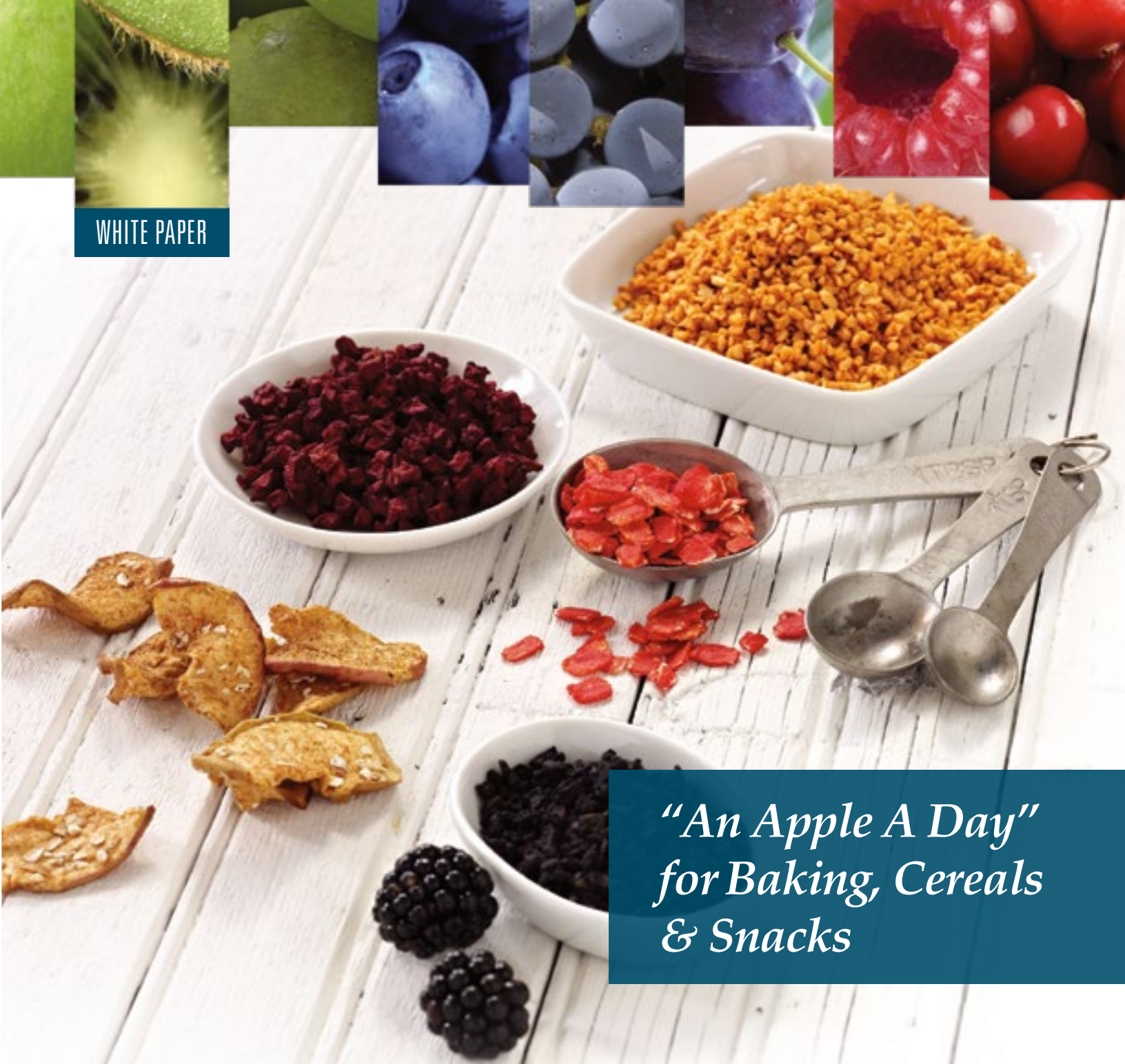


WHITE PAPER

"An Apple A Day" for Baking, Cereals & Snacks

Dehydrated Apples - Adaptable, Appealing, and Attractive

ARTICLE SUMMARY: In this white paper, we will review the selection, processing, shelf life, nutrition, and practical aspects of the use of evaporated and low moisture apple products in snacks, bars, cereals and bakery products.

