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Development of biodegradable packaging ensuring quality and safety of infant food powders distributed in Madagascar

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Introduction

As part of the fight against malnutrition in Madagascar, the social enterprise Nutri'zaza, founded by the NGO Gret, distributes fortified infant formula "Koba Aina" in around 7 million single-dose multi-layer sachets every year.

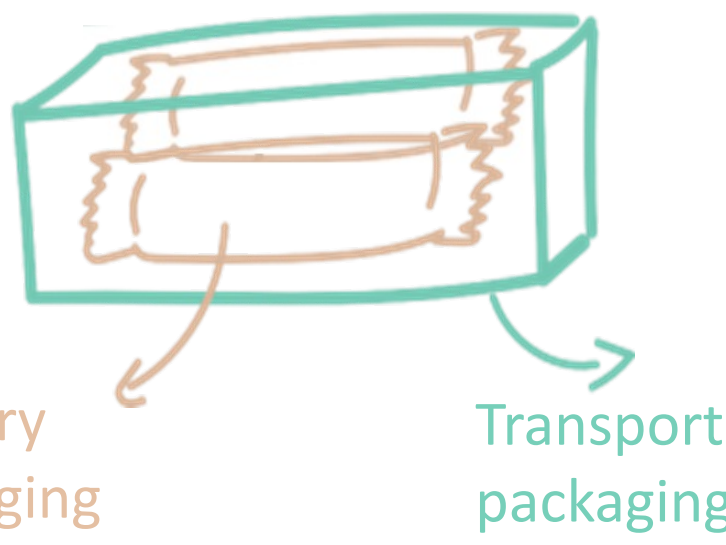
These multi-layered packages, due to their complexity, present challenges in terms of recycling, leading to their accumulation in the environment. This accumulation increases the risk of dispersion in nature, further intensifying the problems of pollution and ecosystem degradation in a country with a lacking waste treatment infrastructure.



Objective

The objective of this work is to minimize environmental impact of infant food packaging by exploring alternatives to plastic packaging, with the aim of reducing environmental pollution.

The concept behind the study is to replace the petrochemical, non-recyclable multi-layer packaging with two disjointed containers separable at end-of-life, adapted to supply chain requirements and consumer needs : **biodegradable** primary packaging and **recyclable** secondary packaging

