td>17</td>
</tr>
<tr>
<td>(9)</td>
<td>11</td>
<td>03</td>
<td>02</td>
<td>16</td>
</tr>
<tr>
<td>(9A)</td>
<td>13</td>
<td>00</td>
<td>00</td>
<td>13</td>
</tr>
<tr>
<td>(10)</td>
<td>22</td>
<td>06</td>
<td>05</td>
<td>17</td>
</tr>
<tr>
<td>(11)</td>
<td>08</td>
<td>10</td>
<td>04</td>
<td>22</td>
</tr>
<tr>
<td>(12)</td>
<td>04</td>
<td>03</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>(13)</td>
<td>14</td>
<td>12</td>
<td>07</td>
<td>33</td>
</tr>
<tr>
<td>(14)</td>
<td>08</td>
<td>06</td>
<td>07</td>
<td>21</td>
</tr>
</tbody>
</table>

Boxes 140 89 85 314 655 **

*Supplied in three-pound, standard mushroom industry boxes.
** Three cooperative growers did not supply any mushrooms for the marketing research study, although they had been assigned a quota of 115 pounds of mushrooms.

Quality Standards Achieved by Virginia Growers

Virginia growers packed out 55.5 percent of the mushrooms supplied for the test market in the Grade 1 category, 15.8 percent in Grade 2, and 17.9 percent in Culls (Table 3). Due to time constraints and logistical problems, about 10.8 percent of the mushrooms did not receive a graded inspection.
Table 3. Shiitake Mushroom Weights and Grades Supplied by Seventeen Virginia Mushroom Growers, 1988

<table>
<thead>
<tr>
<th>Grower (#)</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Culls</th>
<th>Ungraded</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>55.56</td>
<td>7.50</td>
<td>6.55</td>
<td>5.58</td>
<td>75.19</td>
</tr>
<tr>
<td>(2)</td>
<td>7.93</td>
<td>0.44</td>
<td>2.60</td>
<td>0.00</td>
<td>10.97</td>
</tr>
<tr>
<td>(3)</td>
<td>5.12</td>
<td>15.80</td>
<td>6.63</td>
<td>0.00</td>
<td>27.55</td>
</tr>
<tr>
<td>(4)</td>
<td>14.98</td>
<td>2.44</td>
<td>2.19</td>
<td>0.00</td>
<td>19.61</td>
</tr>
<tr>
<td>(5)</td>
<td>25.21</td>
<td>12.00</td>
<td>20.79</td>
<td>0.00</td>
<td>58.00</td>
</tr>
<tr>
<td>(6)</td>
<td>3.23</td>
<td>0.71</td>
<td>18.71</td>
<td>2.59</td>
<td>25.24</td>
</tr>
<tr>
<td>(7)</td>
<td>67.14</td>
<td>23.84</td>
<td>5.23</td>
<td>17.10</td>
<td>113.31</td>
</tr>
<tr>
<td>(8)</td>
<td>18.62</td>
<td>4.95</td>
<td>14.53</td>
<td>8.82</td>
<td>46.92</td>
</tr>
<tr>
<td>(9)</td>
<td>11.17</td>
<td>2.06</td>
<td>31.17</td>
<td>0.00</td>
<td>44.40</td>
</tr>
<tr>
<td>(9A)</td>
<td>8.21</td>
<td>13.64</td>
<td>13.70</td>
<td>0.00</td>
<td>35.55</td>
</tr>
<tr>
<td>(11)</td>
<td>45.11</td>
<td>19.09</td>
<td>13.29</td>
<td>26.10</td>
<td>103.59</td>
</tr>
<tr>
<td>(12)</td>
<td>43.09</td>
<td>3.16</td>
<td>0.79</td>
<td>2.97</td>
<td>50.01</td>
</tr>
<tr>
<td>(13)</td>
<td>55.56</td>
<td>6.05</td>
<td>0.50</td>
<td>0.00</td>
<td>62.11</td>
</tr>
<tr>
<td>(16)</td>
<td>30.29</td>
<td>2.13</td>
<td>14.13</td>
<td>12.84</td>
<td>59.39</td>
</tr>
<tr>
<td>(17)</td>
<td>63.42</td>
<td>14.35</td>
<td>5.36</td>
<td>14.425</td>
<td>97.555</td>
</tr>
<tr>
<td>(X)</td>
<td>42.27</td>
<td>13.82</td>
<td>3.67</td>
<td>6.08</td>
<td>65.84</td>
</tr>
</tbody>
</table>

Total Pounds 496.91 141.98 159.84 96.51 895.235
Percent 55.5% 15.8% 17.9% 10.8% 100%

Total Distributed (tray pack and demos) = 735.48

The Shiitake Mushroom Assembly Route

Shiitake mushrooms were collected from four assembly points to which growers delivered their mushrooms for the study. Collection was done using a rental truck with a 20-foot insulated bed and a refrigeration unit. Truck operators began the assembly process by signing-out the truck at the Richmond Ryder headquarters on Monday each week of the market research period. The truck was driven to Culpeper, Virginia. On Tuesdays, the mushroom collection began at about 7:15 a.m. The total distance in the assembly route was about 390 miles, and the time to drive and collect mushrooms on the route ranged from about 12.16 hours to 14.30 hours (See Tables 4, 5, and 6).
<table>
<thead>
<tr>
<th>Assembly Route</th>
<th>Mileage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel (min)</td>
<td>Loading (min)</td>
</tr>
<tr>
<td>Monday, May 16, 1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richmond to Culpeper</td>
<td>116</td>
<td>155</td>
</tr>
<tr>
<td>Tuesday, May 17, 1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culpeper to Madison</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Madison to Verona</td>
<td>71</td>
<td>97</td>
</tr>
<tr>
<td>Verona to Troutville</td>
<td>72</td>
<td>85</td>
</tr>
<tr>
<td>Troutville to Lynchburg</td>
<td>59</td>
<td>84</td>
</tr>
<tr>
<td>Lynchburg to Halifax</td>
<td>58</td>
<td>86</td>
</tr>
<tr>
<td>Meal stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>390</td>
<td>538</td>
</tr>
<tr>
<td>Conversion to hours for assembly process = 12.16 hours</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Assembly Route</th>
<th>Mileage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel (min)</td>
<td>Loading (min)</td>
</tr>
<tr>
<td>Monday, May 23, 1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richmond to Culpeper</td>
<td>118</td>
<td>205</td>
</tr>
<tr>
<td>Tuesday, May 24, 1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culpeper to Madison</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Madison to Verona</td>
<td>70</td>
<td>109</td>
</tr>
<tr>
<td>Verona to Troutville</td>
<td>72</td>
<td>82</td>
</tr>
<tr>
<td>Troutville to Law, TS</td>
<td>09</td>
<td>17</td>
</tr>
<tr>
<td>Law, TS to Thermo King</td>
<td>08</td>
<td>28</td>
</tr>
<tr>
<td>Thermo King to Lynchburg</td>
<td>48</td>
<td>60</td>
</tr>
<tr>
<td>Lynchburg to Halifax</td>
<td>58</td>
<td>85</td>
</tr>
<tr>
<td>Meal stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>398</td>
<td>605</td>
</tr>
<tr>
<td>Conversion to hours for assembly process = 14.30 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Thermo King was worked on at Lawrence Truck Stop.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>** Thermo King was worked on at Thermo King dealer.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Shiitake Mushroom Assembly Routes for Four Virginia Locations, WEEK 3, May 30 and 31, 1988

<table>
<thead>
<tr>
<th>Assembly Route</th>
<th>Mileage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Travel (min)</td>
</tr>
<tr>
<td>Richmond to Culpeper, Monday</td>
<td>120</td>
<td>205</td>
</tr>
<tr>
<td>Culpeper to Madison, Tuesday</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Madison to Verona, Tuesday</td>
<td>72</td>
<td>97</td>
</tr>
<tr>
<td>Verona to Troutville, Tuesday</td>
<td>72</td>
<td>79</td>
</tr>
<tr>
<td>Troutville to Lynchburg, Tuesday</td>
<td>59</td>
<td>73</td>
</tr>
<tr>
<td>Lynchburg to Halifax, Tuesday</td>
<td>59</td>
<td>90</td>
</tr>
<tr>
<td>Meal stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
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Conversion to hours for assembly process = 14.20 hours
A PHYSICAL EVALUATION
OF THE DISTRIBUTION OF SHIITAKE
MUSHROOMS

Joseph P. Anthony, Jr., Mark W. Warman, Richard G. Mook
Clinton A. Allen, William L. Craig*

Introduction

This report deals with the project objective to demonstrate physical
distribution procedures that will maintain product quality from pickup to
delivery, focuses on the physical distribution and product quality, and is
only secondarily concerned with route development and feasibility.

Summary

A series of test shipments of shiitake mushrooms grown in
Virginia was conducted for three consecutive weeks. Temperatures and
relative humidities were monitored to evaluate the transport environment
and product condition. All of the test shipments began on Tuesday with
product pickups at four assembly point locations and delivery to the
packing plant in Halifax. Wednesday was packing day for all shipments.
On Thursday the mushrooms were delivered to four retail locations.

Test Shipments 1 and 2 were conducted in the same transport
vehicle, and Test Shipment 3 used a different vehicle. The first vehicle
maintained average product temperatures that were 18.2 F and 11.8 F
higher than the thermostat setting of 36 F. The second vehicle maintained
a temperature that averaged only 1.1 F higher than the thermostat, clearly
a better performance. The relative humidity inside the truck was over 90
percent most of the time during the three test shipments.

*Joseph P. Anthony, Jr., Mark W. Warman, Richard G. Mook, Clinton A. Allen, Marketing
Research Branch, Market Research and Development Division, Agricultural Marketing
Service, United States Department of Agriculture; William L. Craig, Export Services Branch,
International Division, Office of Transportation.
Methodology

A series of test shipments was conducted during three consecutive weeks beginning on May 16, 1988, and ending on June 2, 1988. Each week was segmented as follows:

1. Tuesday - pick up mushrooms from growers at four predetermined locations in Madison, Verona, Troutville, and Lynchburg, and deliver the mushrooms to the Southside Virginia Produce Cooperative (SVPC) outside Halifax;

2. Wednesday - weigh, grade, sort, pack, package, and store the mushrooms using a procedure and line developed by agricultural engineers at VPI&SU; and

3. Thursday - deliver the packed mushrooms to four Farm Fresh supermarkets at Great Neck, Kempsville, Hampton, and Williamsburg.

The sites for pickup and delivery are presented in Figure 1.