AUTHORS: Doug Webster, *Director of Product Development, Tree Top, Inc.*
Kevin Holland, *Senior Food Scientist, Tree Top, Inc.*

TREE TOP® Grower Owned Since 1960 fruit ingredients™

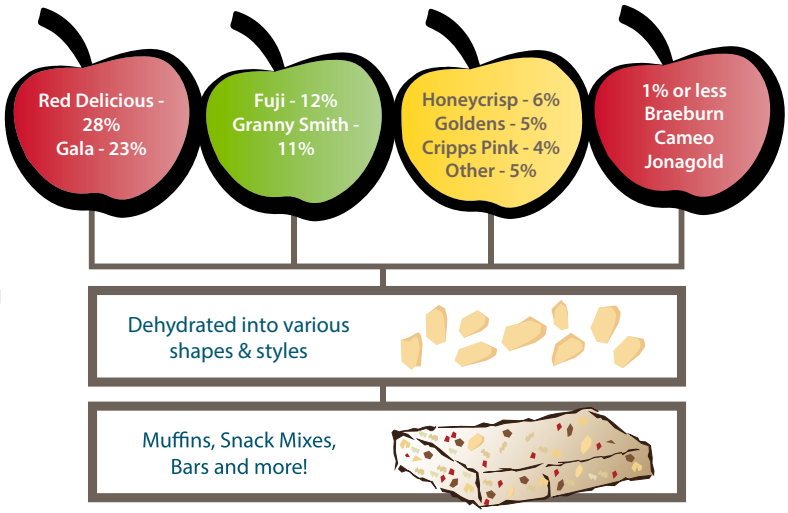
"A" is for apple and the apple in today's menu is adaptable, appealing and attractive. Bakery and snack professionals are finding the apple an attractive accent to their bread, cake, pie, snacks, breakfast and nutritional bars. Tree Top has good news for food development professionals. Apple production is increasing and technology for processing is becoming more innovative, meeting the future needs of the baking, cereal and snack food industries.

Many bakers will remember the days when hand preparation of apples was common. The apple was chosen for clean, sound quality and then peeled, cored, sliced or diced, and included in their favorite apple pie formula. The baker was pleased with the result because he had controlled every step of the process. However, with the growth of bakeries, on-site processing became impractical and the processed apple industry was able to meet the needs of the baker with quality fresh, frozen, canned, or dehydrated apple products.

The total U.S. annual production of apples is about 248 million boxes, or 5,208,000 tons.

Raw Material Selection and Handling

In today's market, apples selected for processing in a dehydration operation depend on the varieties grown in the region and customer need. Most of the United States production is accounted for by 20 varieties. The total annual production of apples is about 248 million boxes, or 5,208,000 tons. The apples that are not sent to the fresh market are processed into all different ingredient forms. Washington State is the largest producer of apples, growing over 60% of U.S. apples.



Varieties:
As noted, apples chosen for dehydration vary according to the availability in the region and the suitability of the variety for dehydration, and commercial use. Figure 1 summarizes the production of fresh apples in Washington State.

Washington State Fresh Boxes (000) (40/lb. Unit)

Varieties	2016
Reds	38,600
Goldens	7,200
Granny Smith	15,500
Fuji	17,200
Gala	31,200
Braeburn	1,600
Jonagold	600
Cameo	400
Cripps Pink	6,200
Honeycrisp	8,300
Other	7,300
Total	**134,100**

fig. 1 - reported March 2017

GALA
Flavor: Crisp and very sweet
Appearance: Pink-orange stripes atop a yellow-blush skin

The predominant apple variety chosen for dehydration is Gala. Gala apples are sweet and mellow in taste, have a semi-firm texture, and are vertically striped or mottled - overall blush in color. Since it stores fairly well in cold and controlled atmosphere storage, it is available almost year-round to the processor. It is uniformly round in shape and, therefore, processes well on automated peelers.

