Foods 2021
The 2nd International Electronic Conference on Foods
Future Foods and Food Technologies for a Sustainable World
15–30 OCTOBER 2021 | ONLINE
foods MDPI

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

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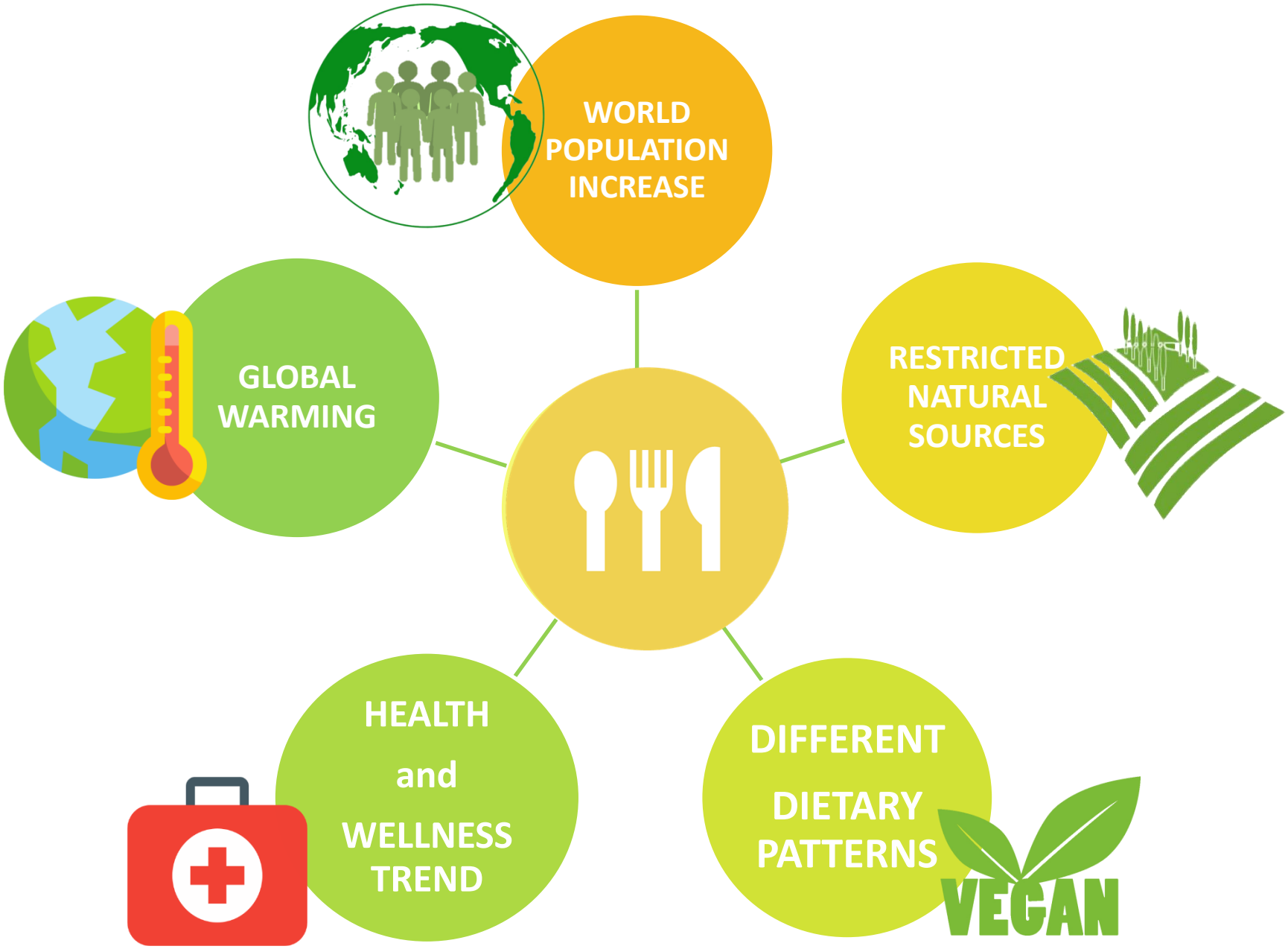


