

Formulating Nutritional Bars for Multiple Markets — A DIAL-IN[®] Approach

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Formulating Nutritional Bars

Ingredient's polyols for use in this application:

- MALTISWEET® B Maltitol Syrup
- MALTISWEET 3145 Maltitol Syrup
- HYSTAR® 5875 Maltitol Syrup
- SORBO® 70% Sorbitol Solution
- MALTISWEET CM40 Crystalline Maltitol
- GLYSTAR® Polyol Solutions
- STABILITE® Polyglycitol

Nutritional bars have served as a convenient way of providing the immediate energy and nutritional needs of fitness enthusiasts and athletes since they were introduced in early 1980s. Since then the nutritional bar market has evolved into a multimillion-dollar industry. The original bars focused solely on nutrition for athletes, and as a result they were often short on taste and texture. Now, nutritional bars are consumed by all kinds of consumers and taste, texture and shelf stability have become as important as function.

Taste and texture are important to the general consumers who are interested in their wellness; function is important to the serious athletes and fitness enthusiasts; and shelf stability is important to all consumers. Overall, it is crucial that the taste, texture and function of the nutritional bar are maintained as long as the product is kept on the shelf, or until it is consumed.

Ingredion has a wide range of polyols (or polyhydric alcohols) for use in nutritional bars which can be used in all formulations to enhance taste and texture (mouthfeel), increase shelf-life stability, and help provide function and performance. These can also be used to replace sugar to achieve a sugar-free, reduced sugar or reduced calorie nutritional bar.

What are the various types of nutritional bars?

Most nutritional bars on the market are no longer solely for the sports enthusiast and are sold for multiple purposes (weight loss, energy, high protein, high fiber etc.). For this reason, many nutritional bars may fit into more than one of the following 4 basic categories. Since the nutritional bars on the market have a wide range of serving size, the values listed below are standardized for 50 grams weight.

- **High Protein Bars**
 - traditionally used as a supplement in high protein weight loss programs or as protein supplement by bodybuilders
 - contain 16 to 20 grams of protein, 10 to 20 grams of carbohydrate, 5 to 10 grams of fat, and 130 to 230 calories (per 50 grams serving size)
- **Protein Bars**
 - have slightly less protein than traditional high protein bars
 - contain 10 to 15 grams of protein, 15 to 25 grams of carbohydrate, 5 to 15 grams of fat, and 180 to 240 calories (per 50 grams serving size)
- **High Carbohydrate Bars**
 - aimed at providing immediate energy or sustained energy (endurance)
 - contain 2 to 9 grams of protein, 30 to 40 grams of carbohydrate, 5 to 15 grams of fat, and 160 to 230 calories (per 50 grams of serving size)
- **Balanced Carbohydrate/Protein/Fat Bars**
 - aimed at providing more balanced nutrition
 - contain 5 to 10 grams of protein, 20 to 30 grams of carbohydrate, 5 to 20 grams of fat, and 200 to 275 calories (per 50 grams serving size)

Some of these nutritional bars also have significant amount of fiber, 5-10 grams or 10+ grams (per 50 grams serving size) as an added nutrition. In all types of nutritional bars, formulations must be developed around ingredients that will provide function, good taste and texture, and product stability throughout the shelf-life.



Importance of glycemic response in exercise

If the nutritional bar is to provide energy, ingredients are selected that affect the glycemic index and therefore control the energy release. The glycemic response is used to describe the human body's response to consuming sucrose or a similar high glycemic sugar. Ingesting a high glycemic sugar significantly increases blood glucose, triggering the production of insulin, removing the sugar from the blood and storing it in the cells of the body. Consuming a high sugar drink or snack prior to exercise releases insulin. This increase of insulin in the blood results in limited amounts of glucose being available for oxidation, which causes a reduction in energy — thereby decreasing athletic performance.

During exercise, the body responds differently to high glycemic sugar foods due to the release of the hormone epinephrine. The release of epinephrine depresses the insulin response causing higher glucose levels in the blood. Increased levels of glucose can provide another fuel source for the muscles, allowing an athlete to save valuable fuel stored in the muscles and liver (glycogen). In delaying the consumption of glycogen, the athlete's endurance is increased. If an athlete exhausts glycogen stores during exercise, he/she will experience what is commonly known as "bonk" or "hitting the wall". In this situation, performance rapidly decreases, muscle weakness sets in, and the athlete becomes lethargic and possibly dizzy. This can also be life-threatening.