FUJI
Flavor: Sweet
Appearance: Red-blush

Fuji apples, also popular for dehydration, are typically round and range from large to very large, averaging 75 mm in diameter. They contain between 11–18% sugars by weight and have a dense flesh that is sweeter and crisper than many other apple cultivars, making them popular with consumers around the world. Fuji apples also have a very long shelf life compared to other apples, even without refrigeration. With refrigeration, Fuji apples can remain fresh for up to a year and are typically available from October through June or July.

GRANNY SMITH
Flavor: Tart
Appearance: Green

The Granny Smith is still in the top 5 of total tons harvested in Washington State, both in fresh fruit production and as a dehydrated product. It is a tart apple with white-green flesh and is firm in texture. Granny Smith is one of several apple cultivars that are high in antioxidant activity, and they boast the highest concentration of phenolics amongst the apple breeds.

HONEYCRISP
Flavor: Sweet, tart
Appearance: Red, yellow-blush

Honeycrisp apples are rapidly becoming a prized commercial variety known for their sweetness, firmness, and tartness. They have much larger cells than most apples, which rupture when bitten to fill the mouth with juice. This apple is becoming so popular, several snack and bar manufacturers are highlighting "made with Honeycrisp apple" on their retail package. Honeycrisp apples lose their crisp texture during prolonged storage which reduces their availability during the months of March through September.

GOLDEN DELICIOUS
Flavor: Sweet, mellow
Appearance: Yellow skin

Golden Delicious apples are sweet and mellow with a tender golden skin, and its flesh stays white after slicing for longer than other varieties. With refrigeration Golden Delicious are typically available from September through August, however this variety has been declining in production and, as a result, not as readily available for processing as traditionally seen.

Quality:
The field representatives for dehydration companies pay close attention to quality as they deal with each fresh apple packing house in the contracting of peeler fruit for a processing season. Defects, such as bruising, bitter pit, and hail damage, can severely affect the quality of the fruit.

A peeler quality apple is a superior apple to the apple that goes to the juice process. Peeler quality apples must meet certain size criteria to be suitable for production equipment and certain appearance quality specifications to be considered for an evaporated (regular moisture) apple product. It also must meet certain pressure test requirements, depending on customer requirements for a soft or firm apple dice in their product.

Pre-Processing Handling:
The fresh apple packing house personnel are educated on the importance of careful handling of the apples that go to the processor. The sorting bins are sometimes water-filled. Since the apples float in water, the incidence of bruising is reduced.

Bins of fruit destined for the processor are stored in cold storage or controlled atmosphere rooms until they are needed. Controlled atmosphere is a low-temperature, low-oxygen (1%), low-carbon dioxide (1.5%) storage room where fruit is, essentially, "put to sleep" in regards to respiration and ripening processes.

Processing

Grading:
When the apples are received at the processing plant, they are graded for quality then transferred into water-filled tanks. The apples are washed and sized to remove very large and small apples that are more suitable for other processes. As they enter the process, apples are inspected visually and sorted for obvious defects.

Peeling and Coring:
Typically, a mechanical peeler removes the skin, then a tube removes the core, and finally small curved blades remove the seed cell pocket from the apple.

Dicing and Slicing:
The peeled and cored apples are then diced or sliced to customer specification. In most processes, the dices are optically sorted removing additional blemishes, seeds, stems, or carpel from the product stream.

