Are your protein bars built to last?

Accelerated approaches to shelf life testing in protein bars

SYNERGY®
INSPIRING TASTE™

THE PROTEIN BAR MARKET

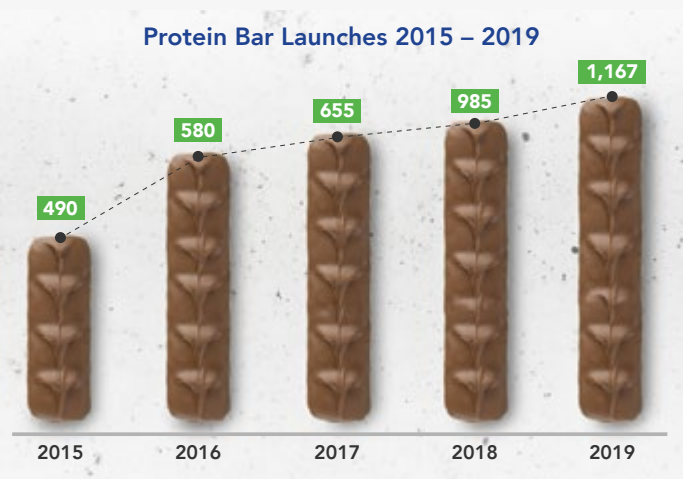
A global perspective

Over the past decade, protein bars have played an increasingly important role as a convenient solution for grab-and-go nutrition. Time-pressed consumers developed more fluid eating patterns, often turning to bars as a meal replacement snack. This placed a premium on satiety and allowed disruptive new brands to drive rapid growth with high-protein claims. Protein became critical in this new role for bars.

At the same time, consumer interest in exercise and physical activity has surged. Marathons, triathlons and new sports such as CrossFit have exploded in popularity as more people view intense physical exercise as an essential element of healthy living. Protein for fitness became more important to this growing group of "weekend warriors" that were not focused on building muscle in the same way as traditional bodybuilders.

People increasingly view time as their most valuable asset. Convenience is more important than ever in food, and consumers are willing to spend more on pre-prepared products that save time on cooking. This is particularly true with younger generations.

Bars have been a key beneficiary of this trend, balancing convenience and portability with a relatively healthy image. For this reason, the global market grew at a rate of 8.8% CAGR over the past 5 years from a value of $3.9B in 2014 to $6B in 2019, and it is set to grow at 7% CAGR to 2024.
**(Euromonitor data 2020)*



Global launches of bars with a high or added protein claim increased by almost 240% over the past 5 years (Mintel 2020)

What was originally a niche offering, sports protein bars extended their distribution and softened their messaging to attract consumers interested more in on-the-go nutrition and satiety than athletic performance. On the other side, snacks companies added protein content to their bars offerings to capitalize on the mainstreaming of this ingredient over the course of the decade.

As this once niche offering has moved mainstream, the taste and texture of protein bars has become increasingly important to todays' consumer, providing manufacturers with key challenges to overcome during the lengthy shelf life of protein bars.
**(Mintel 2020)*

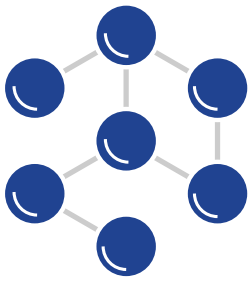
Top 20 Protein Bar Flavours 2019

Chocolate	7.0%
Cookies & Cream	3.7%
Coconut	2.5%
Peanut Butter	2.4%
Chocolate & Caramel/ Caramelised	1.7%
Chocolate & Brownie	1.5%
Caramel (Salted)	1.5%
Chocolate & Peanut Butter	1.5%
Strawberry	1.3%
Vanilla/Vanilla Bourbon/ Vanilla Madagascar	1.3%
Chocolate & Mint	1.2%
Cocoa/ Cacao	1.2%
Peanut Butter & Chocolate	1.2%
Chocolate & Hazelnut	1.0%
Chocolate & Coconut	1.0%
Peanut/ Groundnut	1.0%
Brownie	1.0%
Chocolate & Peanut/ Groundnut	0.9%
Caramel/ Caramelised	0.9%
Chocolate & Cookie Dough	0.9%