The transport vehicles were 20-foot, refrigerated, straight-bed vans with rear and side access doors. The temperature and relative humidity in the vehicle and in the load were moderated from pickup to delivery by a Grant CR-50 recorder placed in the vehicle with 10 thermocouple and 3 humidity sensors positioned as displayed in Figure 2. The thermocouples were located in the following positions:

1) Air
   a) delivery air from the refrigeration unit
   b) return air to the refrigeration unit
   c) ambient air
   d) rear roof
   e) rear floor

2) Product
   a) top left front
   b) bottom right front
   c) center
   d) top right rear
   e) bottom left rear
Figure 1. Assembly and distribution points used for mushroom shipments in Virginia.
Figure 2. Locations of thermocouples and relative humidity sensors.
Three relative humidity sensors were located in the delivery air, the return air, and the center of the load. Temperature and relative humidity measurements were made every 15 minutes after the instrument was turned on at approximately 7:00 a.m. each Tuesday; it was turned off after the last delivery on Thursday.

Mushrooms were packed in a clear plastic tray obtained from Hill Pak; each tray contained 3.5 ounces of No. 1 Shiitake Mushrooms. These consumer packs were placed in master cartons (O.D. 19 3/4 x 11 3/4 x 12 1/2 inches) made of single-wall (double face), wax-impregnated, corrugated fiberboard.

Dividers were used to provide six cells in each layer within the master carton and to protect this fragile product by improving the compression strength of the package. These dividers consisted of two 2 5/8 x 11 inch, and one 2 3/4 x 19 inch pieces of single-wall corrugated fiberboard slotted to form the six cells. One 11 x 19 inch pad of single wall was placed between each of the four layers in each master carton to protect the payload of 24 consumer packs.

RESULTS

Routes

All of the test shipments began in Culpeper, Virginia, with the recording equipment being turned on at 7:00 a.m. on Tuesday of each week. Pickups were made at Madison, Verona, Troutville, and Lynchburg, and delivery was made to the SVPC packing plant located in Halifax County, Virginia. Packing took place on Wednesday of each week. Deliveries were made on each Thursday to the Farm Fresh supermarkets in Great Neck, Kempsville, Hampton, and Williamsburg.

Test shipment 1 began at 7:00 a.m. on Tuesday morning in Culpeper. After picking up mushrooms at the four designated pickup points, the vehicle arrived at SVPC at about 4:50 p.m. The vehicle was parked at the loading dock and the product was cooled by the vehicle’s refrigeration unit until packing the next day. Packing began at 8:30 a.m. on Wednesday morning and was completed at about 10:30 p.m. Procedural delays were encountered in setting up and operating the new packing line. The vehicle’s refrigeration unit was not operating for about 2 to 3 hours during the evening due to ice buildup on the coils, but was operating when the packing plant was shutdown for the night. Deliveries began at 6:30
a.m. on Thursday with departure from SVPC, and ended at about 4:15 p.m., when the refrigeration unit and recorder were turned off in Williamsburg.

Test shipment 2 began at 7:00 a.m. on the following Tuesday in Culpeper when the recorder and refrigeration unit were started. After picking up mushrooms at the four pickup points, the vehicle arrived at SVPC at 6:30 p.m. An electric power cable compatible with the vehicle's refrigeration unit had been installed and the product was refrigerated by the unit under electrical power. Packing began at 8:00 a.m. on Wednesday and was finished at 12:00 noon. The dramatically shorter packing time was due to improved procedures and smaller packing volumes because of lagging retail sales.

The delivery got off to a staggering start at about 6:30 a.m. on Thursday when the refrigeration unit could not be started and the vehicle sprang a fuel leak. After repairs, the delivery began about 11:45 a.m. with departure from Halifax. With difficulty, and after additional repairs, two deliveries were completed. On the way to Williamsburg the vehicle came to a sudden, abrupt, and final halt (never to run again). At 1:15 a.m. on Friday, this test shipment was halted when the recorder was stopped and the remaining mushrooms were transferred to other vehicles.

Test shipment 3 began at 7:00 a.m. on the third Tuesday in Culpeper and would prove to be, thankfully, uneventful. After picking up mushrooms at the assembly points, the newer replacement vehicle arrived at SVPC at 6:10 p.m. The new electric cable was not compatible with this vehicle's refrigeration unit. The product was cooled by diesel operation of the refrigeration unit throughout this test shipment. Packing began on Wednesday at 10:15 a.m. and ended about 11:30 a.m. Again, our procedures were getting better but, more important, reduced sales required less product to be packed. Delivery began at 6:30 a.m. on Thursday and proceeded smoothly. The only variation from the other test shipments was that the Kempsville store was delivered first and the Great Neck store second. The test shipment ended at about 4:10 p.m. at Williamsburg.

Temperatures

The thermostat setting for all of the test shipments was 36 F. The average temperature of the air being delivered from the refrigeration unit was 51.9 F, 15.9 F higher than the thermostat setting. The average ambient temperature for Test Shipment 1 was 69.7 F. The average product temperature (mass mean) was 54.2 F, 18.2 F higher than the thermostat
setting. Some of the higher selected product temperatures displayed probably occurred during the times that the refrigeration unit was not functioning.

The same vehicle was used for Test Shipment 2. With the thermostat set at 36 F, the average air temperature being supplied by the refrigeration unit was 47.8 F, which was 4.1 degrees cooler than the air delivered in Test Shipment 1 and an 11.8 degrees difference from the thermostat setting. The average ambient temperature was 73.5 F for this test shipment, 3.8 degrees higher than for Test Shipment 1. Measurement with this recorder is not random but rather regular sampling, one instance every 15 minutes. With this heavier external heat load, the refrigeration unit was operating more often and the probability of the recording cycle's monitoring the refrigeration unit while operating was decidedly higher.

The average product temperature (mass mean) was 61.4 F, 7.2 degrees higher than for Test Shipment 1, and was decidedly above the desired optimal of 36 F and the acceptable minimal of 48 F (depending upon which supplier's carton you believe). This average product was 25.4 F above the thermostat setting. This vehicle died near the end of Test Shipment 2 and was replaced with a similar vehicle with a similar refrigeration unit (same manufacturer, but a newer model of the same size) for Test Shipment 3.

A different refrigeration unit dramatically pointed out the importance of equipment that functions properly. The thermostat was set at 36 F and the average temperature of the refrigerated air, as regularly recorded, was 35.1 F, 0.9 F lower than the thermostat setting. The heatload on the vehicle was indicated by an average ambient of 68.4 F, which was similar to Test Shipment 1. The operating efficiency on the average product (mass mean) temperature of 37.1 F was 1.1 F higher than the thermostat setting. This operating efficiency is about as close as it is possible to achieve and can be used as a striking example of the importance of a carefully serviced refrigeration unit and a well-calibrated thermostat.

Relative Humidity

After about two hours, the relative humidity in the vehicle and within the load in all of the test shipments was about 80 percent; it soon rose to exceed 90 percent and remained there for the remainder of the shipment period.
Conclusions and Recommendations

The following conclusions and recommendations were drawn from the data collected, from direct observations, and from past experience:

1. The pickup and delivery routes and schedules are feasible, practical, and possible for one driver with a single vehicle to handle.

2. The thermostat on the refrigeration unit used in Test Shipments 1 and 2 was not properly calibrated, as was dramatically emphasized by the results from Test Shipment 3.

3. The vehicle used for these tests was a 20-foot refrigerated straight-bed truck; it appears to be too large for the needs of these growers. A 16-foot or even a 12-foot refrigerated vehicle would be more appropriate and definitely more economical to own and operate.

4. Refrigeration that can maintain more consistent product temperatures at the pickup points should be located.

5. The optimal storage and transport product temperatures should be determined for Virginia Shiitake Mushrooms. One box (VSMMC) recommended 36 F and another (Elix) recommended under 48 F.
PACKING ANALYSIS
AND RECOMMENDATIONS
SHIITAKE MARKETING STUDY

William F. Wilcke, C. Gene Haugh, and Kenneth C. Diehl*

The Southside Virginia Produce Cooperative (SVPC) provided the packing facility and services utilized in packing the shiitake mushrooms. After the assembly routes were completed, the refrigerated truck was parked at the SVPC facility where its refrigeration was used to keep the mushrooms cool overnight. Mushrooms utilized in the research were packed each Wednesday for delivery. SVPC provided three workers, and the remainder of the experimental work was completed by personnel from VSU, Virginia Tech, and one federal agency (USDA).

The responsibility of the Department of Agricultural Engineering in the Shiitake test marketing study was to specify packing materials and methods that would provide a safe, sanitary, attractive product. By the time Agricultural Engineering became involved in the project, planning was well under way, and several important steps relating to packaging had already been taken:

*The decision had been made to sell mushrooms in 3.5-ounce net weight packs.

*Mushroom containers had been ordered, made of clear plastic without lids; were nominally 4 in. wide, 5 in. long, and 2 in. deep with an internal volume of 32.3 cubic inches.

*Gummed, 3-in. by 3-in., preprinted labels that contained the phrase "Net wt. 3.5 oz" had been ordered.

* Assistant Professor, Agricultural Engineering Department, University of Minnesota; Professor, Associate Professor, Agricultural Engineering Department, Virginia Polytechnic Institute & State University.
Given the above information, the agricultural engineers' tasks were as follows:

1. Develop a procedure for weighing, cleaning, sorting, and grading incoming mushrooms.

2. Develop a procedure for filling the plastic containers.

3. Select a material and method for enclosing the plastic containers. The enclosure had to permit enough gas exchange to prevent anaerobic, high-moisture conditions that permit growth of organisms that can cause botulism, yet prevent excessive moisture loss.

4. Estimate the expected mushroom weight loss during the time between packing of mushrooms and purchase by consumers.

5. Devise a method for packing filled plastic containers into shipping cartons.

6. Develop an efficient packing line that would incorporate weighing incoming mushrooms and culls, cleaning, grading, filling packs with appropriate weight, enclosing and labeling packs, and filling shipping cartons.

Discussion

Each of the tasks involved in packaging mushrooms for the Shiitake Marketing Research Study is discussed below.

1. Weighing, cleaning, sorting, and grading incoming mushrooms

The first station in the packing line involved manually weighing and recording the quantity of each grade of mushrooms delivered by each grower. Mushrooms were delivered in 3-lb bulk boxes, so a balance with about 5-lb capacity and 1% precision (0.05 lb or 0.8 oz) was needed. To meet this need, a $2000 digital electronic Mettler balance with 12-lb
capacity, 0.01-lb precision, and a computer interface port was borrowed from the Agricultural Engineering Department. Data sheets for mushroom weights were designed to facilitate manual data entry into a computer spreadsheet program after packing was complete.