Typical sizes for diced apples are:

- ¾ inch x ¾ inch x ¼ inch
- ¾ inch x ½ inch x ¼ inch
- ½ inch x ⅜ inch x ¼ inch
- ⅜ inch x ⅜ inch x ⅜ inch
- ¼ inch x ¼ inch x ¼ inch

Other sizes available:

- Pie Pieces
- Wedges
- Rings
- ¼ inch x 1 inch x NEC

Preservation Treatment:
Sodium sulfite, potassium metabisulfite, and sulfite alternative blends (ascorbic acid, citric acid, sodium chloride, and calcium chloride) have been the traditional agents used to minimize enzymatic and non-enzymatic browning and microbial spoilage in dried fruit. The freshly peeled apples are dipped or sprayed with the chosen solution prior to dehydration.

Tree Top has developed a proprietary blend of sea salt and lemon juice to minimize enzymatic browning

without the need for sulfites. The treatment protects color during drying and maintains a bright color in low moisture food systems. For dried apples with no treatment, Tree Top dries the apples to a water activity (a_w) below 0.60 where spoilage organisms do not grow.

Dehydration Processes:
Most processes use a continuous gas-fired air dryer to reduce the moisture of a fresh apple from 85% to 14-24%. At this moisture, they are shelf stable and typically referred to as evaporated or regular moisture. They can be further dried to an intermediate moisture range of 10 – 14% moisture or dried to below 3.5% for low moisture food applications. Evaporated (regular moisture) apples are typically used for high moisture food systems such as fruit fillings and baked goods, however the snacking industry is using more evaporated apples with the increase of consumer snacking. Intermediate moisture is best suited for snack bars ranging in water activity (a_w) of 0.40 – 0.60, while low moisture is best used for low a_w pastry fillings, crispy snacks/bars and cereal. Drying apples reduces freight costs, increases shelf life, and increases the versatility of use in food systems.

The air flow, bed depth, temperature, and time in each stage are crucial to maintaining quality color and moisture levels in the final product. ***See fig. 2.*** The dices may be subjected to an equalization step after dehydration to assure proper moisture levels in the final product.

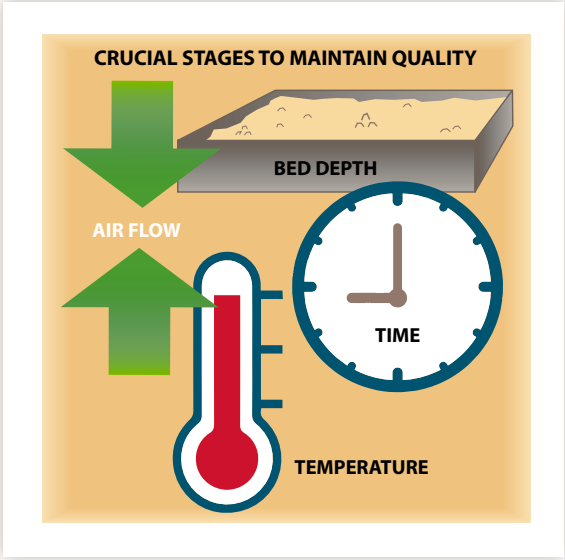


fig. 2

Evaporated (regular moisture) products are custom manufactured to meet customer needs. In the case of a "dry cut," an additional cutting of the evaporated (regular moisture) apple dice is required to produce chips, granules, grind or low moisture powder. These products are used in various bakery fillings and snack bars.