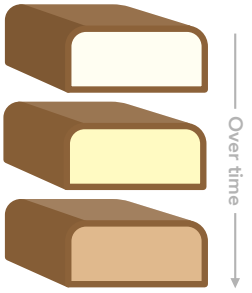
THE CHALLENGE OF FORMULATING PROTEIN BARS

Despite increasing popularity and predicted growth of protein bars, formulating novel protein bars is not without its challenges. Protein bars are typically built around a protein-based 'core'. While the newest wave of bar launches have focussed on additions to the core, including toppings, coatings and inclusions, the bar core remains the primary source of protein and an integral element of protein bars.

Protein cores are known to undergo changes throughout shelf life, these include:



Changes in structure and texture:
Typically hardening.



Changes in colour:
Typically darkening, transitioning from pale off-white to yellow and even brown.

Changes in flavour:
Typically changes in profile and decreasing flavour impact.

These challenges may contribute to decreased acceptability of protein bars during shelf life.

50% of survey respondents reported issues with **bar hardening** at **3 months** → **100%** of survey respondents reported issues with **bar hardening** at **6 months** → **100%** of survey respondents experienced **flavour loss** before **9 months**

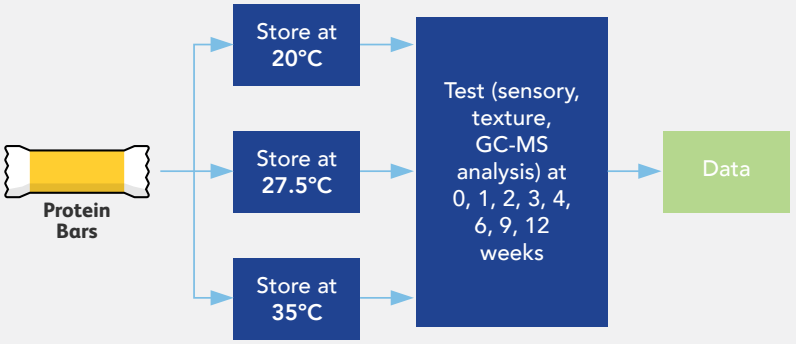
Our Solution:

Adapting Accelerated Shelf Life Testing (ASLT)

To determine the performance of protein bars in terms of hardness and flavour intensity over shelf life, we conducted a study that used Accelerated Shelf Life Testing.

Learn more about Accelerated Shelf Life Testing (ASLT)

The study incorporated storage at three temperatures followed by multiple types of testing at various timepoints throughout shelf life.



Notes on diagram:

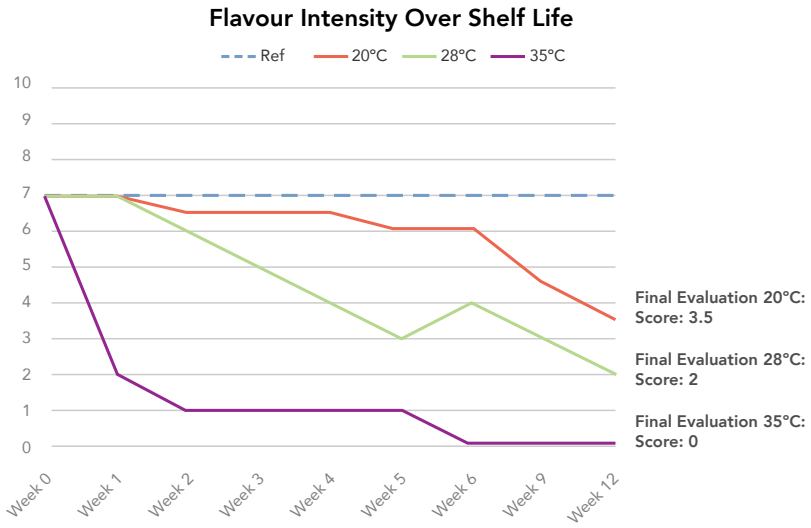
1. Uncoated protein bar cores were flavoured with cookies and cream flavour. The cookies and cream flavour selected represents a group of flavours (including vanilla, chocolate, caramel) which are most commonly used in bar manufacture.

