Using Edible Insects in Production of Cookies, Biscuits, and Crackers

Gamze Nil Yazici* and Mehmet Sertac Ozer
Department of Food Engineering, Faculty of Agriculture, Cukurova University, 01330 Adana, Turkey
*gnboran@cu.edu.tr
Fig 1. The reasons behind the seeking of alternative protein sources

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Nadathur et al., 2017
Fig 2. The alternative and sustainable protein sources
Fig 3. The explanation of ‘entomophagy’ term

Kouřímská and Adámková, 2016
Production: 260,000 tonnes by 2030

Consumption: > 7000 years

Yellow mealworm
‘Novel Food’

> 2000 species
Edible Insect

**Nutritional value**
- High protein
- Essential amino acids
- High vitamin and mineral

**Sustainability and environmental issues**
- Low water pollution
- Low greenhouse gas emission
- Reduction in pesticide usage
- Less land usage and need

**Economic factors**
- Short reproduction cycle
- High growth rate
- High feed conversion ratio
- Reduction in pesticide usage

Fig 4. The advantages of consumption and production of edible insects with different perspectives
Fig 5. The approximate land, feed and water requirement of different animals

Dobermann et al., 2017
Figure 6. The most commonly used edible insects in some bakery products
Table 3. The effects of edible insects on nutritional values of some bakery products

<table>
<thead>
<tr>
<th>Bakery Product</th>
<th>Edible Insect</th>
<th>Usage Ratio</th>
<th>Results</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes subhyalinus</em>)</td>
<td>5, 10, 15, and 20%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Proteint↑, Fat↓, Carbohydrate↓ (except 5% inclusion), Ash↑, Fiber↑ (except 5 and 10% inclusion), Energy↓, Mineral (Na, Ca, P, K, Mg, Fe, Zn, Cu)↑</td>
<td>Niaba et al., 2013a</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes nigeriensis</em>)</td>
<td>5, 10, 15, and 20%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Protein↑, Fat↑, Carbohydrate↓, Ash↑, Fiber↑, Energy↓</td>
<td>Ogunlakin et al., 2018</td>
</tr>
<tr>
<td>Shortcake Biscuit</td>
<td>Mealworm (<em>Tenebrio molitor</em>)</td>
<td>1:9, 1:14, 1:19&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Protein↑, Fat↔, Carbohydrate↓, Ash↑ (except 1:19 inclusion), Energy↔, Antioxidant activity↑, Glycemic index (in vitro)↔, Rapidly digested starch ↓ (except 1:19 inclusion), Slowly digested starch↑ (except 1:19 inclusion)</td>
<td>Zielinska and Pankiewicz, 2020</td>
</tr>
</tbody>
</table>

<sup>a</sup>: the concentration in whole formulation; <sup>b</sup>: the ratio of raw material replacement, <sup>c</sup>: the ratio between raw material (edible insect:flour)
Table 3 (*Continued*). The effects of edible insects on nutritional values of some bakery products

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<tr>
<th>Bakery Product</th>
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<th>Results¹</th>
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<tr>
<td>Biscuit</td>
<td>Cricket (<em>Acheta domesticus</em>)</td>
<td>5, 10, and 15%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Protein&lt;sup&gt;d&lt;/sup&gt;↑, Fat&lt;sup&gt;d&lt;/sup&gt;↑, Carbohydrate&lt;sup&gt;d&lt;/sup&gt;↓, Fiber&lt;sup&gt;d&lt;/sup&gt;↓, Energy&lt;sup&gt;d&lt;/sup&gt;↑, Total titrable acidity↑</td>
<td>Biró et al., 2020</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes subhyalinus</em>)</td>
<td>5, 10, 15, 20, and 25%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Protein↑, Fat↓, Carbohydrate↓, Ash↑, Fiber↑, Energy↓, Mineral (Na, Ca, P, K, Mg, Fe, Zn, Cu) ↑</td>
<td>Niaba et al., 2013b</td>
</tr>
<tr>
<td>Baby biscuit</td>
<td>Grasshopper (<em>Melanoplus cinereus</em>)</td>
<td>5, 7, and 10%&lt;sup&gt;a, b&lt;/sup&gt;</td>
<td>Protein↑, Fat↑, Carbohydrate↓, Ash↓, Fiber↑, Energy↑, Mineral (Fe, Zn) ↑, Protein quality↓</td>
<td>Dewi et al., 2020</td>
</tr>
<tr>
<td>Cookie</td>
<td>Termite (<em>Macrotermes belliscosus</em>)</td>
<td>5, 10, and 15%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Protein↑, Fat↑, Carbohydrate↓, Ash↑, Fiber↑, Energy↑, Mineral↑ (Fe, P, Mg, Mn, K, Na, Zn, Ca, Cu), Amino acids&lt;sup&gt;d&lt;/sup&gt;↑, Protein digestibility↑</td>
<td>Awobusuyi et al., 2020</td>
</tr>
</tbody>
</table>