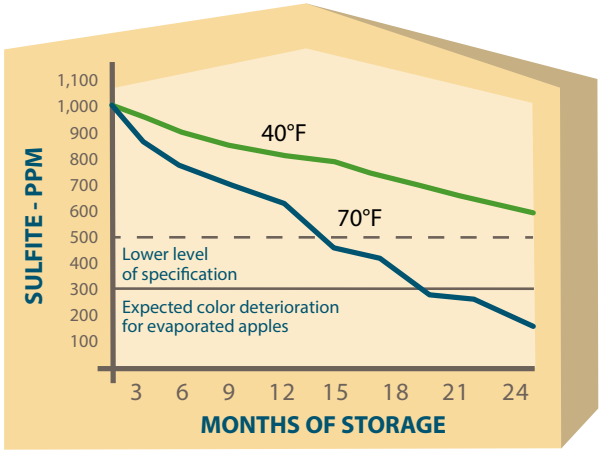


fig. 3

Packing/Storage and Shelf Life:
The evaporated (regular moisture) apple products are typically packed in 40-50 pound fiberboard cases, and low moisture apples, depending on the product type, are typically packed in a 15-30 pound case, although other pack sizes are available. Product is packed within a polyethylene case liner which is either folded or heat sealed to protect the product. The case is sealed with tape and stacked on a pallet. Storage temperature for dried apples is very crucial to the preservation of quality (flavor and color). Sulfites dissipate at different rates, depending on temperature of storage. Figure 3 shows these typical dissipation rates under different conditions.

Storage/Shelf Life Recommendations

	Ambient Storage <70°F	Refrigerated Storage <45°F	Frozen Storage <0°F
Evaporated Apples / Intermediate Moisture Apples			
Contains Sulfites (500-1500 ppm)	18 Months	2 Years	Not Necessary
No Treatment	1 Year	2 Years	Not Necessary
Alternative Preservatives	Not Recommended	6 Months	2 Years
Low Moisture Apples			
Contains Sulfites (500-1500 ppm)	2 Years	4 Years	Not Necessary
No Treatment	2 Years	4 Years	Not Necessary
Alternative Preservatives	18 Months	2 Years	Not Necessary
Low Moisture Powders*			
Standard (with Calcium Stearate)	Not Recommended	2 Years	Not Necessary
Othe Flow Agents (silicon dioxide or other)	Not Recommended	2 Years	Not Necessary

**Low moisture fruit powders are susceptible to clumping with temperature swings, for best handling properties, please maintain refrigerated storage conditions*

Grades and Quality

Dried apple manufacturers work closely with each customer to develop a specification that meets their product requirements. Common attributes are moisture, water activity, sulfite level (if used), sieve analysis, color, maximum allowable vegetative materials (VM) and blemishes (visual defects).

Mechanical removal of peel, core, seeds, calyx, and stems from apples is not 100%. Although this material is not harmful, most manufacturers have maximum allowable limits that are set in the specification. If the apples are bruised during harvesting, packing or in the manufacturing process, these can develop into a visual blemish, which also has limits set forth in the specification. Product grading is performed during the process. Blemishes are monitored from beginning to end so the equipment operators can make changes to reduce the blemish level if necessary.

Typical Uses and Functionalities

Table 1

Apple Type	Functionality	Products
Evaporated (Regular Moisture) Apples		
Dices	Piece identity, flavor extender	Fruit fillings, fried pies, danishes, strudels
Grinds	Extenders, texture, apple sauce, integrity	Cookie filling, granola bars, fruit bars
Wedges/Pie Pieces	Large piece identity	Baked goods, snacks, pies
Chops (whole chopped apple dices)	Piece integrity, flavor, inexpensive	Mincemeat, apple butter
Low Moisture Apples		
Dices	Piece identity, flavor	Cereals, granola bars, dry mixes
Flakes	Rapid rehydration, piece identity	Cereals, instant hot cereals, dry mixes
Tenderized Dices	Semi-rapid rehydration	Refrigerated doughs, cereals
Granules	Small piece identity, appearance, flavor	Cake mixes, muffins, granola bars, cereals, toppings
Powders, Flake Powders	Texture, flavor, prevent "boil out," extender	Apple sauce, cookie fillings, cake mixes, fruit leather

Typical applications for the various evaporated (regular moisture) and low moisture apples and their functions are presented in ***Table 1***. Low moisture apples are low in water activity (a_w =0.15 -0.25) and are used in dry cereal, bakery, and snack products where controlled water activity (a_w) is crucial to prevent oxidative rancidity, microbial deterioration, and color degradation. A crisp, crunchy apple texture may be a necessary attribute to the product.