2. Storage at three temperatures is a necessary step in the design of an accelerated shelf life study, as it measures the change in product deterioration when temperature is increased. These temperatures were chosen to increase product deterioration while minimising heat related structural changes to the bars.

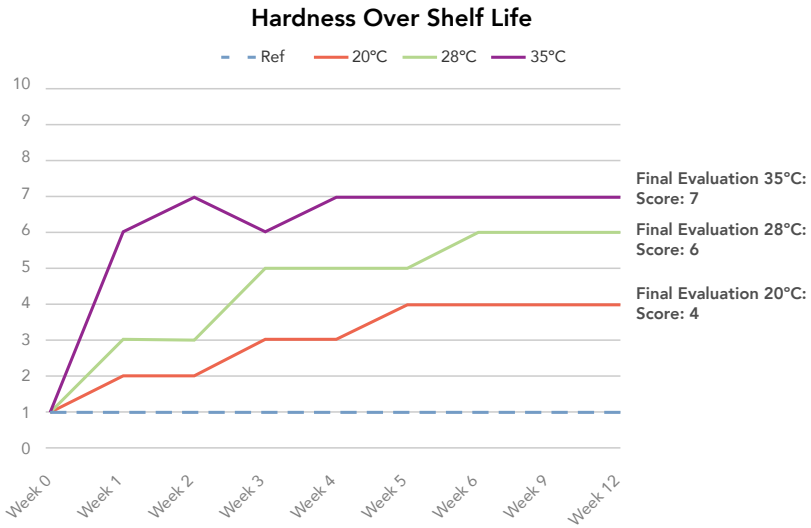
3. Three tests were performed on the bars at various stages of storage (0,1,2,3,4,6,9,12 weeks). These include GC-MS testing to quantify volatile compounds, texture analysis to quantify the hardness of the bars and sensory testing to compare the flavour strength and hardness of the bars.

SENSORY DATA

Study Results

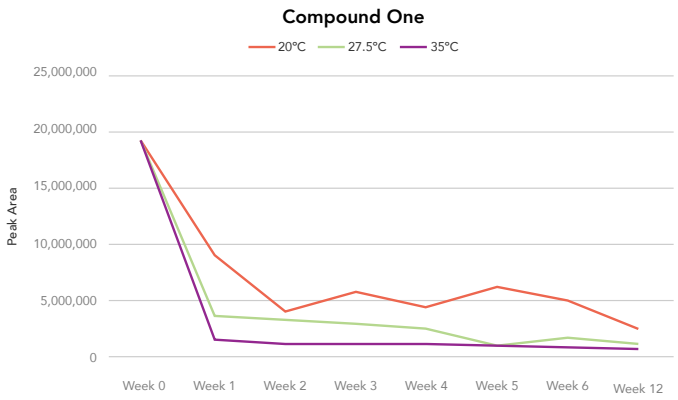


The results from the sensory study demonstrated that bar hardness increased, and bar flavour intensity decreased throughout shelf life. These changes were greater at higher temperatures, demonstrating that increasing temperature can be used to effectively accelerate shelf life for protein bars.

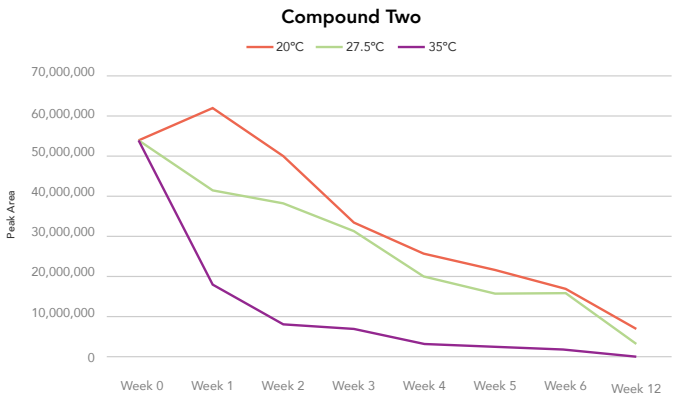


GC-MS DATA

Study Results



Graph of peak area Vs time for compound one across storage temperatures.