A computer program summarized the weights of mushrooms delivered by week and/or by grower (Table 2). Data analysis time could have been saved by connecting the Mettler balance to a computer and entering data automatically as mushrooms were weighed. Although the Shiitake Mushroom Marketing Cooperative could purchase an adequate nonelectronic balance to weigh incoming mushrooms for less than $100, a balance/computer combination that can automatically record and summarize weights would be highly desirable.

Tare weight for the bulk boxes averaged 0.88 lb with little variation among boxes. Under normal circumstances (no wet boxes), tare weight can be assumed constant. Net weights varied from one box to the next, even for the same grower, and ranged from 1.19 to 3.40 lb.

No cleaning and very little grading of incoming mushrooms were originally planned because the growers had agreed to meet strict minimum quality standards suggested by the Virginia Cooperative Extension Service Alternative Agriculture Specialist. Mushrooms delivered for the Marketing Study were to meet the following standards:

* caps no more than 3/4 open
* stems trimmed with a knife to a length no longer than the cap diameter
* cap diameters between 1.25 and 3 inches
* free of insects
* no torn, deformed, or insect-damaged caps
* no wet mushrooms
* harvested less than 3 days before delivery

Initially, grading was to consist only of culling occasional low quality mushrooms. A magnifier light was used to examine any mushrooms of questionable quality. Mushrooms were to be manually sorted by the graders into separate containers for the rough size categories of "small," "medium," and "large" (to make filling the plastic containers faster and easier). The initial plan specified two workers to weigh, grade, and sort incoming mushrooms.
However, many of the standards were violated, and mushroom quality was lower than expected. Quality problems necessitated changes in the grading procedure and packing line. Three grades were established:

Grade 1: mushrooms good enough for packing.
Grade 2: mushrooms good enough for use in taste tests, but with enough minor defects to prevent their sale.
Culls: low quality mushrooms that were not suitable for taste tests; these mushrooms were discarded.

Quality was low partly because spring weather reduced mushroom yields, and growers stretched the standards in an attempt to fulfill their production quotas. The following quality problems were encountered: mushrooms that were too big or too small, were slightly damaged, or had untrimmed stems (Grade 2); and mushrooms that were old, wet, or badly damaged, had diseased stems, or were contaminated with animal hair, metal flakes, or live insects (culls). Over the course of the Marketing Study, mushrooms were graded:

Grade 1: 62.2% average, with a range of 14.3 to 91.6% for individual growers;  
Grade 2: 17.8% average, with a range of 3.1 to 57.4%; and  
Culls: 20.0% average, with a range of 0.8 to 82.6%.

Establishment of extra grades required more weighing and record keeping, so one full-time weigher was added to the packing line. Also, the extra grading required one to two more graders than planned. Grading became the slowest part of the packing process, and when especially low-quality mushrooms were encountered, mushroom flow slowed, and the packers, wrapper, and carton filler were not kept busy. If higher quality mushrooms had been available, packing efficiency would have been greater. With good quality mushrooms, wrapping rather than grading would limit packing line speed.

When the growers discovered that live insects would be a problem, they requested development of a method to kill and/or remove insects at the packing facility. This request came late in the planning process when there was little time or money to do research. Some of the insect control methods considered were as follows:

Use of a small pressure/vacuum pump to blow or suck insect debris from individual mushrooms. The procedure worked, but cleaning individual mushrooms was too slow.
Fumigation with insecticides. Fumigation was not done because of concern about possible harmful residues, and because no chemicals are currently registered for use with shiitake mushrooms.

Fumigation with carbon dioxide. Fumigation was not done because the literature indicated it would take several days to kill insects; high carbon dioxide levels have been shown to cause undesirable stem growth in other kinds of mushrooms; cost and availability of carbon dioxide were expected to be a problem; the effect on growth of harmful anaerobic organisms was unknown; and dead insects would still have to be removed from the mushrooms.

Saline rinse. This was tried on a few mushrooms, but was unsatisfactory because mushrooms were saturated before insects died or crawled out of the gills.

Because food sanitation laws forbid any live insects in produce offered for sale and because no satisfactory methods for killing and/or removing insects were available, all mushrooms containing live insects were culled. Culling because of insects is common in the produce industry; sometimes entire shipments are rejected if live insects are found in just one box. It is apparent that research needs to be done to develop mushroom production practices that reduce insect problems, and to develop low-cost ways to remove insects after harvest.

Having the growers sort mushrooms into three relative-size categories speeded packing somewhat, but average mushroom size varied so much from grower to grower that actual size of "smalls" from some growers exceeded "larges" from other growers. After extra graders were added to the packing line, moving containers of sorted mushrooms from the grading area to the packing area became difficult. Size sorting by the graders was eliminated after the first week and, instead, a 64-in. diameter revolving table was installed to move mushrooms from graders to packers. With the mushrooms spread out on a table, packers could easily see the sizes available and did not need to have mushrooms presorted. The packing line used during Week 1 is illustrated in Figure 3, and the one used during Weeks 2 and 3 is illustrated in Figure 4. Figure 5 is a detailed view of the revolving table.
A: 1.4 kg. (3 lb.) bulk boxes
B: mushrooms not acceptable for packaging
C: grade 2 mushrooms put back into bulk boxes and returned to truck
D: graded, sorted mushrooms
E: filled 99 g. (3.5 oz.) containers
F: labeled and wrapped containers
G: perforated containers
H: filled master cartons
WR: worker who weighed and recorded incoming, grade 2, and cull mushrooms
G1-G3: workers who graded and sorted mushrooms; G3 was part-time
M: magnifier light

P1-P3: workers who filled 99 g. containers; P3 was part-time
LW: worker who labeled and wrapped containers
CP: worker who perforated containers with a hot soldering iron
CF: worker who filled shipping cartons
EW: a part-time extra worker who unloaded and loaded the truck

T1, T2: 1.1 m. (44 in.) wide, 2.4 m. (96 in.) long, 1.0 m. (40 in.) high tables
T3: 0.6 m. (24 in.) wide, 0.9 m. (36 in.) long, 0.8 m. (30 in.) high table
T4: 0.6 m. (24 in.) wide, 1.2 m. (48 in.) long, 0.6 m. (24 in.) high table

Figure 3. Shiitake-mushroom packing line used during Week 1.
A: 1.4 kg. (3 lb.) bulk boxes
B: mushrooms not acceptable for packaging
C: grade 2 mushrooms put back into bulk boxes and returned to truck
D: graded, sorted mushrooms
E: filled 99 g. (3.5 oz.) containers
F: labeled and wrapped containers
G: perforated containers
H: filled master cartons
WR: worker who unloaded truck and weighed and recorded incoming, grade 2, and cull mushrooms
G1-G3: workers who graded mushrooms; G3 was part-time

P1-P3: workers who filled 99 g. containers; P3 was part-time
Lw: worker who labeled and wrapped containers
CP: worker who perforated containers with a hot soldering iron
CF: worker who filled shipping cartons and took them to the truck
T1,T2: 1.1 m. (44 in.) wide, 2.4 m. (96 in.) long, 1.0 m (40 in.) high tables
T3: 0.6 m. (24 in.) wide, 0.9 m. (36 in.) long, 0.8 m. (30 in.) high table
T4: 0.6 m. (24 in.) wide, 1.2 m. (48 in.) long, 0.6 m. (24 in.) high table
M: magnifier light

Figure 4. Shiitake-mushroom packing line used during Weeks 2 and 3.
Figure 5. Revolving packing table.
2. Filling the plastic containers

Equipment is available to fill containers automatically for a wide variety of food products, but it was assumed that it would be many years before Coop members produced enough mushrooms to justify the cost of such equipment. Two to three workers manually filled containers. The procedure was to set an empty container on a balance, tare it, and then select and pack the mushroom sizes needed to obtain an acceptable weight. Mushrooms were placed gill-side down, and positioned so that stems from upper mushrooms did minimum damage to caps of lower ones.

Although the mushroom packs were labeled in ounces, it was more convenient to weigh the mushrooms in grams. One ounce equals 28.35 grams, and 3.5 oz equals 99.23 g. Tare weight for the clear plastic containers was 7 to 12 g and containers had to be overfilled to allow for mushroom moisture loss, so balances (one per packer) with at least 150-g capacity and 1% (1.5 g) precision were needed. The balances actually used were an Ohaus Port-O-Gram with 150-g capacity and 0.05-g precision, AC or battery power, and a computer interface, that cost about $300; an Ohaus Port-O-Gram with 500-g capacity and 0.1-g precision, AC or battery power, and a computer interface, that cost about $350; and an Ohaus Lume-O-Gram with 1000-g capacity and 2-g precision, and battery power (an optional AC adapter is available), that cost about $85. The Port-O-Grams were borrowed from the Agricultural Engineering Department and the Lume-O-Gram was purchased with funds provided for the Marketing Study. The Lume-O-Gram was used when three packers were needed, but it was not very satisfactory. It seems to be necessary to spend $300 to $500 per balance to weigh mushrooms with sufficient accuracy and precision.

To estimate the number of mushrooms required to fill each 3.5-oz container, two packs of Campbell shiitake mushrooms were purchased from a Blacksburg grocery store, and several pounds of bulk mushrooms were purchased from a Blacksburg grower. Both Campbell packs contained 9 mushrooms. Average mushroom weight for one pack was 10.5 g, with individual weights ranging from 1.6 to 23.8 g. For the other pack, average weight was 10.3 g with a range of 5.5 to 16.2 g. Mushrooms from the Blacksburg grower had an average weight of 12.0 g and ranged from 3.5 to 28.1 g. During the Marketing Study, size and density of mushrooms varied greatly from one grower to the next. Weights of individual mushrooms ranged from about 1 g (small diameter, old, and dry) to over 40 g (very large cap and somewhat damp), and number of mushrooms per pack ranged from about 4 to 22. Availability of mushrooms with more uniform
size, age, and moisture content would have reduced variation in quantity and quality of filled containers and speeded packing.

The original plan was to buy the plastic containers used by Campbell Soup Co. for their 3.5-oz packs of shiitake mushrooms. The team members who ordered the containers were unable to obtain the Campbell containers and instead purchased ones with a 35% smaller volume (32.3 cubic inches vs. or 49.7 cubic inches). The smaller containers slowed packing because packers had to spend extra time trying to fit the necessary net weight into them. All of the packs had a surcharge (were filled above level-full), and when mushrooms with especially low density were packed, it was difficult to get enough weight in without mushrooms falling off the top. Although some members of the planning team believed the bulging packs obtained with the small containers would be more appealing to consumers, larger-volume containers would have reduced labor costs.