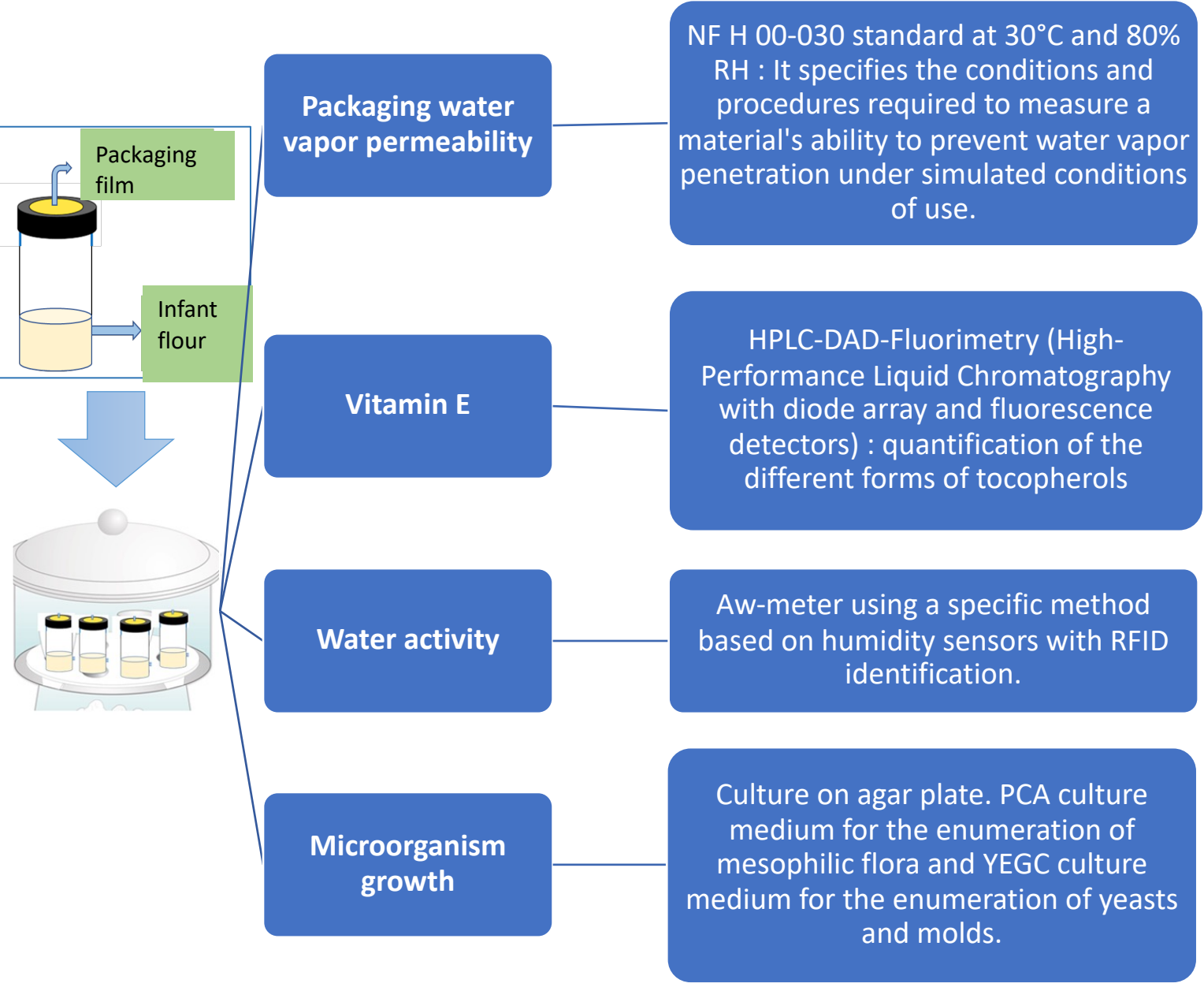


Methodology and experimentation

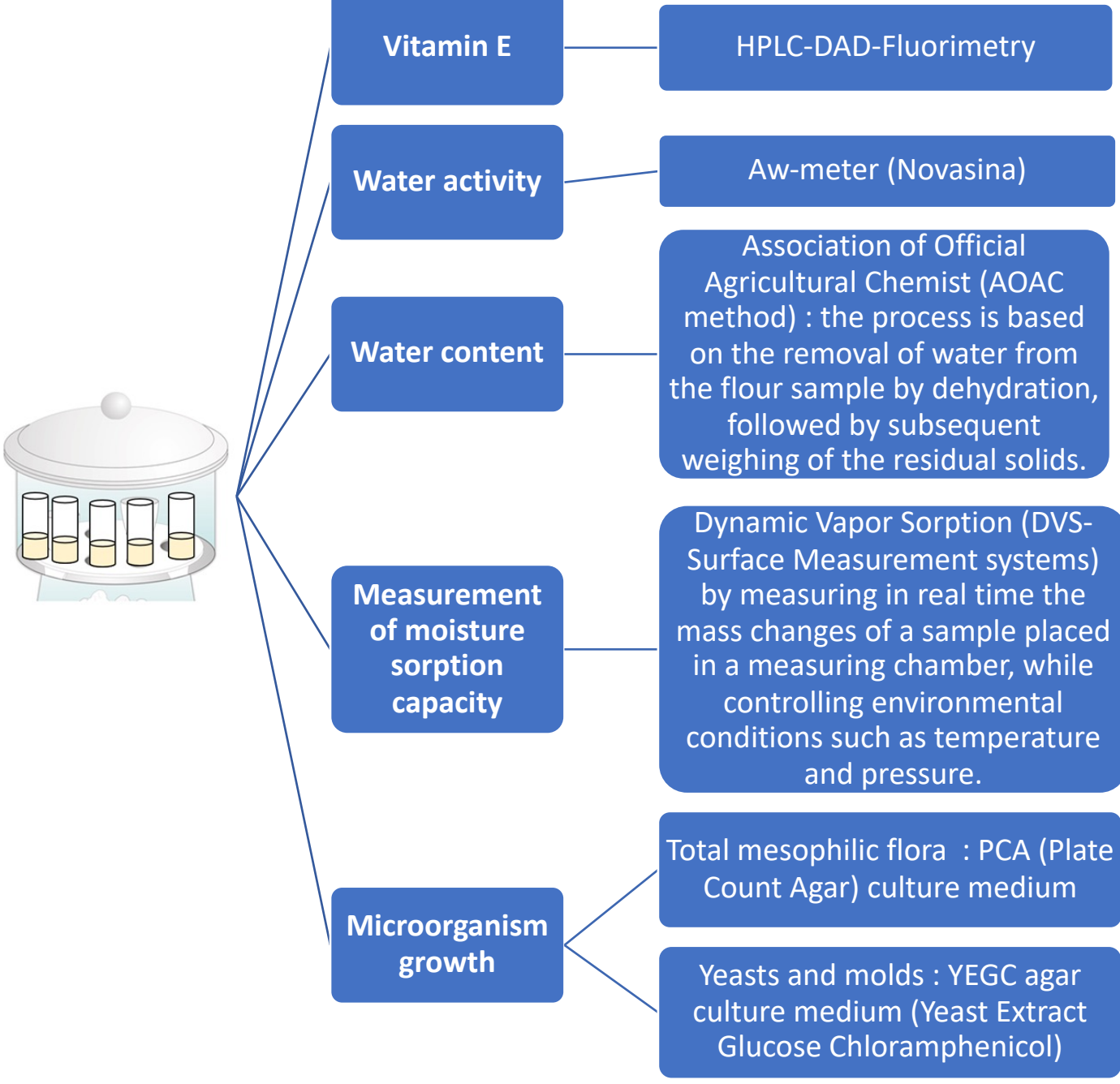
1) Assessment of stability of the nutritional and sanitary quality of unpackaged and packaged food supplements across various environmental conditions

Study of the ageing kinetics of products without packaging and with alternative biodegradable packaging, compared with the product's current packaging : under environmental conditions similar to those encountered in Madagascar (temperature, relative humidity).