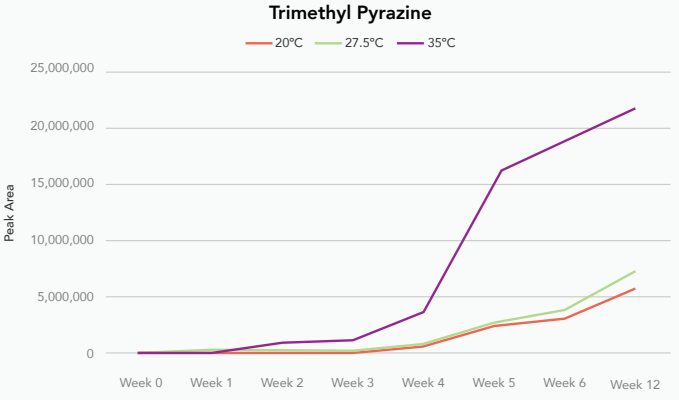


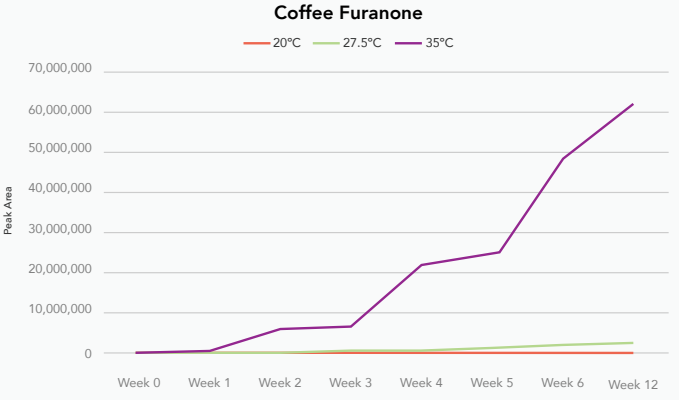
Graph of peak area vs time for compound two across all storage temperatures.

Compound one and compound two were both components of the cookies and cream flavour, with buttery and caramellic profiles respectively. Both showed losses during 12 weeks storage in protein bars.

However, the other components of the flavour (not shown to protect flavour IP) did not show evidence of loss during the shelf life study. This suggests that the majority of the flavour is stable.

As the majority of the compounds in the flavour appear to be stable throughout shelf life, possible theories of flavour deterioration or loss cannot fully explain the significant loss in flavour described by the sensory element of the study.