Fig 1. The reasons behind the seeking of alternative protein sources

Nadathur et al., 2017

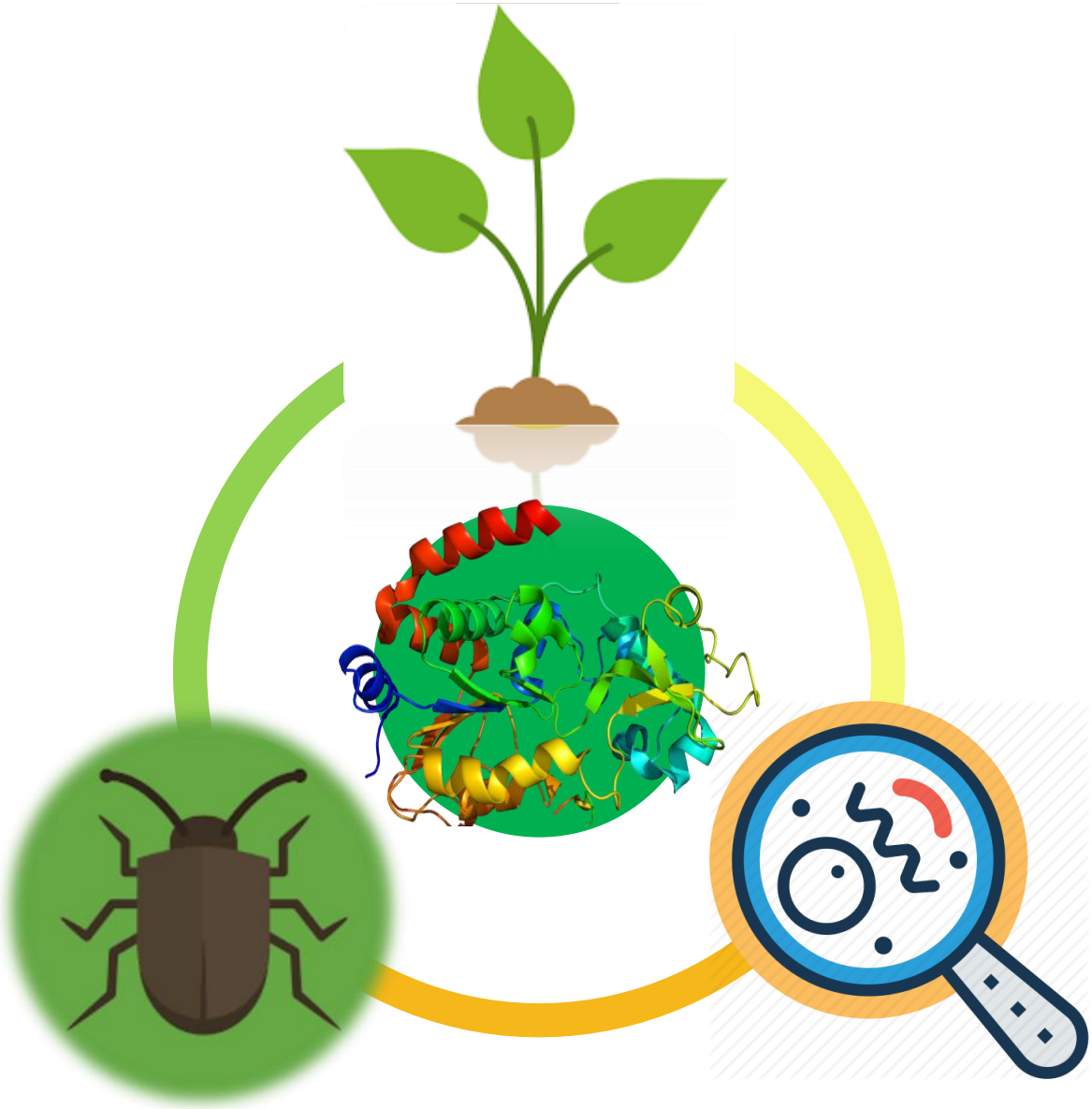


Fig 2. The alternative and sustainable protein sources

Loveday, 2019