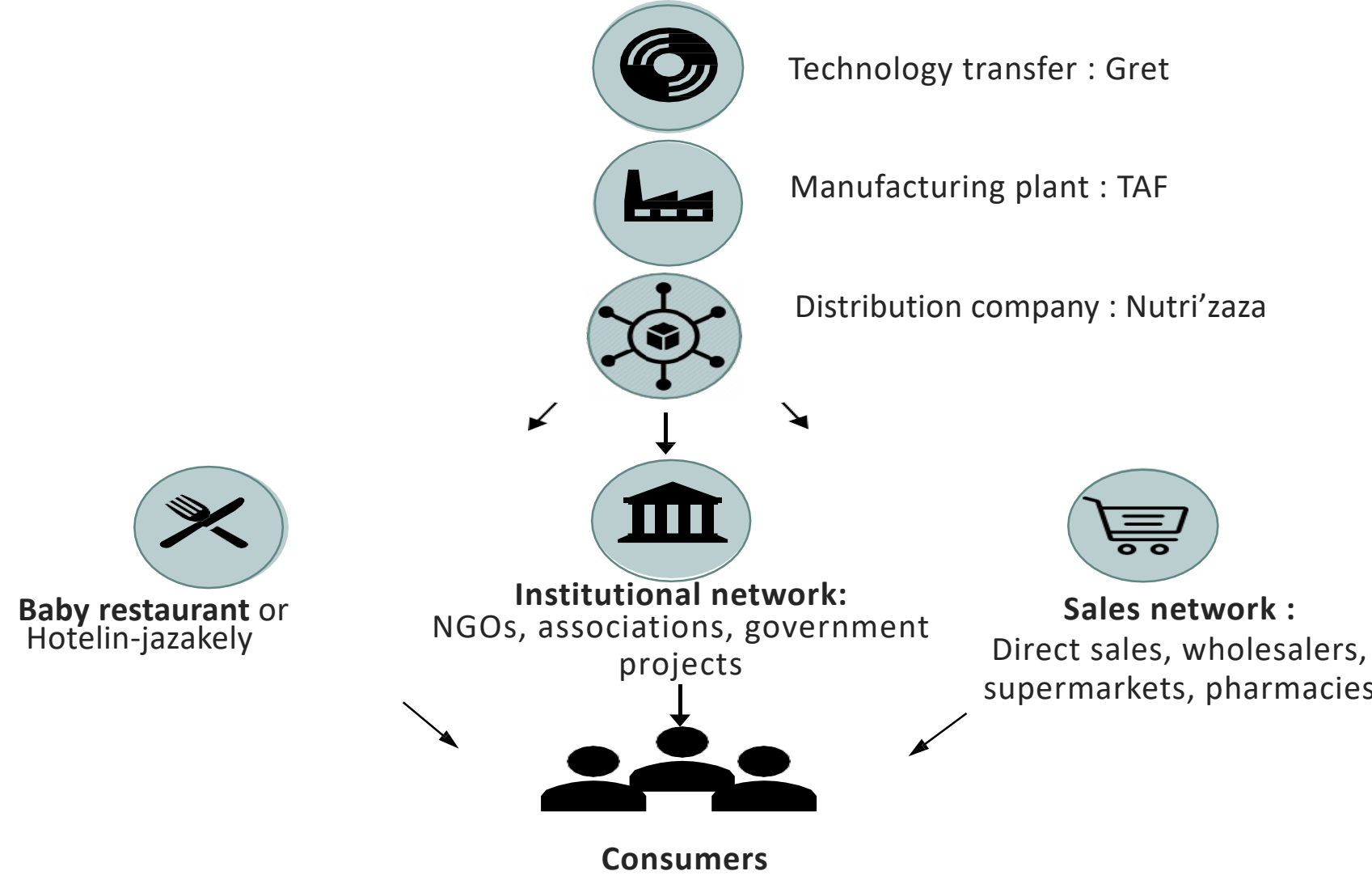
- Study of product shelf life with packaging



- Study of product shelf life without packaging



2) Field study of the conditions encountered by the product during its distribution chain (environmental, logistical, technological)



- **Temperature and relative humidity readings during the product distribution chain:** log 32TH thermohygrometer : automatic temperature and humidity data logger with integrated USB interface and automatic PDF creation

- Distributor and consumer survey to identify target needs :

- What kind of packaging do you often see in your daily life/business ?
- What types of packaging make your daily life easier?
- What types of packaging cause you problems in your daily work?
- What type of packaging can you recycle? How do you recycle it?

