Rizquet
A solution for food insecurity in developing countries through entomophagy

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by
Team Members:
Haley Smolinski, Megan Telebrico, Jaynie Tao, Lisa Mai
Ali Hasan, Spencer Jones, Giselle Hernandez

Faculty Advisor:
Dr. Yao Olive Li & Dr. Shuhong Ye

Department of Human Nutrition & Food Science
College of Agriculture
California State Polytechnic University, Pomona

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Introduction

It is not a secret that malnutrition and food insecurity are most prevalent within developing countries. Entomophagy, or the practice of eating insects, can provide a nutritious relief to these global issues. Edible insects have already become a part of traditional diets found in over 113 countries, including those in developing nations (1). Many of these insects contain a considerable amount of energy, protein, fat, vitamins, and minerals, which is comparable to commonly consumed livestock (2, 3, 4, 5). On the other hand, rice is a staple food for more than half of the world’s population, especially in developing countries (6, 7). It provides 20% of world’s dietary energy and supports the livelihood of more than 1 billion people (8, 6). Other than energy, rice is also a good source of thiamin, riboflavin, niacin, as well as amino acids glutamic and aspartic acid (8). Due to the nutritious benefits of edible insects and rice, Rizquet (riz-kit: Riz = rice and Criquet = locust, in French), was developed as our solution to combat malnutrition and food insecurity for developing nations. This novel product is made primarily by extruding a mixture of brown rice and insect flours, and is meant to be an alternative/supplement to the rice already being consumed within developing countries. Furthermore, cold forming, single-screw extrusion, the specific technology utilized to create Rizquet, is advantageous as it has low capital, operating, processing, and maintenance costs (9). Extruders, in general, require less skilled labor as its operation is continuous and automatic while still producing a high output. Therefore, the combination of cold forming extrusion technology with practical ingredients makes Rizquet a highly economically feasible solution for reducing worldwide hunger.

Hence, the objective of this study is to investigate the feasibility of incorporating an edible insect ingredient in an extruded rice product. In doing so, we will reach our ultimate mission to assist the alleviation of food insecurity and malnutrition in developing countries.
Methods

*Product Formula* – The ingredients chosen for Rizquet were selected due to their practicality. Many of these ingredients are already current staple crops to many developing nations and are easily attainable. Brown rice flour is a major bulk ingredient of Rizquet and provides 18% (Daily Value) of protein, 48% (DV) dietary fiber, 82% (DV) iron, and 67% (DV) zinc (10). Edible insect flour was derived from cricket and locust. Nutritionally, per 100 grams, crickets can contain 125 kcals, 15 g protein, 6.3 g fat, 41 mg iron, and 75 mg calcium as well as other benefits (5). Locusts, while currently not as readily available as crickets in the US, are superior in nutrition as they can offer 598-816 kcal, 13-28 g protein, and 8-20 mg iron per 100 grams (11, 12). A total of three cricket formulations (5%, 10%, and 15%) and two locust formulations (10% and 15%) were developed (Table 1 in Appendix). Brown rice flour was purchased in a local store, while cricket flour and locust flour were obtained from commercial vendors in the US and in Thailand. Vegetable shortening was used in the formulation to provide lubrication during the extrusion process, reducing the level of friction within the extruder caused by the high level of starch in the mixture (13). Water was used to hydrate the flour particles. While having the same granule size as brown rice, tapioca starch was used as a thickening agent (14). Sodium alginate was included for its gelling and as well as thickening properties to enhance the structural qualities of the extruded rice kernels. Lastly, calcium chloride was sprayed on the extruded rice to interact with alginate and to form a crosslinking shell at the kernel surface to maintain the structure and integrity of the extruded rice kernels.

*Product Processing* – Procedures for creating Rizquet can be found in Figure 1 (Appendix).