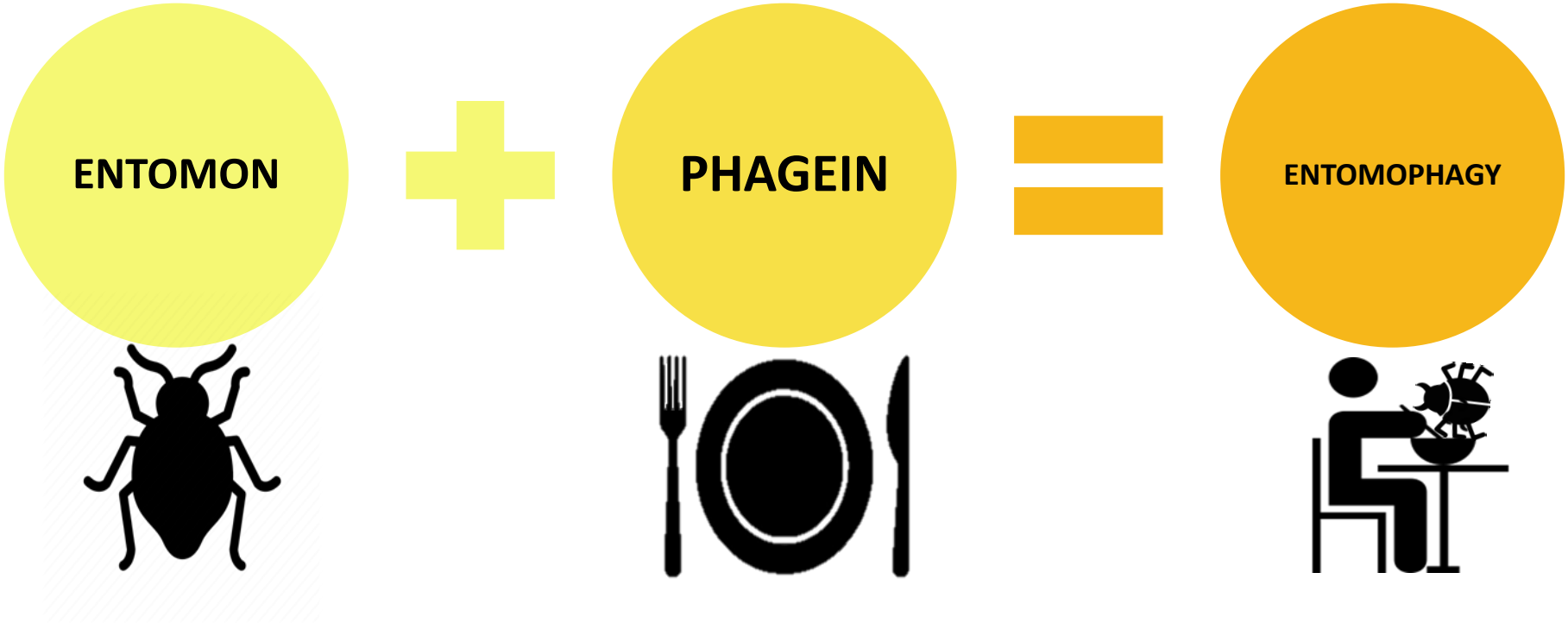
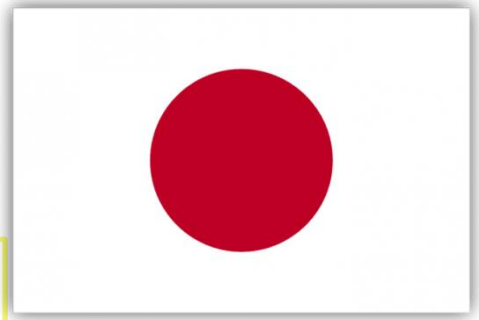


Fig 3. The explanation of ‘entomophagy’ term

Kouřimská and Adámková, 2016

Consumption: > 7000 years



Yellow mealworm

‘Novel Food’