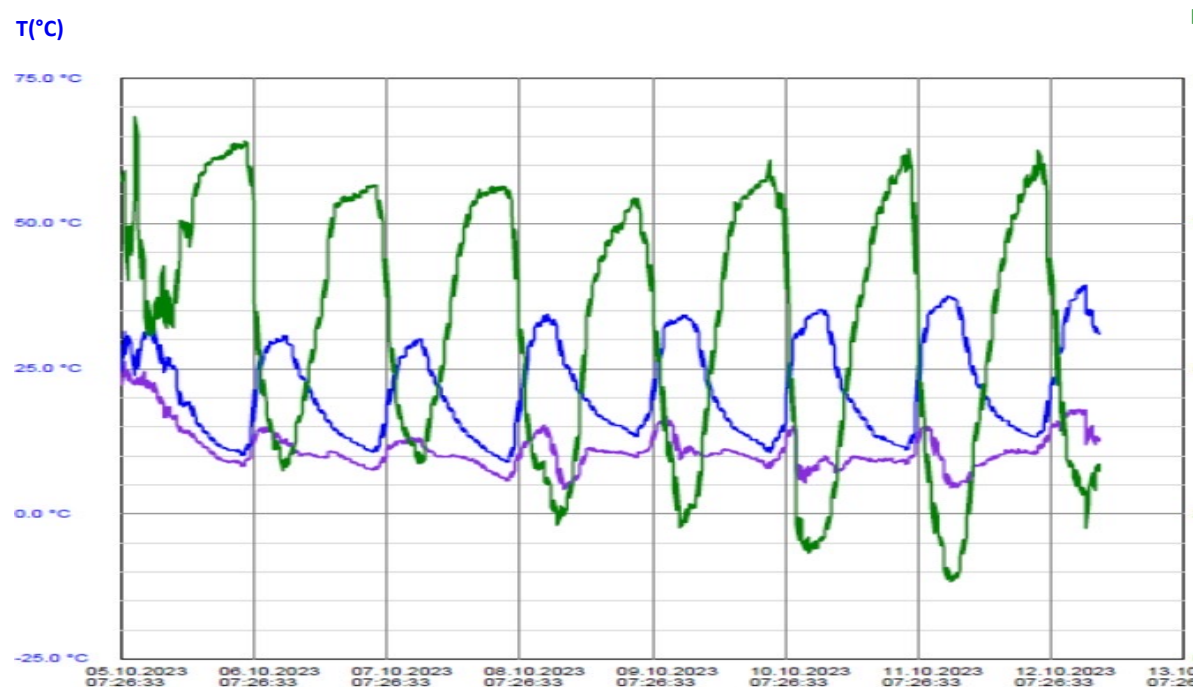
Results

→ Annual temperature variation in Madagascar (theoretical)

Madagascar has a tropical climate with an annual variation : between 15°C to 30°C

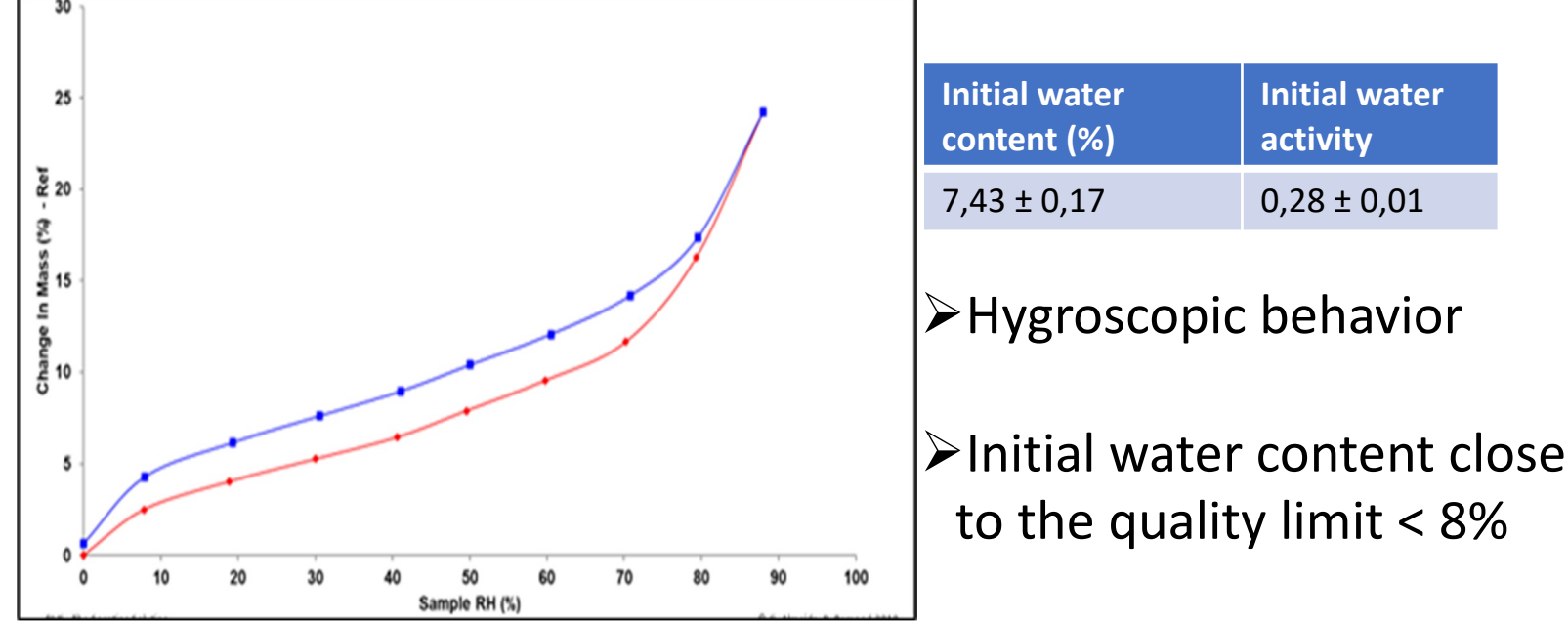
The critical and average climatic conditions were used to determine test conditions in the laboratory.