*Sensory Evaluation* – A total of 16 untrained student panelists were recruited from the Food Science and Technology major at the California State Polytechnic University, Pomona. An
instruction packet was provided for a 3-part sensory test based on 4 formulations against one control - market brown rice (BR). The four formulations included 10% cricket (10CR), 15% cricket (15CR), 10% locust (10LR), and 15% locust (15LR) formulations. Part 1 was a preference evaluation on color, kernel shape, aroma, and taste. The second assessment was a ranking test based on preference for the four samples, where 1 = most pleasing and 4 = least pleasing. Lastly, Part 3 was a similarity test, in terms of texture, between the four insect formulations and the control. Specifically, the gumminess, graininess, chewiness, firmness, and overall mouthfeel were evaluated. Sample ballots can be found in Table 2 (Appendix). Before conducting the tests, all panelists underwent an orientation, and anyone who has food allergies, especially towards shellfish, was excluded.

**Statistical Analysis** – Multiple trials conducted for the quality measurements (water activity, moisture content, and color) were calculated for their central of tendency (mean) and standard deviation. Sensory evaluations involved a one-way ANOVA for the hedonic tests (Part 1 and 3) and the Freidman’s test for the ranking test (Part 2). Further analysis employing the least significant ranked difference (LSRD) calculation was completed to determine if the differences are statistically significant.

**Results & Discussion**

**Objective Evaluation** – Data were collected in order to compare and contrast the appearance, color, water activity, and texture of Rizquet to brown rice (BR). Table 1 (Appendix) displays the similarity in kernel appearance of Rizquet to BR. This similarity reinforces the potential that Rizquet has when serving as a rice alternative. An increase in darkness with greater insect flour additions was also observed. In order to objectively quantify the degree of color difference
among the samples, a colorimeter was employed. A Hunter color scale was used to measure the
degree of lightness (L*), redness (a*), and blueness (b*). Figure 2 (Appendix) marks all data
points collected for colorimeter values. Overall, it was determined that Rizquet samples were
darker in shade and slightly less yellow in hue than BR. Water activity measurements collected
from Rizquet, as depicted in Figure 3 (Appendix) indicated a superior shelf life of Rizquet,
indicating strong promise for product safety and longevity. Texture analysis conducted on
cooked Rizquet revealed the product to be softer and less adhesive than BR. This is marked by a
lower peak point in Figure 4 (Appendix), as less force was involved to compress Rizquet
samples. The adhesiveness of Rizquet is depicted by the ”area-under-the-curve” based on the
data sets and indicates the combined force-time effect, mimicking the chewing and amount of
time necessary to bite down. Having softer and less adhesive attributes, Rizquet demonstrates to
be delicate in texture with less of an “al dente” bite like that of typical brown rice.

Sensory Evaluation – Averages for the preference of the color, kernel shape, aroma, and taste
were calculated for the selected four formulations (Table 3 in Appendix). Results reveal that the
10CR had the most number of attributes with the highest scores while 10LR had the best rating
for its color. All averages signify the qualities to be more than slightly liked.

Data from the Ranking test was analyzed using the Freidman’s test and the collected
averages (Table 4 in Appendix). Results demonstrate that there was no significant difference
between the cricket and the locust rice formulations in terms of preference. However, there was
significant difference between the levels of insect ingredient added. Based on the averaged
rankings, unsurprisingly the higher insect formulations were less preferred to the lower insect
formulations.
Similarities between the insect formulations and BR were also assessed. The results (Table 5 in Appendix) indicate that the lower addition levels of insect flours were more similar to brown rice.

Overall, lower-level insect formulations reveal to be better preferred or matched to the control (brown rice). Although the aim was to incorporate higher levels of the insect ingredient, this result was expected since insect fortified rice is novel to the participants. However, as populations living in developing countries are familiar with entomophagy, Rizquet has a greater likelihood to be well accepted outside the United States. Nevertheless, the insect rice formulations were rated as “slightly like” by our current panel, consequently which still encourages for further exploration of product development and the positive outlook for increasing favorability.