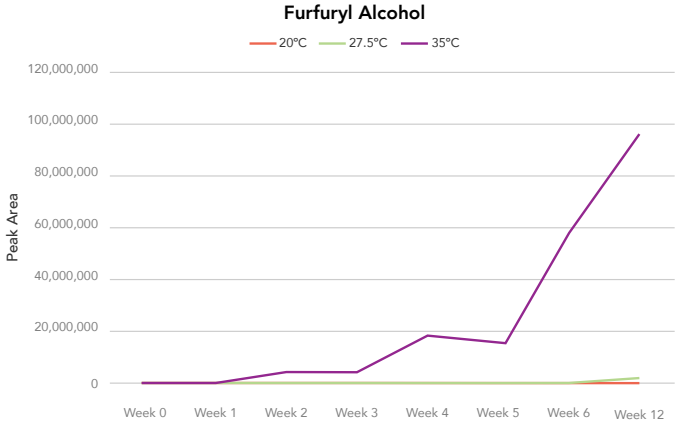


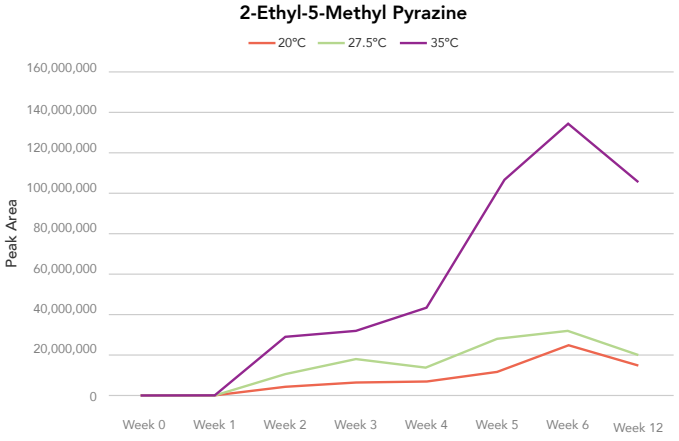
Five compounds were found to form in the protein bars during aging. These compounds and their aroma properties are listed below:

Compound	Aroma	Aroma Strength
Trimethyl pyrazine	Nutty, Cocoa, Potato	Very High
2,5 Dimethyl pyrazine	Musty, Nutty, Cocoa	High
2-Ethyl-5-Methyl pyrazine	Coffee, Nutty	High
Coffee furanone	Brown	Medium
Furfuryl Alcohol	Musty, Caramellic	Medium

All five compounds which formed had roasted, nutty and brown profiles, which may be linked to the musty and brown off-notes identified by the sensory panellists in the aged bars.

...Study Results continued





Interestingly, pyrazines are formed by the Maillard reaction, this observation indicates that a single reaction cascade may be contributing to the full sprectrum of challenges encountered during the aging of protein bars. Chemical changes in the protein bar core itself may be as, or potentially more important than the changes in the flavour, impacting the performance of protein bars throughout shelf life.

Flavour change in protein bars is certainly a complex and difficult challenge. Careful selection of flavours for protein bars, or use of higher dosages, may be effective in covering off notes formed during shelf life to some extent, but are unlikely to solve this challenge entirely.

- Protein bar formulators may want to consider slowing the Maillard reaction within protein bars as much as possible, for example by using sugars which are less susceptible to the Maillard reaction such as non-reducing sugars.

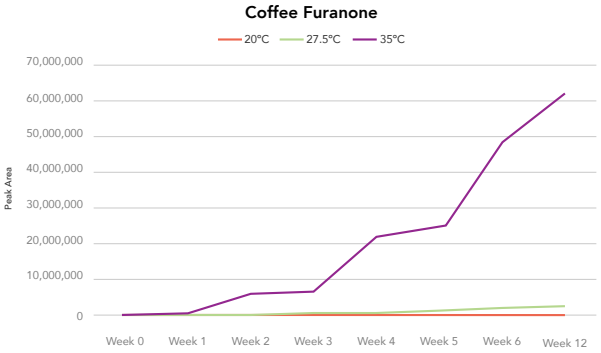
- Consideration should also be given to protein selection to minimize water migration and impact on hardness, there are several ingredients available in the market place that address these issues. Utilization of ingredients that reduce and control the water activity of the bar core will help maintain quality through shelf life.

MODELLING ACCELERATED SHELF LIFE

Accelerated shelf life models are predictions of a food product's real shelf life, based on its performance at conditions that accelerate the deterioration of the product, such as increased temperature.

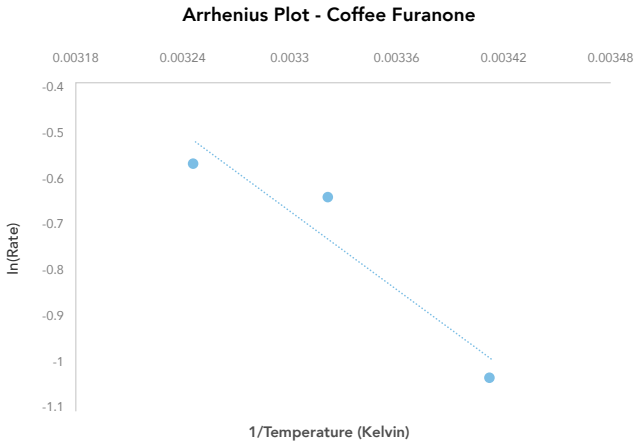
While maintaining flavour throughout shelf life in protein bars has its challenges, one advance which may help formulators improve shelf life in protein bars is a robust and rapid testing protocol. The second aim of this study was to develop an accelerated shelf life model which can accelerate future protein bar development.