> 2000 species

European Commission

ipiff

Production: 260,000 tonnes by 2030

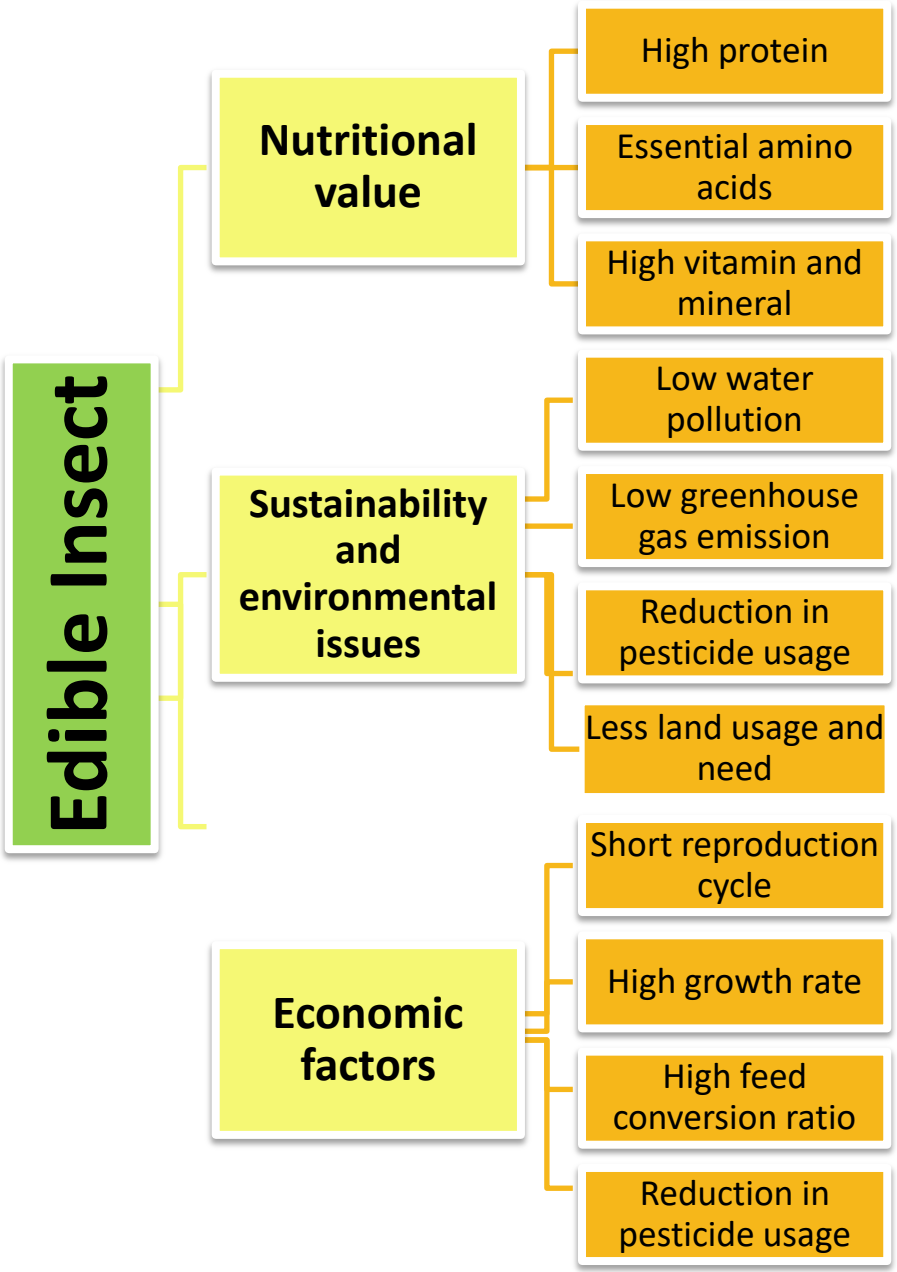


Fig 4. The advantages of consumption and production of edible insects with different perspectives