It was difficult to obtain reliable data on labor requirements for filling the plastic containers because delays in grading interrupted flow of mushrooms to packers, different containers (flat, square polystyrene trays) had to be used the first week because the planned containers were not available, and the grading and sorting procedure was changed after the first week. Nonetheless, for Week 1 (mushrooms sorted by size, packed on square polystyrene trays) three packers averaged 41.98 seconds per container, with individual averages ranging from 31.95 to 49.44 s. During Week 2 (no sorting, mushrooms picked from revolving table, packed into clear plastic containers) one packer averaged 17.56 s per container and another 29.37 s, for an overall average of 23.47 s per container. It is difficult to say which factors contributed most to the reduction in packing time (better mushrooms, faster graders, more experienced packers, different containers, or revolving table), but it is believed that eliminating size-sorting and using the revolving table had the greatest positive effect. It is expected that with larger-volume containers, packing time could be cut to 20 s per container for each packer.

3. Enclosing the plastic containers

Mushrooms and the organisms on them continue to respire after they are packed, using oxygen and producing heat, water, and carbon dioxide in the process. Covering mushrooms with a material that prevents gas and moisture exchange would create a very humid, low oxygen, high carbon dioxide environment inside the container. Such an environment would cause rapid deterioration of the mushrooms and could allow growth
of organisms that cause botulism. Studies have shown that with at least two 0.125-in. diameter holes in the plastic wrap over Agaricus mushrooms, no botulism occurs (Flegg et al., 1985). Campbell mushroom packs typically have 0 to 4 holes, about 0.25-in. diameter, in the plastic overwrap.

It was decided to buy perforated plastic wrap to enclose the mushroom containers, but a supplier could not be located. Instead, nonperforated "produce wrap" was purchased (about $60 per 5000-ft roll) and containers were perforated with a hot soldering iron after they were wrapped. One 0.125-in. diameter hole was made in each lateral side of the containers. The packing line had one worker whose only job was perforating packages, but neither this worker nor the one filling the shipping cartons was kept busy all the time. Both tasks could easily be performed by one person.

To speed wrapping, a Heat Sealing Equipment Co. heat sealer was used (about $200). It had spindles for mounting rolls of produce wrap, a hot bar to cut the wrap, and a Teflon-covered hot plate to seal the bottom of containers. The sealer worked very well; average time to label and wrap a container was 14.2 s. Since average packing time was almost 42 s during Week 1, the wrapper usually kept up with the packers. During Week 2, when packing time dropped to about 23.5 s, the wrapper would not have been able to keep up with the packers if grading had not slowed mushroom flow. Wrapping needs to occur at packing time per container divided by the number of full-time equivalent packers, so a line with two or more packers would probably need another heat sealer and part-time wrapper.

The original plan was to stick gummed labels to the top of filled, wrapped containers. Labeling after wrapping was not satisfactory, however, because the bulging, filled containers did not provide a flat surface to apply labels and because it was difficult and took a lot of time to remove the label backing.

Instead, labels were simply placed on top of the mushrooms (without removal of backing) and were covered by the produce wrap. Having the wrapper position labels added slightly to wrapping time, but having another worker position them in advance did not help because drafts in the packing facility usually blew them out of position.

4. Weight loss from packed mushrooms

Tests on bulk mushrooms purchased from the Blacksburg area grower indicated an initial moisture content of about 85% (wet basis). It
was expected that a product at this high moisture would lose significant weight between time of packing and final sale when held in a perforated container. An estimate of expected weight loss was needed to determine how much to overfill packs so they still contained at least 3.5 oz mushrooms when consumers purchased them. Also, because shiitake mushrooms have a high monetary value, it was undesirable to pack more weight than absolutely necessary.

To estimate weight loss, 10 containers of mushrooms were packed following a procedure similar to the one that would be used during the Marketing Study (clear plastic containers, plastic overwrap, four 0.125-in. diameter holes—but in container tops instead of sides), placed in a single layer in a home-type refrigerator, and weighed every few days for about two weeks. Average weight loss was essentially constant at 0.85\% of initial net weight per day for the entire two-week period. Actual weight loss during the Marketing Study was expected to be slightly less than 0.85\% per day because relative humidity is normally higher in grocery store produce coolers than in a home-type refrigerator and because water loss is restricted somewhat when multiple layers of containers are packed into shipping cartons.

The Marketing Study plan specified a maximum of eight days between packing (Wednesday of one week) and removal of unsold mushrooms from grocery stores (Thursday of the following week). Thus, containers had to be overfilled to allow for eight-days water loss.

\[
\text{Fill weight} = \{1 + [(0.0085) \times (8)]\} \times \text{Desired sale weight} \\
= 1.068 \times \text{Desired sale weight} \\
= 1.068 \times 3.5 \text{ oz} = 3.7 \text{ oz}, \text{ or} \\
= 1.068 \times 99.23 \text{ g} = 106 \text{ g}
\]

Because of variations in mushroom size, it was seldom possible to fill a container to exactly 106 g. Actual fill weights varied from 106 to about 115 g, with a probable average of about 109 g (weights were not recorded). The weight of 48 containers filled during Week 1 (polystyrene trays) averaged 104.6 g ten days after packing. If it is assumed that average initial weight was 109 g, average weight loss was 0.4\% per day. Weight of 23 containers filled during Week 2 averaged 103.0 g after ten days, giving an estimated weight loss of 0.5\% per day.

Mushrooms packaged for the Marketing Study lost less weight than originally estimated, but it was observed that the bottom half of containers retrieved from stores contained visible condensate. Not only does free water provide a good environment for decay organisms, but it also
combines with mushroom spores to form an unsightly white paste on the bottom of containers. In the future, it might be necessary to make more holes or larger holes in the containers, or at least put some holes in the top and some in the bottom to allow more moisture to escape. Changing openings should improve product safety and appearance, but will probably increase weight loss to more than 0.5% per day.

5. Packing shipping cartons

To save money, the decision was made to use the vented, waxed cardboard boxes available from the USDA as shipping cartons. Preliminary measurements of the USDA boxes and clear plastic containers indicated the boxes could hold 24 containers (4 layers, 6 containers per layer). Enough cardboard interlocking dividers and flat shelves were ordered from Corrugated Container Corp. in Roanoke, Va., to prepare about 1000 shipping cartons (total cost $388).

Filled shipping cartons were sealed with polyethylene packing tape instead of staples to reduce the chance of human injury from the sharp staples and the chance of puncturing the top mushroom packs. After cartons were sealed, they were labeled with a colored sticker to indicate which week they were packed (a different color was used each week). Color coding was done to avoid confusion at the grocery store when fresh mushrooms were delivered and old ones retrieved. During Weeks 2 and 3, one worker was used to fill, seal, and label cartons, and move them to the refrigerated truck. The cartons were shipped flat and had to be assembled before use. To save time, cartons were assembled before the packing line was started; assembly required about 5 s per carton. With a wrapping time of 14.2 s per container, it took 5.7 minutes (24 x 14.2 s / 60 s/min) to accumulate enough containers to fill a carton. One worker had plenty of time to fill cartons, assemble cartons, and perforate containers.

The shipping cartons were satisfactory for this project, but there was not quite enough clearance between layers for containers with a large surcharge of mushrooms. No packs were punctured and no mushrooms were damaged, but use of containers with a larger internal volume (to reduce surcharge), or use of taller dividers and just three layers in the shipping cartons would be more satisfactory.

Some mushroom suppliers use smaller, labeled, single-layer shipping cartons that hold only 12 containers. Because some stores sell only a few containers of mushrooms per week, delivering mushrooms more frequently, in smaller quantities, would provide for a fresher, more
attractive product on store shelves. Also, delivering mushrooms in labeled cartons would improve name recognition for the Coop. If the Coop continues retail mushroom sales, it should consider purchasing smaller, labeled shipping cartons designed for use with its plastic mushroom containers.

6. Packing line

The packing line used during Week 1 is illustrated in Figure 3. Two wood tables 44 in. wide, 96 in. long, and 40 in. high were set end to end. A smaller table was set at the end of the line to provide a work area for the container perforator, and a low table was set beside it for the carton filler. All workers stood while working. An extra worker was used part time to get bulk boxes from the truck and to move containers used for sorted mushrooms between grading and packing. For Week 1, about 9 full-time equivalent workers packed 240 lb (960 containers) in about 8 hours (30 lb/hr, 3.3 lb/worker-hr).

Moving containers of sorted mushrooms from grading to packing and returning empty containers back to grading created a materials-handling bottleneck. Also, it seemed that packers did not really need to have mushrooms sorted by size; they just needed to see the range of sizes available to them. So for Week 2 packing, the line was modified as shown in Figure 2. A 64-in. diameter revolving table was installed between the two large tables to move mushrooms from grading to packing. The revolving table eliminated the container-movement bottleneck experienced in Week 1 and provided the packers with a better view of the mushrooms, allowing them to pack slightly faster. Construction details for the revolving table are shown in Figure 5.

Other changes for Week 2 included having the weigher get bulk boxes of mushrooms from the truck, providing stools for workers who wanted them, and adding a small table for the third packer. Week 2, 7.5 full-time equivalent workers packed about 150 lb (600 containers) in 4 hours (37.5 lb/hr, 5.0 lb/worker-hr). Week 3, with the same packing line configuration, 7.5 full-time equivalent workers packed 72 lb (288 containers) in 3 hours (24 lb/hr, 3.2 lb/worker-hr). Productivity was lower Week 3 because mushroom quality was lower and extra grading time was required.

A suggested future mushroom packing line is shown in Figure 6. If grading slowdowns could be eliminated by enforcing quality standards for delivered mushrooms and packing speed improved by using larger volume
A: 1.4 kg. (3 lb.) bulk boxes
B: mushrooms not acceptable for packaging
D: graded, sorted mushrooms
E: filled 99 g. (3.5 oz.) containers
F: labeled and wrapped containers
G: perforated containers
H: filled master cartons
WR: worker who unloads truck and weighs incoming mushrooms and culls
G1, G2: workers who grade mushrooms; no grade 2 mushrooms, just grade 1 or cull
P1: worker who fills 99 g. containers at the rate of 20 s per container
LW1: worker who labels and wraps containers at the rate of 14 s per container
P2, LW2: worker who packs or wraps containers as needed; should spend 70% of time packing and 30% wrapping
CPCF: worker who perforates containers with hot soldering iron, fills shipping cartons, and loads the truck
T1, T2: 1.2 m. (48 in.) wide, 2.4 m. (96 in.) long, 1.0 m. (40 in.) high tables
T3: 0.9 m. (36 in.) wide, 1.2 m. (48 in.) long, 0.8 m. (30 in.) high table
M: suspended magnifier light
SI: soldering iron

Figure 6. Suggested 34 kg/h (75 lb./h) shiitake-mushroom packing line.
containers, another heat sealer and part-time wrapper would be needed. Assuming 20 s/container per packer and 15 s/container per wrapper, a worker would need to spend 70% of the time packing and 30% of the time wrapping to maintain continuous mushroom flow. The suggested line should be able to pack 75 lb (300 containers) per hour (10.7 lb/worker-hr). Workers should be provided with stools to sit on or thick padding to stand on to reduce back and leg fatigue during packing. Also, connecting the balance for weighing incoming mushrooms to a computer would improve speed and accuracy of record keeping and payments to growers.
MICROBIAL ANALYSIS AND RECOMMENDATIONS

Orson K. Miller, Jr. and Moss Baldwin*

Introduction

Our microbiological objectives were to assess initial quality of the mushrooms and to identify existing and potential problems, both biotic and abiotic, that would decrease mushroom quality in the context of the test market. Previous studies of the commercial mushroom *Agaricus bisporus* (Doores et al., 1986), correlating mushroom deterioration with bacterial growth, provided a format for testing microbial numbers throughout the test study. Samples were tested for bacterial load and for the presence of other fungi (molds).