In this case, increased temperature was used to increase the rate of changes in the protein bar. The performance of the bars throughout storage at 20°C (ambient), 27.5°C and 35°C was evaluated by recording the rate of change of the concentration of key volatile compounds at each temperature. This rate increased at higher temperatures, indicating that the bar deteriorated more quickly at higher temperatures.



The rate of formation of coffee furanone was highest at 35°C. The rate at each temperature is determined by plotting a line of best fit to the data.

The rate of formation of coffee furanone at each temperature was:



By plotting the rate at all three temperatures, it is possible to determine the relationship between rate and temperature, in other words, how much the rate of formation of an off-note increased when the temperature increased.

Conventionally, this is performed using what is known as an 'Arrhenius plot', a plot of the natural logarithm against 1/ temperature for each rate. Using the equation of the line from the Arrhenius plot, the rate of reaction at any temperature can be predicted.

Based on the data recorded during this study, an accelerated shelf life method was developed to rapidly predict the performance of protein bars over shelf life. In this method, each 4 weeks at ambient storage is approximated by 1 week of storage at 37.5°C.

In this way, an approximation to 12 months shelf life can be obtained in 12 weeks, which is a much better fit for typical development and launch time for a newly developed product than full 12 month testing.

Method limitations

1. This accelerated shelf life method was developed for use on uncoated protein bar cores, it is unsuitable for use on coated bars due to the low melting point of typical coatings.

2. The bar core composition during this study was closely aligned to that of commercial protein bars. It was based on whey protein and contained glycerol as a humectant, vegetable oil, water and a vegetable-based emulsifier. Further work is needed to confirm whether this accelerated shelf life method is also valid for plant-based protein bars.

3. Accelerated shelf life testing is designed as an indication of the stability of a product throughout shelf life. While it can be used to approximate real-time data and facilitate rapid prototyping during new product development, real-time shelf life studies are the most accurate way to determine the shelf life of a product.

CONCLUSION

As the protein bar market continues to grow, maintenance of eat quality throughout shelf life is certain to be a factor that will influence repeat purchase. To differentiate their product offering, manufacturers can look to improving the shelf life performance of their products, and may find accelerated shelf life techniques a valuable resource to aid new product development.

Synergy has developed an accelerated shelf life testing model for protein bar cores. This model predicts that 1 week at 32.5°C can be used to approximate 1 month at 20°C. This model was validated in a new batch of protein bars containing a summer fruits flavouring, showing a close approximation to real-time shelf life data.

Bar hardening has long been understood to occur due to changes in protein structure. These changes are attributed to a number of underlying mechanisms including water migration, protein aggregation and phase separation over time.

Furthermore, the Maillard reaction (a complex reaction cascade which occurs between sugars and amino acids) may also contribute to changes to protein bars during aging. During the Maillard reaction, amino groups in protein chains react with reducing sugars, disrupting the protein structure and leading to formation of a range of new compounds within the bars, including volatile compounds.

Hardness and Maillard reaction both have an impact on flavour perception and while the majority of flavour compounds were proven to be stable in the bar matrix, some key volatiles did decrease over time.

We have developed a flavour range specifically tailored for protein bar formulation based on the findings from our recent research. The targeted range of flavours include the top ten most popular flavours for protein bars.

To find out more about Synergy's nutrition expertise,
visit: **uk.synergytaste.com/market-solutions/nutrition**
or get in touch at: **uk.marketing@synergytaste.com**.