After intense exercise, glycogen stored in the muscle and liver are depleted. In addition, possible muscle damage must be repaired. Consuming at least 50 grams or higher of glycemic carbohydrates within the first 15 minutes following an hour or more of intense exercise replenishes glycogen stores at a much greater rate than if one waited longer. This allows the athletes to efficiently replenish a good percentage of their muscles and liver with glycogen ensuring optimal performance, especially when consecutive days of intense training or competition are expected. Following this immediate feeding with a post exercise meal rich in complex carbohydrates that are low glycemic further replenishes the glycogen stores, maximizing the amount of carbohydrates stored as glycogen and not fat.

How do Ingredient's polyols affect glycemic response?

Ingredient offers several polyols that enhance a nutritional bar's performance or function. Sugars, such as dextrose, sucrose and maltose, are high glycemic, but polyols, such as MALTISWEET and HYSTAR Maltitol Syrups, SORBO Sorbitol Solution and STABILITE Polyglycitol, are

low glycemic. Depending on the desired function of the nutritional bar, the appropriate ingredient is available. The Ingredient polyol portfolio is designed to replace many sugars and syrups on a 1:1 basis.

What other characteristics are needed to be considered in a nutritional bar formulation?

Nutritional bars may differ in various functions that they are to provide; most of the time to provide energy or a balanced diet, but they all are still food products that need to satisfy all types of consumers in terms of taste, texture and stability.

Taste and texture

As competition continues in the nutritional bar market, manufacturers and formulators have to pay increased attention to taste and texture to separate their products from the rest. Many nutritional bars are enrobed in chocolate-flavored coatings or contain soft centers, such as caramel or cream, to improve taste. Many bars contain sugar or sugar substitutes to increase sweetness. A formulator needs to choose ingredients that enhance taste and sweetness while not impacting the caloric content or the function of the nutritional bar.

Polyols can be used in conjunction with sugars or as replacement of sugars for sugar-free or reduced sugar nutritional bars, and they also help to reduce calories. They come in a wide range of sweetness levels, which allows the formulator more flexibility because the overall taste and sweetness of the formulation can be adjusted and better controlled. For instance, MALTISWEET and HYSTAR Maltitol Syrups are 70-80% as sweet as sucrose while MALTISWEET Crystalline Maltitol is 90% as sweet as sucrose. SORBO Sorbitol Solution is 60% as sweet as sucrose and has a pleasant cooling effect.

Stability (Shelf-life)

Many formulators and manufacturers of nutritional bars have become aware of issues with shelf-life stability after just 2 to 3 months. Such issues are primarily related to the hardening of higher protein based bars during storage. This poor shelf-life stability has become a problem now that the general public has become the major consumer. Gone are the days when the only consumers were the sports athletes who would buy and consume the nutritional bar almost immediately. Now, nutritional bars are sold by mass merchandisers and bought by consumers who keep them for months before consumption. It is important that the nutritional bar be just as good when opened after a few months as it was when it was first made in order to ensure repeat business.

Traditionally, nutritional bars have been made with corn syrup and fructose along with varying levels of glycerin. Glycerin is used for its hygroscopicity, low water activity and plasticizing properties. These bars often have stability issues due to moisture migration where the protein absorbs what little moisture is present, causing the bars to harden over time. Glycerin does not retain moisture well and the loss of moisture causes the bars to become unpalatable in as little as 3 months. Unlike glycerin, polyols such as, MALTISWEET and HYSTAR Maltitol Syrups, SORBO Sorbitol Solution and STABILITE Polyglycitols, can contribute to moisture and are also hygroscopic. This helps to control the moisture of a nutritional bar by picking up and retaining moisture longer than glycerin, thereby helping the bar retain its texture for a longer period of time.



How do I know which Ingredient polyols to use in a nutritional bar formulation?