Direct Observations During Grading and Packing

There were two main causes of quality loss of the test market Shiitake. The most widespread was the infestation of the mushrooms by rove beetles (called thrips in the weight and grade tables), which resulted in entire 3-lb boxes being culled in many cases. The beetles are usually found between the lamellae of the mushroom and are so difficult to eliminate that it is not cost effective to do so.

The second cause was visible contamination by bacteria and fungi (usually molds). This contamination affected only a small number of mushrooms, and it was easily detected in the grading process. In one instance during the first week, the cut surfaces of many of the mushrooms from one grower were colonized by bacteria which created a slimy wet patch surrounded by a dark ring. We reasoned that the knife used to harvest the mushrooms from the logs had become contaminated and spread the bacterial rot from one mushroom to another. Petri plate isolation from

*Professor, Graduate Student, Biology Department, Virginia Polytechnic Institute & State University.
these mushrooms yielded bacteria colonies but in no greater numbers than were found in random samples of all mushrooms. Refrigerated storage of these contaminated mushrooms for ten days did not show any evidence of the bacteria's spreading from the original infection point. There were no similarly contaminated mushrooms from that grower during the next two weeks of the test market.

Contamination by molds was limited. The only outwardly visible case was a *Penicillium* found growing on the pileus of one mushroom. Other fungi isolated from macerated tissue samples were primarily *Trichoderma* and several other molds (Table 7). Also, a few yeasts were obtained from macerated tissues. A total of 17.9% culls were tallied; at least some of the poor quality resulted from splitting and drying of the caps, adulteration by metal filings, animal hair and bark debris, and frayed stems from using a dull knife to harvest mushrooms. The total culls caused by biological factors (insects, bacteria and fungi) were estimated not to exceed 12%.

Table 7. Fungi Found on Shiitake Mushrooms

<table>
<thead>
<tr>
<th>Fungi</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Trichoderma</em> sp.</td>
<td>8</td>
</tr>
<tr>
<td><em>Mycelia sterilia</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Botrytis</em> sp.</td>
<td>1</td>
</tr>
<tr>
<td><em>Mucor</em> sp.</td>
<td>1</td>
</tr>
<tr>
<td><em>Chrysosporium</em></td>
<td>1</td>
</tr>
</tbody>
</table>

Methods

Samples were taken at the collection points by aseptically transferring four to five mushrooms from the 3-lb boxes of each grower into sterile Whirl-pak bags which were then refrigerated until they were processed that evening. The maximum time between sampling and processing was 12 hours. Samples from the packing plant and the stores were processed directly from refrigerated 3.5 oz. plastic packages. Samples were processed by weighing a subsample of 25g. directly into a sterile blender cup containing 250 ml. of Bacto Neutralizing Buffer (BNB) (Difco, 1984). The samples were blended for 1 minute at high speed until a homogenous slurry was formed. The homogenate was serially diluted using 1 ml transfers in 9 ml of BNB. Three dilutions for each sample were spread-plated in duplicate using 0.1 ml aliquots on prepoured Plate Count
Agar. Dilutions of 10-4 were plated on two plates each of potato dextrose agar and malt agar to test for fungal contamination. The plates were incubated for 85 hours at 200°C before counting. Plates were considered countable if they had between 30 and 300 colonies.

Results

The bacterial loads on mushrooms sampled at the collection points ranged from $4.9 \times 10^5$ colony-forming units (CFU) per gram to $1.2 \times 10^9$ CFU/g. and averaged $1.4 \times 10^8$ CFU/g. The average counts after packing rose to $6.9 \times 10^8$ CFU/g. and then dropped to $4.1 \times 10^8$ after 5 days of refrigerated storage (see table 1). The fungal plates revealed low numbers of contaminating fungi. Of 84 samples taken, only 13 showed fungal contamination within one week of sampling. _Trichoderma_ sp. was the only fungal contaminant that appeared with any consistency (Table 7).

Discussion

The handling procedures described in the introduction were found to be generally adequate during the warm, but not hot, climatic conditions encountered during the test market. Under Virginia conditions Shiitake mushrooms can be marketed quite safely within the one-week time frame from harvest to retail store, although adequate provisions for constant refrigeration should be made. The quality remains high, and careful grading will eliminate beetle problems at the point of purchase.

Increases in bacterial numbers were observed during grading and packing, during which time each mushroom was handled at least twice, once by the grader and then by the packer. The bacteria involved were either not able to exploit the Shiitake substrate or were killed by the refrigerated temperatures. Subsequent counts after four days of refrigerated storage returned to background levels. Visually, no mushrooms were found to have bacterial soft rots after ten days of storage. Strict handling procedures using disposable gloves would most likely eliminate or reduce the increased bacterial loads encountered during grading and packing.

Ideally, beetle infestation should be controlled and eliminated at the grower level, but careful inspection will be required in grading mushrooms for the retail market to prevent beetles from reaching the consumer. Growers should be expected to inspect more closely during harvest and shipping to eliminate bark debris and other foreign objects.
from the mushrooms. Animals such as cats and dogs should be kept away from the raising yards and storage areas of harvested mushrooms. The only consistent fungal contaminate in the Petri plate studies was *Trichoderma*. Although only spores were detected during the test market, *Trichoderma* could potentially grow on the mushrooms themselves. The characteristic green colonies on the ends or sides of logs should be treated or removed to keep the spore inoculum of this fungus at a minimum. *Trichoderma* could become a serious problem during peak periods of high heat and humidity.

In general, fresh shiitake is quite resistant to microbial colonization, particularly under the conditions encountered during the test market. The adoption by growers and packers of the several steps mentioned above should greatly reduce the small problems encountered during the test market. We recommend that the entire Ad Hoc Committee develop a set of guidelines for market procedures to maintain the high quality of the Shiitake mushrooms that were seen during the market research period and that these guidelines be distributed to all participants involved in the growing, harvest, transportation, and marketing of Shiitake mushrooms. We further recommend that research and development studies be initiated to identify bacteria and fungi naturally associated with *Lentinus edodes*. It is essential to identify those microorganisms that are introduced from contaminants on logs as well as those that may be present in log yards or in buildings used by growers, all of which could ultimately affect the production and quality of the mushrooms. Finally, methods for the control of insects, bacteria, and fungi must be established and tested under typical climatic conditions encountered by Virginia growers.
CONSUMER ATTITUDES ABOUT SHIITAKE MUSHROOMS

Andrew G. Hankins*

The customer information for a complete assessment of the retail marketing remains to be analyzed; however, several conclusions may be drawn concerning the product movement in the four Farm Fresh test market stores. All Farm Fresh produce managers seemed pleased to participate in the study and supported the merchandising efforts with vigor. Some stores did better with the shiitake mushroom sales than others. This result may be attributed to the income level of customers in certain stores and other demand factors of the customers in the market area. More details should be revealed from a retail store analysis.

During the three-week market study, seventy-seven master cartons (1,848 3.5-ounce tray packs) were delivered to the four stores (Table 8). The Farm Fresh Great Neck Road store had the best product movement. In total the study team delivered shiitake mushrooms valued at $3,030.72 and, of that, the stores sold mushrooms amounting to $1,056.16; that is, only about 35 percent of the mushrooms were sold.

If this economic activity had been a commercial venture and not a test market, the VSMMC would not have covered its marketing costs during the period. However, even if all of the shiitake mushrooms that were delivered had been sold, the marketing costs might have been covered, but no profit would have been left for the grower.

The profitable use of the retail marketing channel for Virginia shiitake mushrooms depends on the opportunities to increase product volume. A refrigerated truck used in the study had additional capacity for assembling and distribution; therefore, costs could have been reduced if larger volumes had been handled. Distribution costs could be lowered by

*Associate Professor and Extension Specialist, Alternative Agriculture, Virginia State University, Petersburg, Virginia.
delivering directly to the wholesaler and eliminating the retail store delivery costs. The packing line must be more efficient. Greater attention to product quality needs to be effected at the grower level. The inspection process at SVPC slowed the entire production process.

**Table 8. Shiitake Mushroom Deliveries and Returns at Four Farm Fresh supermarkets, 1988**

<table>
<thead>
<tr>
<th>Store</th>
<th>Date Delivery</th>
<th>Date Returns</th>
<th>Containers</th>
<th>Value (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#193</td>
<td>5/19</td>
<td>5/26</td>
<td>77</td>
<td>3,030.72</td>
</tr>
<tr>
<td>GN</td>
<td>5/26</td>
<td>6/9</td>
<td>47</td>
<td>1,849.92</td>
</tr>
<tr>
<td></td>
<td>6/02</td>
<td>6/9</td>
<td>78</td>
<td>124.64</td>
</tr>
<tr>
<td>#187</td>
<td>5/19</td>
<td>5/26</td>
<td>77</td>
<td>3,030.72</td>
</tr>
<tr>
<td>KV</td>
<td>5/27</td>
<td>6/9</td>
<td>47</td>
<td>1,849.92</td>
</tr>
<tr>
<td></td>
<td>6/2</td>
<td>6/9</td>
<td>78</td>
<td>124.64</td>
</tr>
<tr>
<td>#269</td>
<td>5/19</td>
<td>5/26</td>
<td>77</td>
<td>3,030.72</td>
</tr>
<tr>
<td>HPTM</td>
<td>5/26</td>
<td>6/9</td>
<td>47</td>
<td>1,849.92</td>
</tr>
<tr>
<td></td>
<td>6/02</td>
<td>6/9</td>
<td>78</td>
<td>124.64</td>
</tr>
<tr>
<td>#321</td>
<td>5/19</td>
<td>5/27</td>
<td>77</td>
<td>3,030.72</td>
</tr>
<tr>
<td>WMBG</td>
<td>5/27</td>
<td>6/9</td>
<td>47</td>
<td>1,849.92</td>
</tr>
<tr>
<td></td>
<td>6/2</td>
<td>6/9</td>
<td>78</td>
<td>124.64</td>
</tr>
</tbody>
</table>

(*) one box equals twenty four trays; each tray is priced at $1.64 or $39.36 per box of 24.

