

# The New Salad Crop Revolution

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## HISTORY OF LETTUCE

When discussing recent changes in a system, it is always useful to place those changes in some sort of historical context, in order to assess the magnitude and significance of the changes. The recorded history of cultivated lettuce (*Lactuca sativa* L., Asteraceae) begins in Ancient Egypt (Keimer 1924; Harlan 1986). Unrecorded development may have originated in the Middle East, where there appears to have been great diversity in wild lettuces, and it is possible that cultivation began there as well. But the record we have begins in the IV Dynasty of Ancient Egypt (about 2500 BCE), with realistic representations of lettuce in tomb paintings. The Early and Middle Dynasty paintings are easy to recognize as lettuce, because of the realism. Along with other types of representations, of people, animals, objects, and other plants, the appearance of lettuces in the Late Dynasties becomes more stylized and less recognizable, except by inference and comparison. Some early scholars referred to the pictures as those of artichoke, cypress, or other plants.

The paintings show lettuce with thick stems and long, narrow, pointed leaves (Ryder 1999). Stem lettuce is still cultivated in Egypt; the stems are eaten raw, like a stalk of celery. Another form of lettuce bolts easily, has long narrow leaves, and produces seeds that are crushed for production of a cooking oil. This oilseed form is grown now in Egypt and neighboring countries, but may also be quite ancient.

Modern stem lettuces look a little like romaine lettuce and it is likely that this latter form arose as lettuce began to move around the Mediterranean Sea. Flat rosetted forms frequently appear as sports in romaine lettuce, and it seems likely that non-heading leaf lettuces first appeared in this way. Lettuce was quite popular in Ancient Greece and Rome, and existed in a number of forms, with either green or red leaves.

Lettuce moved north into Western Europe and various new forms are described as early as the 15<sup>th</sup> century. These included the butterhead, Latin, and crisphead forms. Columbus may have taken lettuce to the New World in 1494, on his second voyage. The last step in the proliferation of lettuce types was taken in 1941, with the release of 'Great Lakes', the first true iceberg type. It is larger and firmer than the crisphead lettuces developed earlier in Europe, which are known as Batavia types.

Lettuce also went to China, and was first noted there in the 5<sup>th</sup> century. Chinese lettuce is also of the stem type but it is consumed as a cooked vegetable rather than raw.

With this information as background, we can examine more recent developments. In the last quarter century, substantial changes have occurred in the lettuce and salad industries. Four of these changes will be discussed: (1) the types of lettuce that are used in various regions of the world have changed; (2) the development of value-added products, particularly in the area of consumer packaging; (3) the addition to salads of many new leafy species, particularly in miniature or baby form; and (4) the increasing consciousness, among consumers, dieticians, and restaurateurs, of the nutrient and anti-oxidant value in green and red leafy salad vegetables.

## LETTUCE TYPES AROUND THE WORLD

There are six edible forms of lettuce in the species *L. sativa*: crisphead (iceberg and Batavia), romaine, butterhead, leaf, Latin, and stem (Ryder 1999). All except iceberg occur in red and green leaf forms. Over the years, different forms became important in different regions. In the Mediterranean region (Spain, Italy, the Middle East, and North Africa), romaine lettuce, in various forms and colors, was the principal type. In Northern Europe, most people used butterhead lettuce and the Batavia form of crisphead lettuce. Stem lettuces remained important in Egypt, the Middle East, and China.

In the United States, in early years, up to the beginning of the 20<sup>th</sup> century, lettuce consumption was distributed among all types, but principally among butterhead, leaf, and American Batavia types. At the turn of the century (Tracy 1904), the number one lettuce was 'Prizehead' (red leaf), followed by 'Hanson' (Batavia), 'Tennis Ball Black Seeded' (butterhead), and 'Big Boston' (butterhead) (Table 1).