Ingredient offers several polyol products that enhance a nutritional bar's taste and texture, and shelf-life stability. The following is a guideline to some of the benefits that each of Ingredient's polyols imparts to this application:

- **MALTISWEET B and MALTISWEET 3145 Maltitol Syrups**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - available in concentrations from 75 to 85% solids
 - 3.0 kcal/gram on a dry basis
 - 70-80% as sweet as sucrose
 - provides cohesion, texture, plasticity and humectancy
- **HYSTAR 5875 Maltitol Syrup**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - 3.0 kcal/gram on a dry basis
 - 70-80% as sweet as sucrose
 - provides cohesion, texture, plasticity and humectancy
- **SORBO 70% Sorbitol Solution and SORBEX® 70 Sorbitol Solution Non-GMO IP**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - 2.6 kcal/gram on a dry basis
 - 60% as sweet as sucrose
 - pleasant cooling effect
 - better static humectant than glycerin (hydrates more slowly at high relative humidity and retains moisture more effectively at lower relative humidity)
- **GLYSTAR Polyol Solutions**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - non-crystallizing combination of sorbitol, glycerin, and/or propylene glycol (different ratios of glycerin:sorbitol are available)
 - contains only 14% water so is useful in formulations that cannot allow for high water content of other polyol solutions
 - better taste than straight glycerin
- **STABILITE and HYSTAR Polyglycitols**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - provides varying degrees of elasticity and hardness to centers
 - provides less stickiness than typical maltitol syrups
- **MALTISWEET CM40 Crystalline Maltitol**
 - low glycemic response
 - sugar-free
 - non-cariogenic
 - 2.1 kcal/gram
 - low laxation potential of 100 grams/day
 - 90% as sweet as sucrose

The appropriate polyol is available to suit the needs of any nutritional bar formulation. Ingredient would be happy to assist you with your formulation work and to help you choose the right product or product combinations.

CASE STUDY Impact of replacing corn syrup and fructose with Hystar Maltitol Syrup on taste, texture and stability

In studies done by Ingredion's Global Sweetener Development Group, it was shown that substituting corn syrup and fructose with maltitol/polyglycitol solutions, such as Hystar 5875 Maltitol Syrup, produced nutritional bars with the following taste/texture and stability benefits:

- increased shelf-life stability
- better moisture control within the bar
- softer centers
- more chewable centers

Four formulations were studied; three of them containing corn syrup, fructose and varying amounts of glycerin, and the other one containing Hystar 5875 Maltitol Syrup plus 5% glycerin (Table 1).

The study demonstrated that by using Hystar 5875 Maltitol Syrup, more moisture control was observed in the nutritional bar's center. Water activity data suggested that over time the bar made with Hystar 5875 Maltitol Syrup demonstrated negligible decrease in water activity while the control bar with 5% glycerin (along with corn syrup and fructose) showed more pronounced decrease (Figure 1). Note that the bar produced with Hystar 5875 Maltitol Syrup started at a higher water activity (although still

TABLE 1: FORMULATIONS STUDIED

INGREDIENTS	5% GLYC.	9% GLYC.	14% GLYC.	HYSTAR 5875 + 5% GLYCERIN
Whey protein concentrate	12.0	10.9	10.0	11.2
Ca caseinate	10.3	9.3	8.5	9.6
Profam 930	8.6	7.8	7.1	8.0
Oat fiber	0.9	0.8	0.7	0.8
Fibrim	0.5	0.5	0.4	0.5
GLOBE® Plus 10 DE Maltodextrin	3.5	7.8	10.4	9.6
Lecithin	0.5	0.5	0.4	0.5
Glycerin	5.4	9.3	13.8	5.0
Corn syrup	29.6	26.9	24.6	0.0
Fructose	28.2	25.7	23.5	0.0
Vanilla flavor	0.6	0.6	0.5	0.6
HYSTAR 5875 Maltitol Syrup	0.0	0.0	0.0	54.2

within acceptable shelf life limitations), but the change in water activity was less pronounced over time.

The study also demonstrated that nutritional bars made with Hystar 5875 Maltitol Syrup had a softer center, denoted by a lower hardness value compared to that of the control formula with 5% glycerin (Figure 2). Furthermore, it exhibited a lower stiffness than the control bar, a value that characterizes the bar's texture during chewing. A lower elasticity value represents a nutritional bar that seems to melt in the mouth. A high value represents a bar that takes more work to chew.

Shelf-life evaluation showed that all nutritional bars increased slightly in their peak hardness value at similar rates over a period of 3 months. Although this was observed, the textural properties measured through elasticity were quite different. Nutritional bars made with Hystar 5875 Maltitol Syrup demonstrated a minor change in elasticity value while the control increased greatly (became stiffer) as shown in Figure 3.