De Carvalho et al., 2020

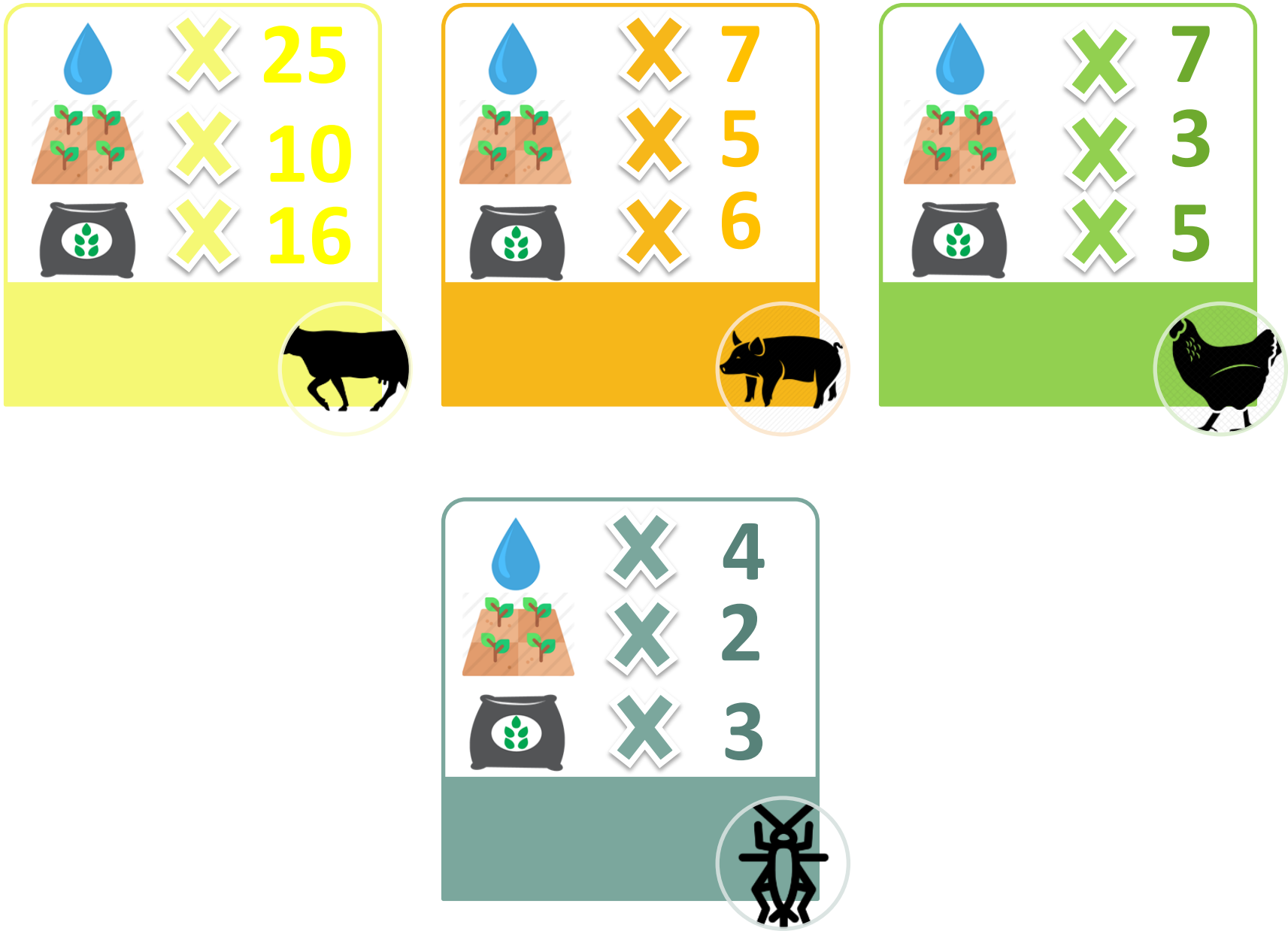


Fig 5. The approximate land, feed and water requirement of different animals

Dobermann et al., 2017