**Conclusion** – Rizquet has been established to have a longer shelf life than market brown rice. While other objective assessments show the product to have a darker color and softer texture, this does not demonstrate any negative characteristics for Rizquet. On the other hand, sensory evaluations reveal lower-addition-level insect formulations were slightly liked against the market brown rice, and more preferred and better matched compared to higher-addition-level formulations. While the addition level of insect flour ingredient (10% vs. 15%) showed significantly difference between formulations, no statistically significant difference was demonstrated between types of insect flour incorporated (cricket vs. locust). Rizquet has overall shown positive results as an innovative way to answer the call to reduce food insecurity and malnutrition in developing countries.
References

Appendix

Table 1. Visual comparison of Rizquet formulations

<table>
<thead>
<tr>
<th>Cricket formulas</th>
<th>5% cricket flour</th>
<th>10% cricket flour</th>
<th>15% cricket flour</th>
<th>Brown Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locust formulas</td>
<td>10% locust flour</td>
<td>15% locust flour</td>
<td>Brown Rice</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Sample ballot for Part 1 (Preference of Various Characteristics on a 9-Point Scale) and Part 3 (Similarity of Insect Formulations to Market Brown Rice on a 9-Point Scale)

<table>
<thead>
<tr>
<th>Sample#</th>
<th>284</th>
<th>501</th>
<th>717</th>
<th>409</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guminess</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Average preference ratings for various attributes of insect rice formulations

<table>
<thead>
<tr>
<th>Attribute</th>
<th>10% cricket</th>
<th>15% cricket</th>
<th>10% locust</th>
<th>15% locust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>5.25</td>
<td>5.13</td>
<td>6.19</td>
<td>4.25</td>
</tr>
<tr>
<td>Kernel shape</td>
<td>6.88</td>
<td>6.25</td>
<td>5.94</td>
<td>4.94</td>
</tr>
<tr>
<td>Aroma</td>
<td>6.38</td>
<td>5.38</td>
<td>4.50</td>
<td>3.75</td>
</tr>
<tr>
<td>Taste</td>
<td>6.50</td>
<td>5.25</td>
<td>5.63</td>
<td>4.31</td>
</tr>
</tbody>
</table>

Table 4. Average ranking scores for 4 insect rice formulations

<table>
<thead>
<tr>
<th>10% cricket</th>
<th>15% cricket</th>
<th>10% locust</th>
<th>15% locust</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.64</td>
<td>2.71</td>
<td>2.43</td>
<td>3.21</td>
</tr>
</tbody>
</table>

Table 5. Average similarity ratings of 4 insect formulations to market brown rice

<table>
<thead>
<tr>
<th>Attribute</th>
<th>10% cricket</th>
<th>15% cricket</th>
<th>10% locust</th>
<th>15% locust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gumminess</td>
<td>4.13</td>
<td>4.88</td>
<td>4.63</td>
<td>5.44</td>
</tr>
<tr>
<td>Graininess</td>
<td>5.53</td>
<td>6.00</td>
<td>6.00</td>
<td>5.67</td>
</tr>
<tr>
<td>Chewiness</td>
<td>5.13</td>
<td>4.75</td>
<td>5.00</td>
<td>5.06</td>
</tr>
<tr>
<td>Firmness</td>
<td>5.3</td>
<td>5.44</td>
<td>5.69</td>
<td>5.44</td>
</tr>
<tr>
<td>Overall Mouthfeel</td>
<td>5.06</td>
<td>4.06</td>
<td>5.06</td>
<td>4.25</td>
</tr>
</tbody>
</table>
1. Weigh all ingredients
2. Mix for 10 minutes
3. Extrude dough mass into rice shape
4. Dry sample at 165°F for 6 hours
5. Sieve through samples to obtain desired shape and size
6. Cook sample

Measure:
- Water activity
- Moisture content
- Color

Conduct:
- Sensory evaluation
- Texture assessment

Figure 1. Process flow diagram for Rizquet formulation

Figure 2. Hunter L*a*b* value comparison of Rizquet formulations to brown rice

Figure 3. Water activity comparison of Rizquet formulations to brown rice

Note: Texture value for brown rice = 0.60 g

Figure 4. Texture comparison of various Rizquet formulations