Two decades later (Morse 1923), the top variety by a large margin was 'New York', followed by 'Big

**Table 1.** The five most important lettuce cultivars in the United States, 1904 and 1923. In approximate descending order of importance. Source: Tracy 1904; Morse 1923.

1904		1923	
Cultivar	Type	Cultivar	Type
Prizehead	Red leaf	New York	Crisphead
Hanson	Crisphead	Big Boston	Butterhead
Black Seeded Simpson	Green leaf	Grand Rapids	Green leaf
Tennis Ball Black Seed	Butterhead	Salamander	Butterhead
Big Boston	Butterhead	Hanson	Crisphead

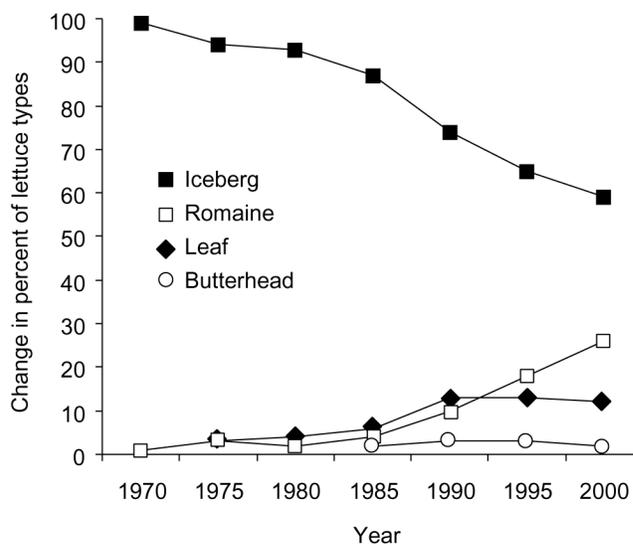
Boston', 'Grand Rapids' (green leaf), 'Salamander' (butterhead), and 'Hanson'. The ascent of 'New York', a larger, firmer, Batavia type, marks the early development of the Western shipping industry, which essentially replaced the market garden production in the highly populated Eastern and Midwestern states. Lettuce could be grown year round in the West (California and Arizona), irrigated through wells or canals (and thus be independent of rainfall with its excesses and droughts), in cool weather ideal for good growth, and shipped in large volume at all times. The best lettuce for these conditions, particularly in shipping ability, was crisphead lettuce, and for most of the century, nearly all the lettuce was of this type. 'New York' was replaced by the Imperial cultivar group, and then finally by 'Great Lakes', the first true iceberg type.

In the 1970s, things began to change. People began to travel and discovered foods that other people had been eating. The British and Scandinavian peoples discovered the American mixed salad, and with it, iceberg lettuce, which very quickly became the major type grown and consumed in those countries. Iceberg showed up on the menus in hotels everywhere in the world, as Western business travelers appeared in the hotel dining rooms.

In the US, the salad bar became popular and offered diners an array of vegetables including several kinds of lettuces. Also, it became practical to ship the more tender lettuces long distances because of improvements in cooling equipment, especially in long distance trucks, which could move across country in four days. The non-iceberg lettuces grew in popularity. Nearly every restaurant featured Caesar salad, made with romaine lettuce. The result: in the Salinas Valley, Monterey County, California, 40% of total production is now non-iceberg, and 75% of that is romaine (Data from Monterey County Crop Reports) (Fig. 1). These figures are quite indicative of the trend for the entire country.

The popularity of other lettuces also grew in other countries, following business, tourism, and awakened interest in new, fresh items. So, to a certain extent we have returned to the diversity that existed a century or more ago.