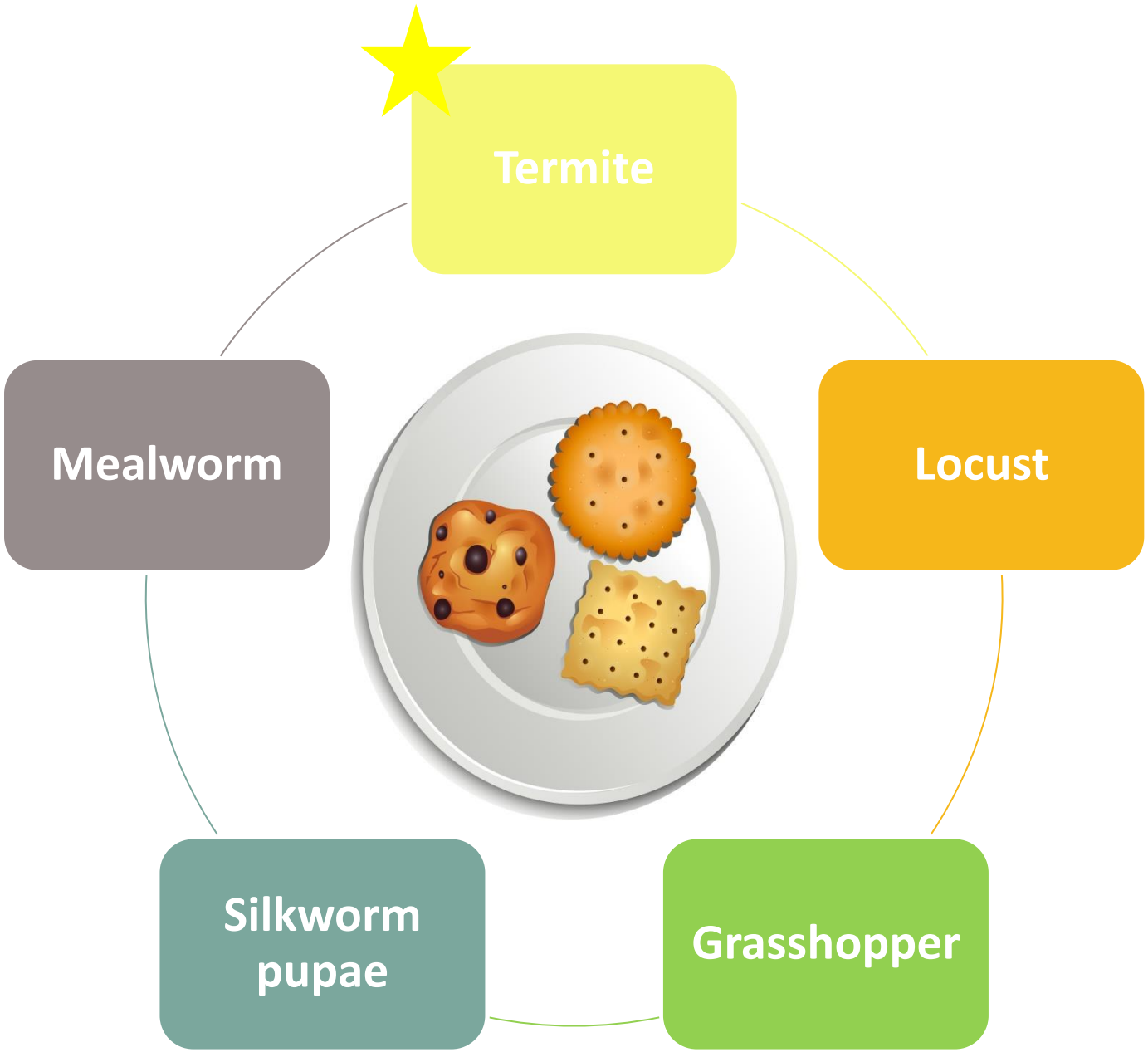


Figure 6. The most commonly used edible insects in some bakery products

Table 3. The effects of edible insects on nutritional values of some bakery products