→ Variation on site in temperature and relative humidity during the off-season in Madagascar

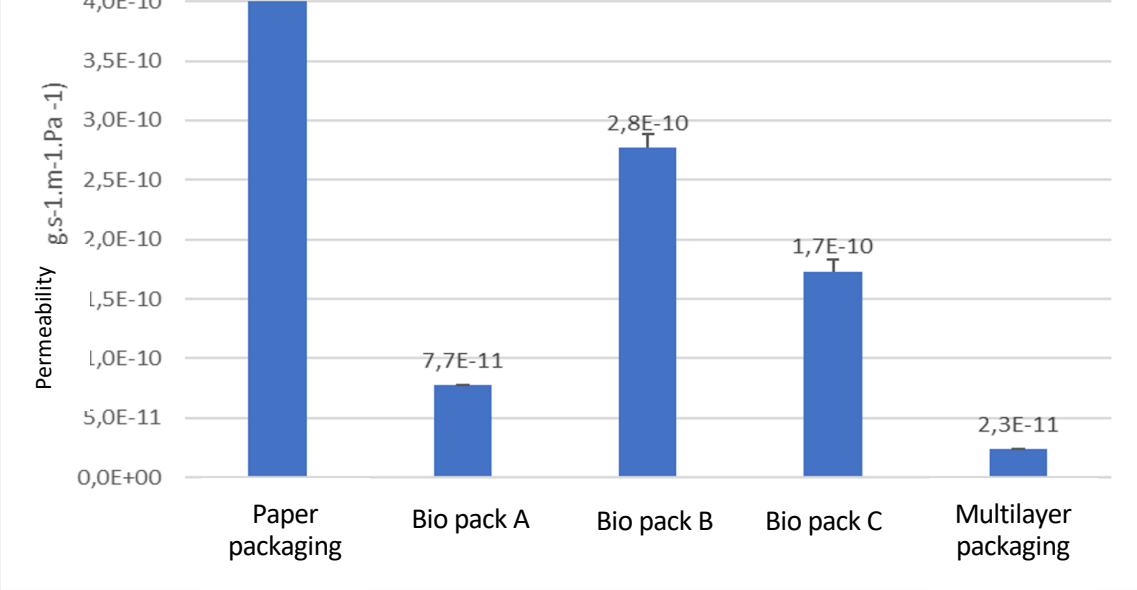


As a result of the fieldwork, temperatures and relative humidities are within the range of theoretical conditions, but are very dynamic. Also, products are transported without a cold chain.