**In-store Shiitake Mushroom Display and Demonstrations**

Virginia shiitake mushrooms were displayed for demonstration purposes and for sale from May 20 - June 8, 1988, at four Farm Fresh, Inc. store locations in Tidewater Virginia. On Friday and Saturday of each week in-store mushroom demonstration programs were conducted to educate consumers about shiitake mushrooms. These programs were held on May 20th and 21st, May 27th and 28th, and June 3rd and 4th.

Three of the stores selected for the shiitake mushroom market research study were located in relatively high income neighborhoods, and one store was not. Trained in-store demonstrators served taste samples, asked questions about customer reaction to the mushrooms, and answered questions about using the mushrooms. Mushroom recipes were distributed at the retail sale site. The customers were served soup and a shiitake mushroom dip on crackers.
The in-store product demonstrators recorded customer reaction to the mushrooms on forms provided to them. Seven questions were asked of each customer willing to answer. The responses of the shoppers showed that only about one-third of those surveyed had ever tasted shiitake mushrooms and even fewer had ever used them. About 81 percent of those persons surveyed said the taste of the mushroom appealed to them. However, only about 68 percent said they would purchase Virginia shiitake mushrooms, and only about 39 percent felt the price was fair. About 83 percent felt the packaging of the mushrooms was attractive. The following is a summary of the responses:

1. Have you ever tasted shiitake mushrooms?
   - YES 98, 32%
   - NO 208, 68%

2. Have you ever used shiitake mushrooms?
   - YES 78, 26%
   - NO 228, 74%

3. Does the taste appeal to you?
   - YES 245, 81%
   - NO 61, 19%

4. Would you purchase Virginia grown-shiitake mushrooms?
   - YES 209, 68%
   - NO 97, 32%

5. Do you feel the price is fair?
   - ($2.59 for a 3 1/2 ounce container)
   - YES 118, 39%
   - NO 188, 61%

6. Is the packaging attractive?
   - YES 228, 83%
   - NO 52, 17%
The following comments made by customers, the demonstrators, and the produce managers during the market research program illustrate their specific feelings toward the mushroom products served in the stores:

In-store demonstrator one at Virginia Beach:

"After three weekends of selling and representing Virginia shiitake mushrooms, examples of my feedback from customers contacted is: 'They are delicious, cooked anyway!' People were very impressed. Very few had negative comments pertaining to the taste. Most customers felt the price was definitely too high, but will continue to buy. I enjoyed working with the program. It made a believer out of me."

Other Farm Fresh customers said:

"Price only limitation"
"Used them in a stir-fry, they are delicious."
"Poster is wonderful."
"Too expensive"
"Recipe masks flavors. What does the mushroom actually taste like?"
"No good raw"
"Good flavor but too expensive"
"Great flavor"
"Everyone is talking about it - delicious."
"Tried dip and soup and will definitely buy again, a little expensive though."
"Delicious! Would buy frequently"
"Too expensive"
"Very good; however, they are too expensive."
"Last week we tried making the dip at home. It was great. Easy to make and wonderful to eat. I will buy more!"
"Must buy often, but really too expensive"
"The dip is very good. Looking forward to using them"
"Super Delicious!"
"I'll make the dip today"
"Excellent dip"
"Great sales lady sold me on them"
"Will buy at a later date, too high"
"Excellent, like to see date on package"
"Very satisfied; purchased some last week"
In-store demonstrator two, Virginia Beach:

"[The mushrooms were] firm, round and fully packed. Actually many came in the store just to taste our mushrooms. Many are still reluctant to buy due to price, and many would buy after sampling."

Manager, Hampton Store:

"The produce manager said he knew they wouldn't sell at that price."

Manager, Virginia Beach:

"Many said they would rather have quality instead of quantity. Actually had customers return to buy more. The test is in the taste! All enjoy the unique taste. The coverage in the paper brings many over to sample. More acceptance this week though many are still skeptical due to price."

In-store demonstrator, Hampton:

"The mushrooms will run around $12.00 a pound so the people are complaining at how high they are. For the recipes it would cost a small fortune."

In-store demonstrator, three, Virginia Beach:

"Everyone liked the flavor. Cost was only a small percentage for not buying. Color and shape was not a factor - just the good flavor. This was the most interesting product I've sold. All were delighted with the taste and texture. It's an excellent seller. They loved the dip and soup."

Some customer comments were:

"Would like to see the price drop a little"
"Will continue to buy"
"The poster is great."
COST OF MARKETING
VIRGINIA SHIITAKE MUSHROOMS

Charles W. Coale, Jr., and C. Gene Haugh*

Observed Packing Costs for Marketing Research Mushrooms

The packing costs for mushrooms during the market research period may not represent accurately a commercial operation, because of the low volume of output. However, the cost analysis does show the critical volumes needed to have a feasible economic operation and the possible limiting points in the process. Given the packing labor and packaging inputs, the analysis shows that it cost $2.55 to pack a pound of mushrooms during the period (Table 9). To control the cost of packing, a greater degree of mechanization is needed than the research work station provided. Many suggestions were made for improving the packing work station layout.

Table 9. Shiitake Mushroom Packing Cost for a Three-Week Marketing Research Period, 1988

<table>
<thead>
<tr>
<th>Mushroom Packing Functions</th>
<th>Cost/Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Tasks(*)</td>
<td></td>
</tr>
<tr>
<td>Weighing mushrooms (1 worker), Grading mushrooms (2 workers), Packing mushrooms (2 workers), Overwrap mushrooms (1 worker), Packing master container and supplying weighing station (1 worker)</td>
<td>$ 595.20</td>
</tr>
<tr>
<td>Total packing labor</td>
<td>$ 595.20</td>
</tr>
<tr>
<td>Master carton (USDA Experimental)</td>
<td>-nc-</td>
</tr>
<tr>
<td>Tray pack (hamburger tray) -- 960 x $.045</td>
<td>43.20</td>
</tr>
<tr>
<td>(plastic tray) -- 888 x $.085</td>
<td>75.48</td>
</tr>
<tr>
<td>Plastic overwrap -- 1848 x 1.2' x $.021</td>
<td>46.57</td>
</tr>
<tr>
<td>Cardboard spacers</td>
<td>110.00</td>
</tr>
<tr>
<td>Labels 1848 x $.0316</td>
<td>58.40</td>
</tr>
<tr>
<td>Scale Rental</td>
<td>100.00</td>
</tr>
<tr>
<td>Total Packing costs</td>
<td>$1,028.85</td>
</tr>
<tr>
<td>Mushrooms packed (pounds)</td>
<td>404.25</td>
</tr>
<tr>
<td>Cost per Pound</td>
<td>$2.55</td>
</tr>
</tbody>
</table>

(*) Estimated by time study.

*Professor, Agricultural Economics Department; Professor, Agricultural Engineering Department, Virginia Polytechnic Institute & State University.
Observed Packing Costs for Commercial Mushrooms

During 1989, members of the VSMMC packed mushrooms for commercial distribution. The mushroom packing operation involved packing in a three-pound box instead of a 3.5 ounce container. The labor costs estimated for the bulk pack amounted to about 18.5 cents per pound compared to an estimated value of $1.17 for a 3.5 ounce consumer pack. The additional labor costs for the consumer pack represents value-added to the commodity. If the local grower packs or participates in the packing process, he captures the additional value from the marketing cost. During June, total costs incurred by VSMMC for packing mushrooms in bulk amounted to about 55 cents per pound compared to about $2.36 for packing in 3.5 ounce container.

Estimated Packing Costs for Commercial Mushrooms

The estimated costs for a commercial mushroom packing line were calculated based on economic-engineering data collected during the mushroom research study (Table 10). Mushroom packing output is limited

<table>
<thead>
<tr>
<th>Mushroom Packing Functions</th>
<th>Cost/Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Tasks (*)</td>
<td></td>
</tr>
<tr>
<td>Weighing mushrooms (1 worker), Grading mushrooms (2 worker), Packing mushrooms (2 worker), Overwrap mushrooms (1 worker), Packing master container and supplying weighing station (1 worker)</td>
<td></td>
</tr>
<tr>
<td>Total packing labor cost</td>
<td>$ 448.00</td>
</tr>
<tr>
<td>Master carton (73 cartons)</td>
<td>73.00</td>
</tr>
<tr>
<td>Tray pack (plastic tray) -- 1898 x $.085</td>
<td>161.33</td>
</tr>
<tr>
<td>Plastic overwrap -- 1898 x 1.2' x $.021</td>
<td>47.82</td>
</tr>
<tr>
<td>Cardboard spacers</td>
<td>110.00</td>
</tr>
<tr>
<td>Labels 1898 x $.0316</td>
<td>59.98</td>
</tr>
<tr>
<td>Scale Rental ($100.00/ 40 days)</td>
<td>2.50</td>
</tr>
<tr>
<td>Total packing costs</td>
<td>$902.63</td>
</tr>
<tr>
<td>Mushrooms packed (pounds)</td>
<td>382 (**)</td>
</tr>
<tr>
<td>Cost per Pound</td>
<td>$2.36</td>
</tr>
</tbody>
</table>

(*) Estimated by time study.
(**) Assuming a packing efficiency of 85% and idled packing rate of 0.25 ounces per second.

by a bottleneck at the overwrapping work station. Observations showed that a 3.5 ounce container took 14 seconds to wrap. At the rate observed, 0.25 ounces of product/second were packed. The estimated input costs amounted to about $902.63 for packing an estimated 382 pounds of mushrooms. Of that figure, about $448.00 consisted of packing labor costs
and $454.63 of packaging material and weighing equipment. The estimated cost per pound for a commercial operation would amount to about $2.36, which includes $1.17 per pound for labor costs.

Research Findings of Physical Mushroom Distribution

The Virginia shiitake mushrooms were distributed to four designated retail stores on each Thursday of the market research period. The refrigerated truck left Halifax for Tidewater Virginia. The distribution routes ranged from 331 to 359 miles, and time of delivery from 10.61 to 12.00 hours (Tables 11, 12, 13). Additional time was needed to complete the route delivery during week 2.