This diversity has presented challenges to lettuce breeders. It is now necessary to breed desirable traits such as resistance not just into iceberg cultivars, but also into romaine, butter, and leaf lettuces in separate programs. Also, new, or previously unnoticed diseases, have surfaced. A form of tomato bushy stunt virus has appeared which attacks primarily romaine and red leaf lettuce (Obermaier et al. 2001). There are no commercial cultivars of either



**Fig. 1.** Change in the percentage of different lettuce types, produced in Monterey County, California, 1970 to 2000 by five year increments.

type that are resistant. A crown blight, of unknown fungal origin, attacks romaine almost exclusively (Koike and Subbarao 2001). Verticillium wilt, unknown in lettuce until 1995, causes severe damage to all commercial iceberg types and most other lettuces (Subbarao et al. 1997). Breeding programs have been initiated to transfer resistance to the various types.

### THE VALUE-ADDED REVOLUTION

In the 1970s, two phrases came into the language of the produce industry: lightly processed and value-added. Until then, lettuce, spinach, cabbage, chicory, and endive went to market as whole heads, trimmed, packed in corrugated boxes, and cooled. At that time, light processing by chopping and shredding of the product was begun. Early on, lettuce was cored, shredded, washed, and packed into large plastic bags for shipping to fast-food outlets or large institutions such as hospitals and schools. The package contained either all iceberg lettuce or a mixture of iceberg lettuce with shredded red cabbage and carrots. Within a few years, this market was expanded into consumer packaging, as small one or two meal packages appeared on supermarket shelves.

At first these contained the same items as the large institutional packages. But, very quickly, and with gathering momentum, a tremendous variety of combinations appeared, such that supermarkets might devote 10% of their vegetable shelf space to these packages. Salad packs might include: iceberg and romaine, romaine and butter, two lettuce types plus radicchio, spinach leaves, romaine hearts, or field greens. Then, the Caesar salad kit came along, with romaine lettuce, croutons and a package of dressing. Other products, including various dressings, bacon bits, or chicken chunks, were added to the mix. You could buy a package of shredded red cabbage, or cole slaw, or even broccoli slaw.

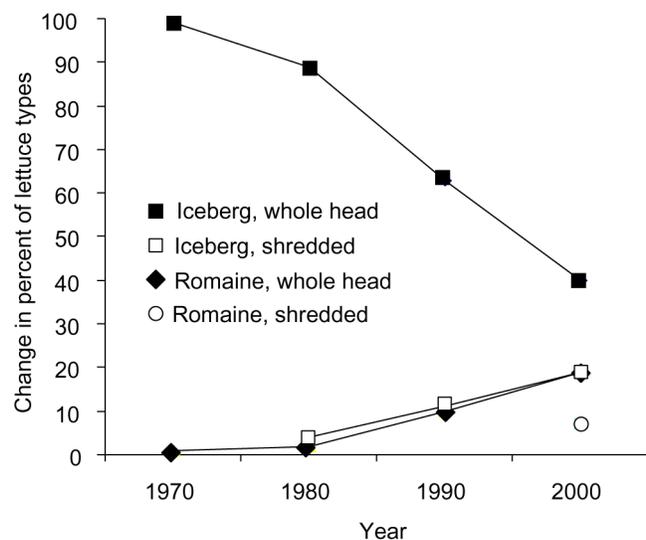
In the early days, lettuce remaining from fields harvested in the standard manner was used for shredding and packaging. The lettuce was usually overmature, and the quality was poor. But as the demand increased, more and more fields were planted, under a guaranteed price contract, specifically for harvesting into bins for use in packages. The products dramatically increased in freshness and quality. In 1970, nearly all lettuce grown in California was for whole head harvesting. Approximately 35%–40% of the lettuce in California is now grown and cut up for packaging. The changes that have taken place are breathtaking (Fig. 2).

The research needs specific to value-added products would be those that contribute to the shelf life of the foods in the package and to the appearance of the product. Shelf life is related to prevention of wilting, off-flavors, and rotting diseases. Good appearance requires bright colors, especially for red leaves, and the absence of lesions caused by tipburn, cut-surface browning, and other physiological disorders. Both types of problems can be addressed by genetic improvement and by improved packaging materials, in-package atmospheres, and pre-packaging treatment of the vegetables.