Cereals:
Low moisture apples are used primarily in the cereal, and snack food industries. The cereal industry utilizes mostly low moisture apple products as granules, flakes, and dices in ready-to-eat, cooked, or instant-type breakfast cereals. The apples can also be colored and flavored with other fruit flavors, such as strawberry, peach, and blueberry, to increase their versatility in cereal products.

Bakery Foods:
The baking industry uses custom-made fillings (apple, raspberry, blueberry, etc.) which are formulated using evaporated (regular moisture) apples for flavor, texture, piece identity, and extending other higher cost fruit. A baker may also develop his own formulation for a pastry filling. The apple fillings are deposited on Danish pastries, strudels, or in soft cookies or filled fruit bars. Evaporated (regular moisture) or intermediate moisture apples may also be added to a dry mix suitable for cakes, cookies, or muffins.

Snack Foods:
A rapidly growing use of dehydrated apples is in the snack food industry, specifically fruit and nut granola bars and fruit rolls. Intermediate or low moisture apple granules or dices in combination with cinnamon or various fruit flavors are a great snack for lunch, coffee breaks, picnics, or athletic activities.

Reconstitution for Bakery Production Applications

Water Temperature
Evaporated (regular moisture) apples can be reconstituted with either hot or cold water. ***See fig. 4***. Although the most popular method for reconstitution is to heat the evaporated (regular moisture) apples with 3-5 parts water, apples may be slowly reconstituted using a cold water soak. These cold water reconstituted apples can be worked into a cold or hot starch filling if a firm texture and piece integrity are desired. Customers may want to experiment with cook time and quantity of water addition to determine the ideal texture for their application.

Effect of Variety
Varietal differences in sugar/acid ratios determine the perceived sweetness and tartness of the fruit. The higher acid apples (Granny Smith, etc.) will taste tarter. Also, the malic acid content can interfere with applications incorporating a leavening agent (sodium bicarbonate, etc.), requiring adjustments in the amount of apples, the type of apples, or the amount of leavening acids (sodium acid pyrophosphate, potassium acid tartrate, sodium aluminum sulfate, anhydrous monocalcium phosphate, sodium aluminum phosphate, etc.). Excess carbon dioxide production prior to baking can produce an undesired texture in muffins or cakes. Refrigerated doughs for biscuit or muffin products require limited initial carbon dioxide release during preparation and packaging and considerable gas release during baking. Thus, sweeter apple varieties such as Golden Delicious, Fuji and Gala have been used, since the titratable acidity is lower than Granny Smith apples.

All Purpose Filling
A common use of evaporated (regular moisture) apples is in a typical cooked filling. The apples