a: the concentration in whole formulation; b: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour), d: Not given as statistically
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<tr>
<th>Bakery Product</th>
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<th>Usage Ratio</th>
<th>Results(^1)</th>
<th>References</th>
</tr>
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<tr>
<td>Biscuit</td>
<td>Mulberry silkworm pupae (Bombyx mori) Locust</td>
<td>15%</td>
<td>Weight↓, Width↑: silkworm; ↔: locust, Thickness↑, Spread ratio↓</td>
<td>Akande et al., 2019</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (Macrotermes subhyalinus)</td>
<td>5, 10, 15, 20, and 25(^b)</td>
<td>Weight↓, Diameter↑ (except 5% inclusion), Thickness↓, Spread ratio↑, Specific volume↔</td>
<td>Niaba et al., 2013a</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (Macrotermes nigeriensis)</td>
<td>5, 10, 15, and 20(^b)</td>
<td>Weight↑, Diameter↑ (except 5% inclusion), Spread ratio↑, Breaking strength↓, Sensory properties: taste↓, aroma↔, texture↔, overall acceptability↓ (except 5% inclusion)</td>
<td>Ogunlakin et al., 2018</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Mealworm (Tenebrio molitor)</td>
<td>1:9, 1:14, 1:19(^c)</td>
<td>Diameter↔, Thickness↔ (except 1:9 inclusion), Spread ratio↔ (except 1:9 inclusion), L*↓, a*↑, b*↓</td>
<td>Zielińska and Pankiewicz, 2020</td>
</tr>
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a: the concentration in whole formulation; b: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour)
Table 4 (*continued*). The effects of edible insects on technological properties of some bakery products

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<tr>
<th>Bakery Product</th>
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<th>Results&lt;sup&gt;1&lt;/sup&gt;</th>
<th>References</th>
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<tr>
<td>Biscuit</td>
<td>Cricket (&lt;i&gt;Acheta domesticus&lt;/i&gt;)</td>
<td>5, 10, and 15%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Total titrable acidity↑, Color: L*↓, a*↑, b*↓, Texture: hardness↔,</td>
<td>Biró et al., 2020</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (&lt;i&gt;Macrotermes subhyalinus&lt;/i&gt;)</td>
<td>5, 10, 15, 20, and 25%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Weight↓, Diameter↑, Thickness↓, Spread ratio↑, Specific volume↓</td>
<td>Niaba et al., 2013b</td>
</tr>
<tr>
<td>Cookie</td>
<td>Termite (&lt;i&gt;Macrotermes bellicosus&lt;/i&gt;)</td>
<td>5, 10, and 15%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Weight↓, Diameter↓, Thickness↑ (except 5% inclusion), Spread factor↓, Color: L*↓, a*↑, b*↑, Texture: hardness↓, fracturability↑</td>
<td>Awobusuyi et al., 2020</td>
</tr>
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<sup>a</sup>: the concentration in whole formulation; <sup>b</sup>: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour)
Table 5. The effects of edible insects on sensorial properties of some bakery products

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<thead>
<tr>
<th>Bakery Product</th>
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<th>Usage Ratio</th>
<th>Results¹</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Biscuit</td>
<td>Mulberry silkworm pupae (<em>Bombyx mori</em>), Locust</td>
<td>15%</td>
<td>Sensory properties (taste, appearance, color, crispness, overall acceptability) ↔, Aroma ↓</td>
<td>Akande et al., 2019</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes subhyalinus</em>)</td>
<td>5, 10, 15, and 20%</td>
<td>Sensory properties (taste, aroma, appearance, color, texture, overall acceptability) ↔</td>
<td>Niaba et al., 2013a</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes nigeriensis</em>)</td>
<td>5, 10, 15, and 20%</td>
<td>Sensory properties: taste ↓, aroma ↔, texture ↔, overall acceptability ↓</td>
<td>Ogunlakin et al., 2018</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Cricket (<em>Acheta domesticus</em>)</td>
<td>5, 10, and 15%</td>
<td>Sensory properties: odor ↔, flavor ↓ (except 5% inclusion), color ↓ (except 5% inclusion), texture ↔, overall liking ↓</td>
<td>Biró et al., 2020</td>
</tr>
<tr>
<td>Biscuit</td>
<td>Termite (<em>Macrotermes subhyalinus</em>)</td>
<td>5, 10, 15, 20, and 25%</td>
<td>Sensory properties: taste ↔ (except 25% inclusion), aroma ↔, color ↓, texture ↔ (except 20 and 25% inclusion), appearance ↔, overall acceptability ↔</td>
<td>Niaba et al., 2013b</td>
</tr>
<tr>
<td>Baby biscuit</td>
<td>Grasshopper (<em>Melanoplus cinereus</em>)</td>
<td>5, 7, and 10%</td>
<td>Sensory properties: taste ↑, aroma ↑, color ↑, texture ↑</td>
<td>Dewi et al., 2020</td>
</tr>
<tr>
<td>Cracker</td>
<td>Cricket, Termites (soldier termite, winged termite)</td>
<td>8%</td>
<td>Sensory properties: taste ↓, flavor ↓, aroma ↓, color ↓, appearance ↓, overall acceptability ↓</td>
<td>Akullo et al., 2018</td>
</tr>
</tbody>
</table>

a: the concentration in whole formulation; b: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour)
Palm weevil larvae (*Rhynchophorus phoenicis Fabricius*)
- Pregnant women
- 35 and 70%

Ghana
n=130
Ayensu et al., 2019

Termite, Cricket, Grasshopper, and palm weevil
- 1:3 sorghum flour
- 20, 40, 60% (in total concentration)

Nigeria
n=79, 84
Awobusuyi et al., 2020

Cricket
- 30%, was acceptable as a control sample for Mexican consumers

USA, Spain, Mexico
n=600 (200 of each country)
Castro Delgado et al., 2020

House cricket
- 4-week-long parallel randomized study
- Children (age: 5-10)
- 10%

Kenya
n=54
Homann et al., 2017

Figure 7.
CONCLUSION

• Using edible insects could be a good alternative and valuable resource to enrich bakery products by increasing the nutritional value and meet the protein shortage.

• Therefore, further studies should mainly focus on making edible insect-enriched food products more appealing for the consumers by modifying food formulation or masking some off-flavors, and also determine the optimum conditions about pre- (rearing) and post-processings of edible insects (drying, defatting, etc.).
REFERENCES

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THANK YOU FOR YOUR ATTENTION