Table 11. Shiitake Mushroom Distribution Routes for Four Farm Fresh Supermarket Locations, WEEK 1, May 19, 1988

<table>
<thead>
<tr>
<th>Distribution Route</th>
<th>Mileage</th>
<th>Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel</td>
<td>Loading</td>
</tr>
<tr>
<td>Halifox to Great Neck</td>
<td>222</td>
<td>294</td>
</tr>
<tr>
<td>Great Neck to Kemp'ille</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>Kemp'ille to Hampton</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>Hampton to Wm'burg</td>
<td>26</td>
<td>46</td>
</tr>
<tr>
<td>Wm'burg to Richmond</td>
<td>55</td>
<td>115</td>
</tr>
</tbody>
</table>

Meal stops
- Breakfast: 54 minutes
- Lunch: 30 minutes

Totals 350 miles, 531 (8.85*), 85 (1.42*), 84 (1.4*)

*Hours

Table 12. Shiitake Mushroom Distribution Routes for Four Farm Fresh Supermarket Locations, WEEK 2, May 26, 1988

<table>
<thead>
<tr>
<th>Distribution Route</th>
<th>Mileage</th>
<th>Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel</td>
<td>Loading</td>
</tr>
<tr>
<td>Halifox to Great Neck</td>
<td>223</td>
<td>275</td>
</tr>
<tr>
<td>Great Neck to Kemp'ille</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td>Kemp'ille to Hampton</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Hampton to Wm'burg</td>
<td>32</td>
<td>70</td>
</tr>
<tr>
<td>Wm'burg to Richmond</td>
<td>58</td>
<td>92</td>
</tr>
</tbody>
</table>

Meal stop
- Lunch: 30 minutes

Totals 359 miles, 495, 195, 30

(*) Ryder truck needed repairs to fuel line, oil line, and transmission.
Table 13. Shiitake Mushroom Distribution Routes for Four Farm Fresh Supermarket Locations, WEEK 3, June 2, 1988

<table>
<thead>
<tr>
<th>Distribution Route</th>
<th>Mileage</th>
<th>Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Travel</td>
</tr>
<tr>
<td>Thursday, June 2, 1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halifax to Kempsville</td>
<td>196</td>
<td>259</td>
</tr>
<tr>
<td>Kemps'lle to Great Neck</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>Great Neck to Hampton</td>
<td>36</td>
<td>51</td>
</tr>
<tr>
<td>Hampton to Wm'burg</td>
<td>26</td>
<td>39</td>
</tr>
<tr>
<td>Wm'burg to Richmond</td>
<td>55</td>
<td>105</td>
</tr>
<tr>
<td>Meal stops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>331</td>
<td>483</td>
</tr>
</tbody>
</table>

Research Costs for Assembly and Distribution of Mushrooms

Although the assembly and the distribution of mushrooms occurred in separate functions, the cost of assembly and distribution is analyzed jointly because both functions resulted from continuous economic activity. A refrigerated truck was rented for a week at a time and used for assembly, for cold storage during packing, and for distribution of product.

An analysis showed that total costs associated with the assembly function—for the assembly of a total of 895 pounds of mushrooms from Virginia growers—amounted to $1,425.17, or about $1.59 per pound, for the marketing research period (Table 14). These cost figures were derived from the travel mileage, time-in-transit, and cost data from the rental agreement with Ryder Company (Tables 4, 5, 6).

The distribution costs for the delivery of packed product to four Farm Fresh retail stores amounted to about $1,332.71, or about $1.81 per delivered pound of shiitake mushrooms (Table 14). These cost figures were derived from the travel mileage, time-in-transit, and cost data from the rental agreement with Ryder Company (Tables 11, 12, 13).

The costs in the assembly and distribution processes include the wage rates for a truck driver. The study team members provided driving service during the market test; however, during a commercial operation a driver would be needed. The assembly costs without a truck driver would
amount to about $1.24 cents per pound. The distribution cost without a truck driver would amount to about $1.45 per pound of delivered mushrooms.

### Table 14. Shiitake Mushroom Assembly and Distribution Costs for a Three-Week Test Marketing Period, 1988

<table>
<thead>
<tr>
<th>Function</th>
<th>Cost in dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Assembly</td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td></td>
</tr>
<tr>
<td>Fixed lease (a 3-week period)</td>
<td>$667.50</td>
</tr>
<tr>
<td>Mileage (1170)</td>
<td>257.40</td>
</tr>
<tr>
<td>Fuel</td>
<td>121.09</td>
</tr>
<tr>
<td>Thermo King (121.5 hours x $.50)</td>
<td>60.00</td>
</tr>
<tr>
<td>Driver</td>
<td></td>
</tr>
<tr>
<td>Wages (40.66 hours x $7.85)</td>
<td>319.18</td>
</tr>
<tr>
<td>Total Assembly Costs</td>
<td>$1,425.17</td>
</tr>
<tr>
<td>Mushrooms (pounds)</td>
<td>895.00</td>
</tr>
<tr>
<td>Cost per Pound for Assembly</td>
<td>$1.59</td>
</tr>
<tr>
<td>2) Distribution</td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td></td>
</tr>
<tr>
<td>Fixed lease (a 3-week period)</td>
<td>$667.50</td>
</tr>
<tr>
<td>Mileage</td>
<td>228.80</td>
</tr>
<tr>
<td>Fuel</td>
<td>107.39</td>
</tr>
<tr>
<td>Thermo King (121.5 hours x $.50)</td>
<td>60.00</td>
</tr>
<tr>
<td>Driver</td>
<td></td>
</tr>
<tr>
<td>Wages (34.27 hours x $7.85)</td>
<td>269.02</td>
</tr>
<tr>
<td>Total Distribution Costs</td>
<td>$1,332.71</td>
</tr>
<tr>
<td>Mushrooms distributed (pounds)</td>
<td>735.48</td>
</tr>
<tr>
<td>Cost per Pound for Distribution</td>
<td>$1.81</td>
</tr>
<tr>
<td>Cost per Pound for Assembly and Distribution</td>
<td>3.40</td>
</tr>
</tbody>
</table>
Estimated Costs for Commercial Assembly and Distribution

If the truck-loading factor (382 pounds per day) represented a daily commercial production situation, the estimated costs would be within the lower expected range of profitability (40-60 percent of wholesale price; Table 15).

Table 15. Estimated Costs for Shiitake Mushroom Assembly and Distribution Costs for a Commercial Operation, 1989

<table>
<thead>
<tr>
<th>Function</th>
<th>Cost in dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1) Assembly</strong></td>
<td></td>
</tr>
<tr>
<td>Truck</td>
<td>$222.50</td>
</tr>
<tr>
<td>Fixed lease (a 1-week period *)</td>
<td>$85.80</td>
</tr>
<tr>
<td>Mileage (390)</td>
<td>40.36</td>
</tr>
<tr>
<td>Fuel</td>
<td>20.25</td>
</tr>
<tr>
<td>Thermo King (40.5 hours x $.50)</td>
<td>106.36</td>
</tr>
<tr>
<td>Driver</td>
<td>475.27</td>
</tr>
<tr>
<td>Wages (13.55 hours x $7.85)</td>
<td>1.02</td>
</tr>
<tr>
<td><strong>Assembly Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Mushrooms assembled, 465 pounds</td>
<td>$1.02</td>
</tr>
</tbody>
</table>

| **2) Distribution** |                     |
| Truck    | $222.50          |
| Fixed lease (a 1-week period) | $76.27 |
| Mileage (347) | 35.79 |
| Fuel | 20.25 |
| Thermo King (40.5 hours x $.50) | 89.87 |
| Driver | 444.68 |
| Wages (11.42 hours x $7.85) | 1.16 |
| **Distribution Costs** | |
| Mushrooms distributed, 382 pounds | $1.16 |

| **Cost per Pound for Assembly and Distribution** | $2.18 |

*Lease costs are divided equally between assembly and distribution. Research showed that 1.2176 pounds of mushrooms were assembled for each pound of mushrooms distributed. The difference was the cull material that could not be marketed.
Summary of Assembly, Packing, and Distribution Costs

The cost of assembly, packing, and distribution of mushrooms under research conditions amounted to about $5.95 per pound (Table 16). The VSMMC received a wholesale price of $7.50 per pound, leaving $1.55 for the grower returns. For this market research, however, an USDA grant covered the assembly, packing, and distribution costs so that the growers were not penalized by losses.

Table 16. Shiitake Mushroom Marketing Cost for a Three-Week Marketing Research Period, 1988

<table>
<thead>
<tr>
<th>Mushroom Marketing Functions</th>
<th>Cost/lb</th>
<th>% of Wholesale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly of Mushrooms</td>
<td>1.59</td>
<td>21.2</td>
</tr>
<tr>
<td>Packing of Mushrooms</td>
<td>2.55</td>
<td>34.0</td>
</tr>
<tr>
<td>Distribution of Mushrooms</td>
<td>1.81</td>
<td>24.1</td>
</tr>
<tr>
<td>Total Cost of Marketing</td>
<td>5.95</td>
<td>79.3</td>
</tr>
</tbody>
</table>

Based on a $7.50 Wholesale Mushroom Price

The components of marketing costs show their relative value to one another (Tables 16). An examination of the market channel costs shows that assembly accounted for 21.2 percent of the costs, packing 34.0 percent, and distribution 24.1 percent. In total, 79.3 percent of the wholesale price was allocated to the marketing of the product. Generally, marketing costs for food products range between 40 and 60 percent of the wholesale price. The cost structure for marketing mushrooms should change as the market volume of mushrooms increases and as packing methods are improved.

Given the estimated commercial-scale operation for the 3.5 ounce mushroom pack, the following price/cost ratio is estimated. The cost estimates for a commercial mushroom pack would fall in the lower range of profitability, or about 60 percent the targeted wholesale price (Table 17). Savings should be sought in all three areas of marketing. However, the highest value cost function and the work area offering the greatest savings potential are mushroom packing. The estimated costs, even on a commercial scale, are still too high, given other relative costs in the marketing channel. The marketing cost (assembly, packing and distribution) figure does not take into account the cost of administration of the mushroom marketing program.
Evaluation of Estimated Costs for Marketing Mushrooms

If the wholesale price were maintained at $7.50 per pound for the 3.5 ounce container, growers would realize about $2.96 per pound for mushrooms packed on a commercial scale (Table 17). Only mushrooms graded #1 were packed in a 3.5 ounce container. The $2.96 dollar-per-pound value for the 3.5 ounce container is compared to the recent commercial bulk pack value at about $3.96 for #1 bulk and $2.74 for #2 bulk, or a weighted average return of $3.46 per pound.

Given the market structure in the bulk wholesale and the tray retail markets, the distribution costs incurred in this research study might be reduced when compared to commercial distribution because the research delivery was made to each store, whereas a commercial distribution network would deliver directly to a warehouse for further distribution to retail units.

The difference in net returns between the 3.5-ounce tray pack and the three-pound bulk pack represents about 51 cents per pound cost saving in favor of the bulk pack. As the market conditions change, the net margins will change and the product will move between marketing channels based on price conditions.