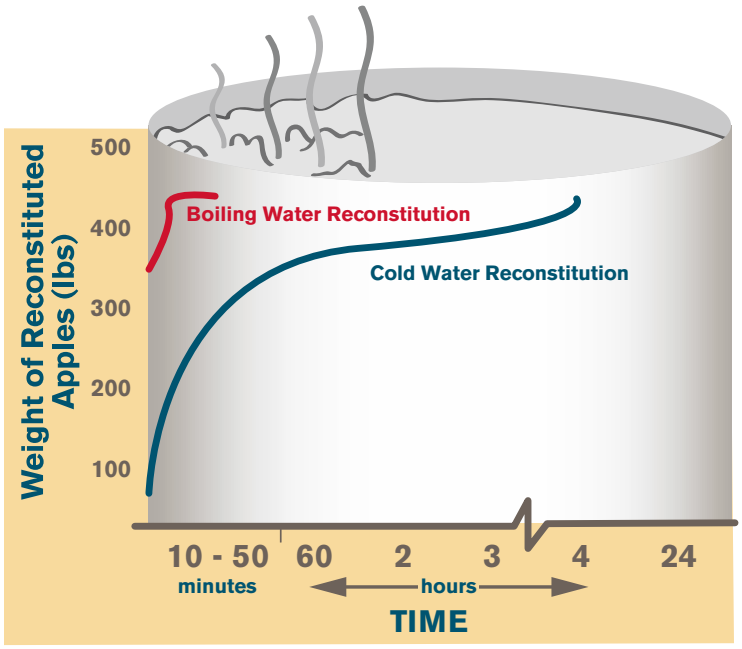


fig. 4

are simmered for five to ten minutes or until the desired reconstituted texture is obtained. The blend of sugars and spices can be varied to meet the expectations of the bakery professional and are added after the apples have been cooked to limit competition with the apples for the available water. The proper amount of starch (to give the desired consistency) is added as a slurry with water and cooked until the mixture thickens. The starch type must be acid stable, freeze-thaw stable for specific applications, smooth in consistency, and bland in flavor. For a fried pie application, the starch may have to be increased to stabilize the pie during and after the frying operations.

Effect of Season:
Evaporated (regular moisture) apples vary in their reconstitution ratio with the time of year when processed. Early season (August – September) fruit is higher in acid, lower in sugar solids, and firmer in texture. The cook times may have to be increased to produce the desired texture. The level of water in the formulation may have to be decreased to allow for lower absorption. The level of citric acid and/or lemon juice may have to be decreased to produce the desired tartness level. The piece integrity of early season fruit in a filling is a consistent, firm, intact apple dice.

Late season fruit (late October – late November) tends to be softer when reconstituted. A greater reconstitution ratio is likely to be seen in mature fruit requiring an increased level of water in the formulation to achieve the desired consistency. The acidity is lower and sweetness or sugar solids are higher than early season fruit. Some dices may lose their piece integrity if cooked excessively. The length of cooking time may have to be increased to minimize loss of texture. Controlled atmosphere fruit (January – July) typically has intermediate firmness.

Effect of Variety:
The variety of apples chosen for a filling will make a difference in the characteristics of that filling. Red Delicious apples tend to cook up to a sweeter, softer dice. Golden Delicious apples allow flexibility in texture and flavor. Granny Smith apples are typically a firm, tart dice in a filling.

Boil Out:
At times a phenomenon known as "boil out" will occur in fruit pies due to low soluble solids. Moisture can be bound and soluble solids increased through the use of apple powder or apple flake powder to help reduce boil out.

Nutritional Composition

Evaporated Apples with Sodium Sulfite

NUTRIENT OR ITEM	
Calories (per/100 g)	298
Ash (g/100 g)	2.8
Fat (g/100 g)	0.0
Saturated Fat (g/100g)	0.0
Trans Fat (g/100 g)	0.0
Moisture (g/100 g)	23.3
Total Carbohydrates (g/100 g)	72.4
Total Sugars (g/100 g)	57.9
Added Sugars	0.0
Dietary Fiber (g/100g)	9.0
Protein (g/100 g)	1.2
Cholesterol (g/100 g)	0.0
Vitamin A as b-carotene (IU/100 g)	<70
Vitamin C (mg/100 g)	2.0
Vitamin D (mg/100 g)	0.0
Sodium (mg/100 g)	555.4
Potassium (mg/100 g)	685.5
Calcium (mg/100 g)	29.1
Iron (mg/100 g)	0.5

Evaporated Apples - No Additives

NUTRIENT OR ITEM	
Calories (per/100 g)	322
Ash (g/100 g)	1.7
Fat (g/100 g)	0.0
Saturated Fat (g/100g)	0.0
Trans Fat (g/100 g)	0.0
Moisture (g/100 g)	17.7
Total Carbohydrates (g/100 g)	79.5
Total Sugars (g/100 g)	62.7
Added Sugars	0.0
Dietary Fiber (g/100g)	10.8
Protein (g/100 g)	1.1
Cholesterol (g/100 g)	0.0
Vitamin A as b-carotene (IU/100 g)	<70
Vitamin C (mg/100 g)	2.2
Vitamin D (mg/100 g)	0.0
Sodium (mg/100 g)	12.6
Potassium (mg/100 g)	777.4
Calcium (mg/100 g)	19.6
Iron (mg/100 g)	0.4