→ Water sorption analysis of infant powder

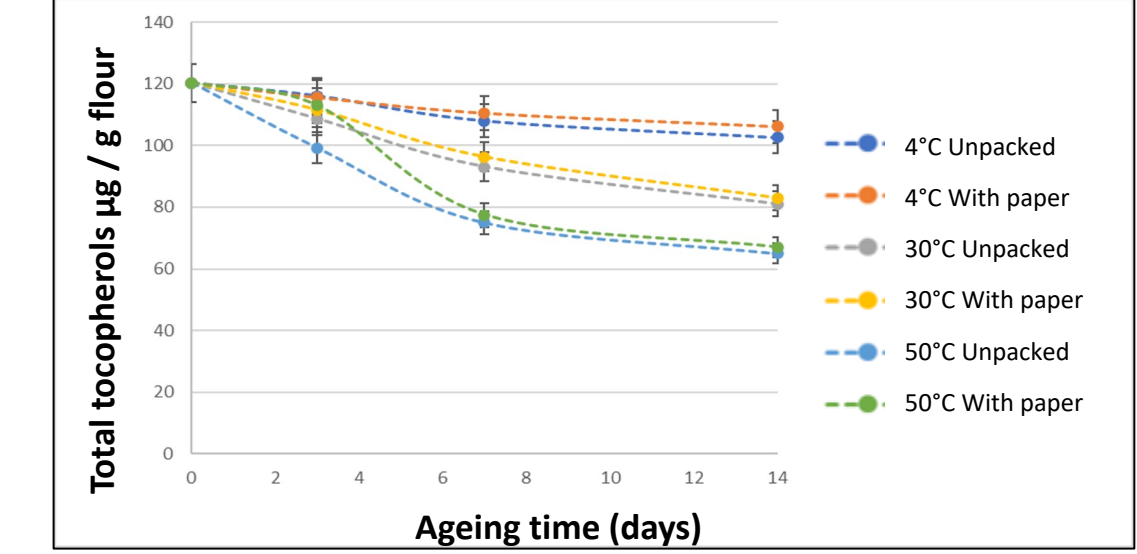


→ Water vapor permeability of tested packaging



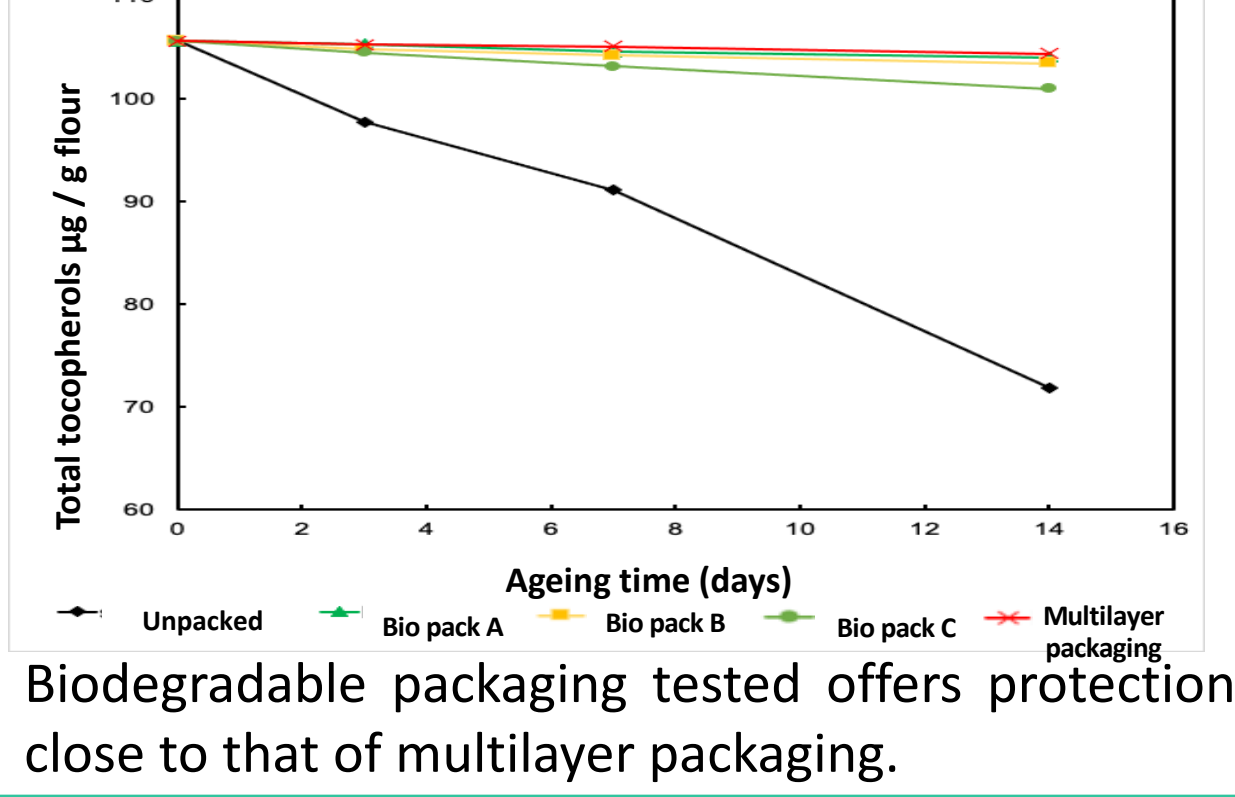
One of the biodegradable packages tested has a water permeability close to that of multilayer plastic. Paper, on the other hand, is highly permeable to water.