Traditionally, it was thought that to increase the softness of a nutritional bar, one must increase the glycerin level. Increasing the glycerin level too much can lead to problems such as off-taste and warming sensations caused by an exothermic interaction with moisture. In this study, it was found that the glycerin level must be increased to 9% (from a control of 5%) in order to produce a bar with a similarly soft center as the bar made with Hystar 5875 Maltitol Syrup (Figure 2). Increasing glycerin to 9% of the formulation decreased the hardness but the stiffness (chew) remained higher (Figure 2). This produced a bar

FIGURE 1: COMPARISON OF THE WATER ACTIVITY OF NUTRITIONAL BAR FORMULATIONS OVER 1 MO.

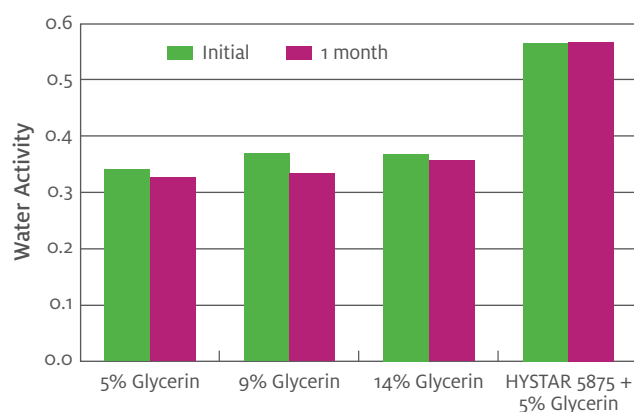
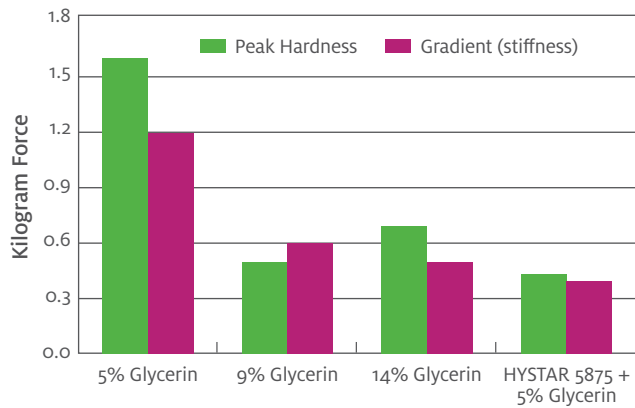
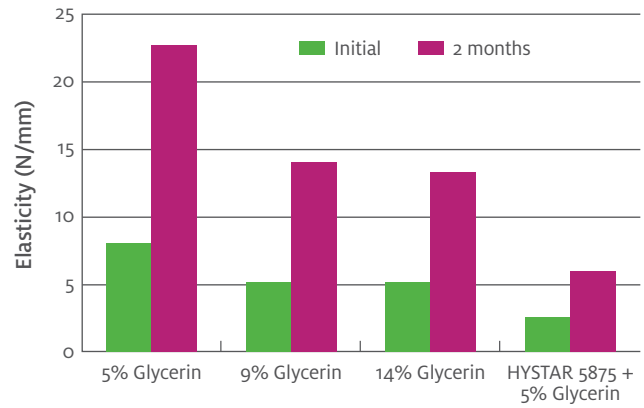


FIGURE 2: COMPARISON OF HARDNESS OF NUTRITIONAL BAR CENTERS AFTER 3 MOS.



with a soft initial bite which became quite chewy (requiring more work to chew). On the other hand, the bar made with HYSTAR 5875 Maltitol Syrup was soft and easy to chew. There also seems to be a limit at which glycerin can be added in this particular application. As the glycerin level was increased to 14%, case hardening of the center was observed over time, possibly due to moisture and glycerin

FIGURE 3: COMPARISON OF ELASTICITY VALUES OF NUTRITIONAL BAR CENTERS OVER 2 MOS.



migration. The result was a harder exterior with a softer interior that had lower stiffness (Figure 2).

Overall, this case study demonstrates that replacing corn syrup, fructose, and/or glycerin in a nutritional bar formulation with the maltitol/polyglycitol solutions available from Ingredion can improve the texture during shelf-life storage.

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