Table 17. Estimated Costs for Shiitake Mushroom Assembly and Distribution Costs for a Commercial Operation, 1989

<table>
<thead>
<tr>
<th>Mushroom Marketing Functions</th>
<th>Cost/lb in $</th>
<th>% of Wholesale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly of Mushrooms</td>
<td>1.02</td>
<td>13.6</td>
</tr>
<tr>
<td>Packing of Mushrooms</td>
<td>2.36</td>
<td>31.5</td>
</tr>
<tr>
<td>Distribution of Mushrooms</td>
<td>1.16</td>
<td>15.5</td>
</tr>
<tr>
<td>Total Cost of Marketing</td>
<td>4.54</td>
<td>60.6</td>
</tr>
</tbody>
</table>

Based on a $7.50 Wholesale Mushroom Price
STRENGTHS OF THE MUSHROOM MARKETING STUDY

Charles. W. Coale, Jr.*

The shiitake mushroom marketing study revealed the following factors that made the market research program successful. Each factor is discussed here for its value in future planning strategies.

A Carefully Planned Marketing Program

Several months were spent in planning, to define the scope of the test market and to muster resources to complete the project. A five-sector marketing channel (production, assembly, packing, distribution, and retailing) was defined, and personnel were assigned to manage each sector.

Production -- VSMMC conducted meetings with grower members to secure their support for supplying mushrooms for the market. Grower instruction was offered concerning cultural practices and market quotas.

Assembly -- VSMMC specified four assembly locations for cooperative members to deliver their mushrooms in three-pound boxes. Each assembly location had cooling room facilities and was open during pick-up periods.

Packing -- The SVPC provided space and personnel services for the mushroom packing process. Engineering layout, equipment design, and packing methods were provided to plan a retail tray-packed mushroom.

Distribution -- Each week of the marketing research, the study team delivered packed mushrooms to the four retail stores.

*Professor and Extension Economist, Agricultural Economics Department, Virginia Polytechnic Institute & State University.
Retailing -- Each retail store in the study conducted an in-store demonstration on each Friday and Saturday of the research period to introduce shiitake mushrooms to its customers.

Committed Virginia Shiitake Mushroom Growers

Production quotas were assigned to each member of the VSMMC, and all members performed to provide the products on a weekly basis.

Committed Public Agency Personnel

The mushroom marketing research program involved the contributions of one federal agency, two state universities, and one state agency. All personnel worked well together to accomplish the program objectives.

Excellent Support From Private Industry Groups

The retail marketing channel for the market research was strengthened by the cooperation given by the Southside Virginia Produce Cooperative board, management, and employees and by the Farm Fresh, Inc. top management, store and produce managers, instore demonstrators, and produce department personnel. This support enabled the VSMMC to have access to the marketing channel for a realistic mushroom marketing program.

Excellent Relations With Retail Customers

The Farm Fresh demonstrators were enthusiastic about the shiitake mushrooms that they were demonstrating, and they developed good relations with the customers. Both the demonstration center and the mushroom products being served were attractive and appealing to customers. The charts featuring cultural practices of the shiitake mushroom, supported with color photographs, created excitement among shoppers viewing the mushrooms. The Friday and Saturday in-store demonstrations created high visibility for the mushrooms in the produce department.
Careful Attention To Detail In The Marketing Process

The personnel working on the mushroom marketing program were very careful about executing their duties to ensure that the marketing functions were carried out according to plan. They even worked on Memorial Day in order to market product on time.
WEAKNESSES OF THE MUSHROOM MARKETING STUDY

Charles W. Coale, Jr.*

This marketing research program was not error free. The major problems cited as weaknesses in this study can be traced to a failure to communicate information that would have improved the marketing program. Several concerns are cited to document the impact on product movement in the retail produce department.

Overall Program

The personnel duty assignments lacked a task-oriented schedule. In spite of the comprehensive planning, some tasks were not completed before or during the marketing research period. This lack of attention to detail kept the research team somewhat off balance because adjustments had to be made during the project. The program would have been executed without any flaws if the problems noted below had not occurred.

Assembly Sector

The failure of the "thermo king" refrigeration unit to operate properly for a short time delayed the arrival of the truck at the packing location for about one and one half hours during the second week. However, product temperatures in the cold storage van did not appear to rise significantly as a result of the cooling unit's not running.

Packing Sector

Plastic Consumer Trays -- One problem experienced at the packing sector was the failure of the tray manufacturer to deliver the plastic trays for packing mushrooms that had been specified by the food retailer

*Professor and Extension Economist, Agricultural Economics Department, Virginia Polytechnic Institute & State University.
for the market research. The manufacturer had promised to deliver one day before the packing date (5/17/88). This problem occurred only during the first week of the market research. The lack of trays caused time to be wasted while personnel searched for an alternative packing material.

**Contingency Plan For Marketing Surplus Shiitake Mushrooms** -- The demand for shiitake mushrooms did not clear the market during week one of the test market. All mushrooms that were assembled and packed were not used in the test market. An attempt was made to market those mushrooms not utilized, but not all surplus shiitake mushrooms were profitably sold.

**Distribution Sector**

During the second week of the research, the rented Ryder truck suffered three mechanical failures, so that the mushrooms couldn't be delivered on schedule. Two deliveries were made Thursday evening and two Friday morning. However, in spite of the truck breakdowns, mushrooms were in the store for demonstration and sale during the research period.

**Retail Store Sector**

Two communications failures at retail probably caused some loss of sales of the mushroom products.

**In-store point of purchase material** -- In-store arrangements were made to demonstrate shiitake mushrooms two days (Friday and Saturday) each week during the research period. However, although the USDA had offered to provide in-store point-of-purchase material for five days each week that the mushrooms would not be demonstrated, only a brochure developed by the Virginia Department of Agriculture and Consumer Services and Farm Fresh was available to customers.
Lack of in-store monitoring. -- Members of the market research team should have monitored the displays more carefully. The word "shiitake" was spelled incorrectly (shitake). After careful investigation, it was found that the shiitake name is spelled incorrectly in the product reference book. The produce department was using what information was available, but the research team could have prevented this problem by visits to the department and by discussions about shiitake mushroom with each of the produce managers.
RECOMMENDATIONS

A Virginia Shiitake Market Research Study

Charles W. Coale, Jr.*

The marketing study team makes several recommendations based on the research findings concerning the feasibility of marketing Virginia-grown mushrooms in a retail marketing channel. Based on the study objectives, marketing shiitake mushrooms in a retail channel is feasible if an efficient channel is properly structured. A feasible marketing channel is based on the following recommendations related to cultural practices and biological control, marketing and distribution efficiency and costs, engineering efficiency and costs, and consumer acceptance based on handling, quality, and price. Costs must be controlled in mushroom growing, assembly, packing, and distribution sectors if a retail marketing channel is to be profitable.

_Culture practices and biological control_

Changes are needed in cultural practices and biological control to improve the market quality of shiitake mushrooms. The first recommendation is to eliminate the rove beetle (thrip) by non-chemical means such as cleaning under-brush from growing areas and eliminating host areas for the rove beetles. Second, eliminate bacteria and fungi (usually moulds) contamination from mushrooms by sterilizing cutting tools, removing bark from mushroom tissue, maintaining clean work stations for packing, refrigerating mushrooms after harvest, and inspecting mushrooms prior to shipping to second handler.

*Professor and Extension Economist, Agricultural Economics Department, Virginia Polytechnic Institute & State University.
Marketing and distribution efficiency and costs

The two important marketing cost functions for mushrooms are assembly and distribution. In the market research program, marketing costs were higher than corresponding commercial industry standards. Recommendations for controlling sector costs include: increasing the vehicle loads in the assembly and distribution process, locating assembly points with refrigeration to maintain consistent product temperatures, scheduling product in-advance at assembly points, and utilizing one driver and one vehicle on a route. In addition, mushroom boxes should have consistent temperature information. During the marketing research, different temperature recommendations were observed on mushroom boxes from different packers.

Engineering efficiency and costs

The third important cost component in mushroom marketing is the packing efficiency. Recommendations for controlling packing costs include: rejecting low quality mushrooms, designing packing workstations for reducing costs, developing work methods to fully utilize workers time, and maintaining adequate levels of input inventories. Refer to engineering section for specific details of the recommendations.

Consumer acceptance based on handling, quality, and price

The shiitake consumers surveyed offered comments that can enhance the prices and revenues for the mushroom market. Less than a third of the consumers responding had ever tasted shiitake mushrooms and about one quarter used them. About sixty one percent believed the mushroom price was too high for the value received.

If shiitake growers expect their mushrooms to generate enough revenues to cover total industry costs, several recommendations should be implemented. The recommendations for improving consumer acceptance should consist of changing the following merchandising practices. Consumers attitudes toward shiitake mushrooms should be changed by offering popular press information, providing recipes and nutritional value about the product, locating the product with other upscale products in produce, and pricing the product on a competitive basis.
Research shows that the quality of shiitake mushrooms deteriorates at ambient temperatures. It is recommended that food retailers merchandise shiitake mushrooms on refrigerated shelf space to maintain quality of the product and reduce potential losses from product deterioration.
REFERENCES


Virginia's Agricultural Experiment Stations

1–Blacksburg
Virginia Tech, Main Station
Dairy, Poultry, Crops, and all other topics

2–Steeles Tavern
Shenandoah Valley Agricultural Experiment Station
Beef, Forages, Fruit, Pest Management, Sheep

3–Orange
Northern Piedmont Agricultural Experiment Station
Alfalfa, Corn, Crops, Small Grains

4–Winchester
Winchester Agricultural Experiment Station
Tree Fruits, Pest Management

5–Middleburg
Middleburg Agricultural Experiment Station
Equine Nutrition

6–Warsaw
Eastern Virginia Agricultural Experiment Station
Field Crops, Small Grains

7–Holland Station, Suffolk
Tidewater Agricultural Experiment Station
Corn, Peanuts, Pest Management, Small Grains, Soybeans, Swine

8–Blackstone
Southern Piedmont Agricultural Experiment Station
Forages, Small Fruits, Small Grains, Tobacco, Turfgrass

9–Critz
Reynolds Homestead Agricultural Experiment Station
Aquaculture, Forestry, Wildlife

10–Glade Spring
Southwest Virginia Agricultural Experiment Station: Sheep, Beef, Burley Tobacco, Forages

11–Hampton
Virginia Seafood Agricultural Experiment Station
Seafood Processing

12–Virginia Beach
Hampton Roads Agricultural Experiment Station
Ornamentals, Vegetables, Fruit, Pest Management

13–Painter
Eastern Shore Agricultural Experiment Station
Field Crops, Herbs, Pest Management, Vegetables