→ Trends in tocopherol levels in paper-packed products



- Tocopherols degradation increased with storage temperature.
- Paper packaging is ineffective in tocopherols protection.

→ Product shelf-life in relation to packaging : total tocopherol content



Biodegradable packaging tested offers protection close to that of multilayer packaging.

→ Results of distributor and consumer surveys on packaging

	Woven polypropylene bag	Cardboard	Plastic film
Advantages	- Water and tear resistant - Easy to handle - Reusable and versatile (dry grain collection, product display, textile transport)	- Resistant (shock, heat, transport) - Good presentation on receipt and in storage (associated with a quality product) - Reusable and stackable (product display, sending parcels to the bush, packaging for bulk purchases) - Biodegradable	- Lightweight - Flexible - Water-resistant - Transparent (for product presentation)
Disadvantages	- Devalues the product: dry grains are usually packaged in these types of packaging in Madagascar. - Unattractive - Does not help to efficient organization of products, often lying on the ground	- Water-sensitive - Tearable - Bulky	- Tears easily - Difficult to dispose of at end-of-life (source of pollution in many cities)

→ Evolution of microorganism growth

■ With paper packaging

Conditions	3 days	7 days	14 days	21 days	28 days
	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw
80% RH - 4°C					
80% RH - 30°C	0,51	0,65	0,73	0,75	0,68
80% RH - 50°C			0,79		0,89

CFU/g within regulatory limits

CFU/g exceed the microbiological threshold set by regulations

The product is stable for up to 14 days when packed in paper packaging at a medium temperature in Madagascar (30°C). At 50°C, microorganism growth stops.

■ Without packaging, with biodegradable packaging and with the product's current multi-layer packaging

Conditions	10	13 days	17 days	24 days
	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw	Total flora Yeasts and molds aw
80% RH - 4°C				
80% RH - 30°C	0,27 ± 0,01		0,73 ± 0,01	0,82 ± 0,01
80% RH - 30°C			0,28 ± 0,01	0,74 ± 0,03
80% RH - 30°C			0,30 ± 0,01	0,31 ± 0,02
80% RH - 30°C			0,30 ± 0,01	0,32 ± 0,02
80% RH - 30°C			0,30 ± 0,01	0,32 ± 0,01
80% RH - 30°C			0,28 ± 0,01	0,31 ± 0,01
80% RH - 30°C				0,35 ± 0,02

The unpackaged product is microbiologically stable for up to 13 days. With the biodegradable packaging tested, compared with the multi-layer packaging of the current product, the products are stable for the duration of the study (24 days).

Conclusions

- Infant flour in Madagascar requires careful handling due to its fragility, necessitating protective packaging and tamper-evident seals.
- Distribution channels play a crucial role, with 80% having a short turnover in Tananarive and 20% reaching provinces over 1 to 3 months.
- Of the four biodegradable packages tested, one stood out and showed promising results, but a longer-term study will be undertaken. At the end of this study, a mathematical model adapted to the African context will be developed to predict the shelf life of food products in their packaging.
- Limited packaging suppliers in Madagascar add complexity.

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