Low Moisture Apples with Sodium Sulfite

NUTRIENT OR ITEM	
Calories (per/100 g)	371
Calories from Fat	0.0
Ash (g/100 g)	3.705
Fat (g/100 g)	<0.1
Saturated Fat (g/100 g)	0.0
Trans Fat (g/100 g)	0.0
Moisture (g/100 g)	3.49
Total Carbohydrates (g/100 g)	91.2
Total Sugars (g/100 g)	81.5
Added Sugars	0.0
Dietary Fiber (g/100g)	11.2
Protein (g/100 g)	1.56
Cholesterol (g/100 g)	0.0
Vitamin A as b-carotene (IU/100 g)	<70
Vitamin C (mg/100 g)	<0.5
Vitamin D (mg/100 g)	0.0
Sodium (mg/100 g)	771.3
Potassium (mg/100 g)	871.0
Calcium (mg/100 g)	35.7
Iron (mg/100 g)	0.6

Low Moisture Apples – No Additives

NUTRIENT OR ITEM	
Calories (per/100 g)	371
Calories from Fat	0.0
Ash (g/100 g)	3.705
Fat (g/100 g)	<0.1
Saturated Fat (g/100 g)	0.0
Trans Fat (g/100 g)	0.0
Moisture (g/100 g)	3.49
Total Carbohydrates (g/100 g)	91.2
Total Sugars (g/100 g)	81.5
Added Sugars	0.0
Dietary Fiber (g/100g)	11.2
Protein (g/100 g)	1.56
Cholesterol (g/100 g)	0.0
Vitamin A as b-carotene (IU/100 g)	<70
Vitamin C (mg/100 g)	<0.5
Vitamin D (mg/100 g)	0.0
Sodium (mg/100 g)	1.7
Potassium (mg/100 g)	871.0
Calcium (mg/100 g)	35.7
Iron (mg/100 g)	0.6

These are average values and should be used only to approximate the nutritional composition of any food formulations. Nutritional data not found on this list are present in levels not required by NLEA standards.

About the Authors

Doug Webster, Director of Product Development, Tree Top, Inc.

Doug Webster has been with Tree Top, Inc. since 2000 and is currently Director of Product Development. In this role, he leads a research and development team, creating custom fruit solutions for customers of Tree Top. Doug earned a B.S. in biology at Western Washington University and a M.S. in food science from Washington State University. After completing his masters, he moved to the Yakima Valley focusing his endeavors in the hop, wine, and fruit industries. Doug is a wine maker and, until recently, owned his own winery. He now only makes wine for family and friends.

Kevin Holland, Senior Food Scientist, Tree Top, Inc.

Kevin has been with Tree Top, Inc. since 2011 and is currently a Senior Food Scientist. In this role, he focuses on process research, troubleshooting existing products and processes, providing technical support to internal and external customers, and maintaining research projects. Kevin earned a B.S. in biology with a minor in philosophy at the University of Pittsburgh at Bradford and a Ph.D. in food science from Virginia Tech. After completing his doctorate, he worked for a year as a postdoctoral associate at Virginia Tech investigating antimicrobial alternatives to sodium benzoate in beverages. Kevin has three children, all under the age of five. He is our in-house cider expert and enjoys demoing his hard cider creations with the Tree Top team.

References

Charlotte L. Deuel Tree Top August 1986

Yepsen, Roger (1994). Apples. New York: W. W. Norton & Co

Lee, C.Y.; N.L. Smith (2000). Apples: An Important Source of Antioxidants in the American Diet

Granny Smith is healthiest apple, Retrieved 2013-02-27

Cabe, Paul R.; Baumgaten, Andrew; Onan, Kyle; Luby, James J.; Bedford, David S. (2005).

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220 E. Second Ave., Selah, WA 98942
(800) 367-6571 ext. 1435
Jeannie.Swedberg@treetop.com
treetopingredients.com