Bakery Product	Edible Insect	Usage Ratio	Results	References
Biscuit	Mulberry silkworm pupae (*Bombyx mori*), Locust	15%[a]	Protein↓, Fat↑:silkworm;↓:locust, Carbohydrate↑, Ash↑, Fibre↓, Energy↑:silkworm;↓:locust, Mineral (Zn, P and K)↑:locust;↓:silkworm 'compared with skimmed milk'	Akande et al., 2019
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, and 20%[b]	Proteint↑, Fat↓, Carbohydrate↓ (except 5% inclusion), Ash↑, Fiber↑ (except 5 and 10% inclusion), Energy↓, Mineral (Na, Ca, P, K, Mg, Fe, Zn, Cu)↑	Niaba et al., 2013a
Biscuit	Termite (*Macrotermes nigeriensis*)	5, 10, 15, and 20%[b]	Protein↑, Fat↑, Carbohydrate↓, Ash↑, Fiber↑, Energy↓	Ogunlakin et al.,2018
Shortcake Biscuit	Mealworm (*Tenebrio molitor*)	1:9, 1:14, 1:19[c]	Protein↑, Fat↔, Carbohydrate↓, Ash↑ (except 1:19 inclusion), Energy↔, Antioxidant activity↑, Glycemic index (in vitro)↔, Rapidly digestied starch ↓ (except 1:19 inclusion), Slowly digested starch↑ (except 1:19 inclusion)	Zielińska and Pankiewicz,2020

a: the concentration in whole formulation; b: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour)

Table 3 (*Continued*). The effects of edible insects on nutritional values of some bakery products

Bakery Product	Edible Insect	Usage Ratio	Results[1]	References
Biscuit	Cricket (*Acheta domesticus*)	5, 10, and 15%[b]	Protein[d]↑, Fat[d]↑, Carbohydrate[d]↓, Fiber[d]↓, Energy[d]↑, Total titrable acidity↑	Biró et al., 2020
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, 20, and 25%[b]	Protein↑, Fat↓, Carbohydrate ↓, Ash↑, Fiber↑, Energy↓, Mineral (Na, Ca, P, K, Mg, Fe, Zn, Cu) ↑	Niaba et al., 2013b
Baby biscuit	Grasshopper (*Melanoplus cinereus*)	5, 7, and 10%[a, b]	Protein↑, Fat↑, Carbohydrate↓, Ash↓, Fiber↑, Energy↑, Mineral (Fe, Zn) ↑, Protein quality↓	Dewi et al., 2020
Cookie	Termite (*Macrotermes belliscosus*)	5, 10, and 15%[b]	Protein↑, Fat↑, Carbohydrate ↓, Ash↑, Fiber↑, Energy↑, Mineral↑ (Fe, P, Mg, Mn, K, Na, Zn, Ca, Cu), Amino acids[d]↑, Protein digestibility↑	Awobusuyi et al., 2020

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

Table 4. The effects of edible insects on technological properties of some bakery products

Bakery Product	Edible Insect	Usage Ratio	Results[1]	References
Biscuit	Mulberry silkworm pupae (*Bombyx mori*) Locust	15%	Weight↓, Width↑:silkworm;↔:locust, Thickness↑, Spread ratio↓	Akande et al., 2019
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, 20, and 25%[b]	Weight↓, Diameter↑ (except 5% inclusion), Thickness↓, Spread ratio↑, Specific volume↔	Niaba et al., 2013a
Biscuit	Termite (*Macrotermes nigeriensis*)	5, 10, 15, and 20%[b]	Weight↑, Diameter↑(except 5% inclusion), Spread ratio↑ Breaking strength↓, Sensory properties: taste↓, aroma↔, texture↔, overall acceptability↓(except 5% inclusion)	Ogunlakin et al.,2018
Biscuit	Mealworm (*Tenebrio molitor*)	1:9, 1:14, 1:19[c]	Diameter↔, Thickness↔(except 1:9 inclusion), Spread ratio↔(except 1:9 inclusion), L*↓, a*↑, b*↓	Zielińska and Pankiewicz,2020

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

Bakery Product	Edible Insect	Usage Ratio	Results[1]	References
Biscuit	Cricket (*Acheta domesticus*)	5, 10, and 15%[b]	Total titrable acidity↑, Color: L*↓, a*↑, b*↓, Texture: hardness↔,	Biró et al., 2020
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, 20, and 25%[b]	Weight↓, Diameter↑, Thickness↓, Spread ratio↑, Specific volume↓	Niaba et al., 2013b
Cookie	Termite (*Macrotermes belliscosus*)	5, 10, and 15%[b]	Weight↓, Diameter↓, Thickness↑ (except 5% inclusion), Spread factor↓, Color: L*↓, a*↑, b*↑, Texture: hardness↓, fracturability↑	Awobusuyi et al., 2020

a: the concentration in whole formulation; b: 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

Bakery Product	Edible Insect	Usage Ratio	Results[1]	References
Biscuit	Mulberry silkworm pupae (*Bombyx mori*), Locust	15% [a]	Sensory properties (taste, appearance, color, crispness, overall acceptability) ↔, Aroma ↓	Akande et al., 2019
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, and 20%[b]	Sensory properties (taste, aroma, appearance, color, texture, overall acceptability)↔	Niaba et al., 2013a
Biscuit	Termite (*Macrotermes nigeriensis*)	5, 10, 15, and 20%[b]	Sensory properties: taste↓, aroma↔, texture↔, overall acceptability↓	Ogunlakin et al.,2018
Biscuit	Cricket (*Acheta domesticus*)	5, 10, and 15%[b]	Sensory properties: odor↔, flavor↓ (except 5% inclusion), color↓(except 5% inclusion), texture↔, overall liking↓	Biró et al., 2020
Biscuit	Termite (*Macrotermes subhyalinus*)	5, 10, 15, 20, and 25%[b]	Sensory properties: taste↔(except 25% inclusion), aroma↔, color↓, texture↔(except 20 and 25% inclusion), appearance↔, overall acceptability↔	Niaba et al., 2013b
Baby biscuit	Grasshopper (*Melanoplus cinereus*)	5, 7, and 10%[a, b]	Sensory properties: taste↑, aroma↑, color↑, texture↑	Dewi et al., 2020
Cracker	Cricket, Termites (soldier termite, winged termite)	8%[b]	Sensory properties: taste↓, flavor↓, aroma↓, color↓, appearance↓, overall acceptability↓	Akullo et al., 2018

a: the concentration in whole formulation; b: the ratio of raw material replacement, c: the ratio between raw material (edible insect:flour)

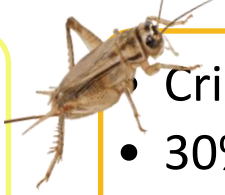
Palm weevil larvae (*Rhynchophorus phoenicis Fabricius*)

- Pregnant women
- 35 and 70%

Ghana

n=130

Ayensu et al., 2019



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

USA, Spian, Mexico

n=600 (200 of each country)

Castro Delgado et al., 2020

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

Nigeria

n=79, 84

Awobusuyi 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.).

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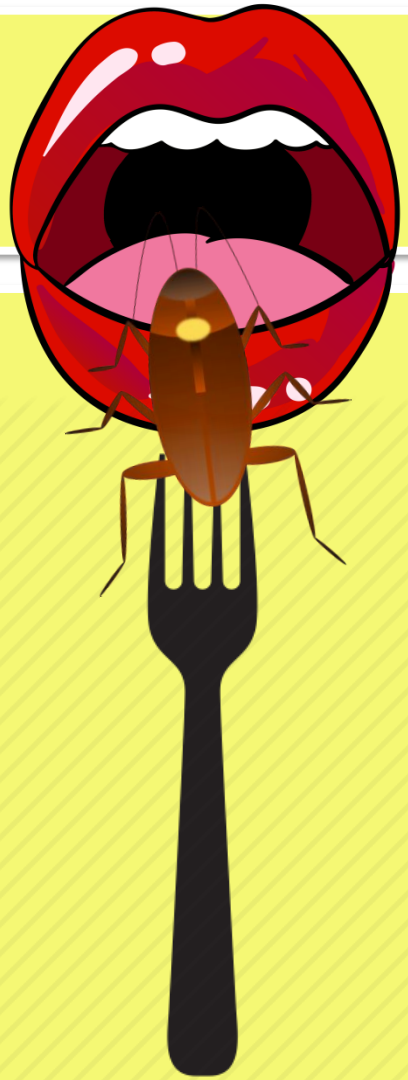

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