### NEW LEAFY SPECIES FOR SALADS

*Mezclar* is a Spanish word meaning “to mix.” “Mesclun” is a name used for a salad mixture of leaves of various species. Traditionally, in the Provence region of France, mesclun consisted of four items: chervil, arugula, lettuce, and endive in precise proportions. Mesclun is also known as spring mix, boutique salad, or field greens. In Monterey County alone, nearly 3600 ha of spring mix vegetables were grown in 2000, up from less than 200 in 1995.

Mesclun is a unique product for several reasons. It is made up principally of small whole leaves, harvested when they are 10 cm long, or less. They are seeded in beds, and harvested with a small knife at about four weeks. Several types of lettuce may be



**Fig. 2.** Change in the percentage of whole-head and shredded iceberg and romaine lettuce, 1970 to 2000, by ten year increments.

mixed in a single bed; other species are grown each on a separate bed. The final mixture is a jewel box of colors; a symphony of flavors, achieved by various combinations of 10–15 items. These may include several lettuces (green and red romaine, green and red leaf, oak leaf, green and red butter, Latin), as well as beet tops, spinach, swiss chard, perilla, frisee, radicchio, tat soy, mizuna, mustard, various kales, orach, mache, chervil, dandelion, purslane and, of course, arugula.

Many of these items are familiar to us in other guises. Spinach (*Spinacia oleracea* L.), swiss chard (*Beta vulgaris* L.), beet tops (*B. vulgaris* L.), all Chenopodiaceae, mustard (*Brassica juncea* L.), and kale (*B. oleracea* L.), both Brassicaceae, may be more familiar as cooked vegetables. Radicchio and frisee (curly endive) (*Cichorium intybus* L. and *C. endivia* L., Asteraceae, respectively) are usually found on the produce counter near the lettuces, in whole head form. The other species on the list may require some description.

Mizuna and tat soy are Oriental vegetables (*Brassica campestris* L. or *B. rapa* L., Brassicaceae). Mizuna has deeply cut leaves. Tat soy has very dark green spoon shaped leaves, which grow in a tight rosette. Perilla [*Perilla frutescens* (L.) Britt., Lamiaceae] is also Oriental. The leaves may be either intense red or green.

Orach (*Atriplex hortensis* L., Chenopodiaceae) is best known as a spinach substitute, having similar flavor, but without the puckering effect from oxalic acid. Maché (*Valerianella locusta* L., Valerianaceae) is a popular salad vegetable in Western Europe, particularly in the spring. It is also known as corn salad or lamb's lettuce and was grown in this country many years ago. Chervil (*Anthriscus cerefolium* Hoffm., Apiaceae) is related to celery and parsley. The leaves are quite aromatic and it is commonly used as an herb.

Dandelion, purslane, and arugula are probably better known as weeds, but have been selected for cultivated use. Dandelion (*Taraxacum officinale* Wiggers, Asteraceae) has two additional uses: wine is made from the flowers and a coffee substitute from the root. A related species, *T. kok-saghyz*, was once considered as a possible source of natural rubber. Purslane (*Portulaca oleracea* L., Portulacaceae) is one of our worst weed pests, but the cultivated forms are used either as an annual flower or as a vegetable. Arugula (*Eruca vesicaria* L. Cav., Brassicaceae) is also known as rocket (England), rucola (Italy), roquette (France), and garghir (Middle East). It is one of the most popular of the baby greens because of its unique, spicy flavor.

Nearly all the current research on these vegetables relates to whole plant production. Growers of the baby vegetables have concentrated on planting, growing, harvesting, and packaging procedures. There has been some cultivar work, primarily by Japanese, French, or Italian seed companies. Few studies have been done on insect and disease control, including resistance, and very little is known about nutrient content.

## SALADS AND NUTRITION

The final aspect of the salad revolution is the increasing interest in nutritional content of leafy vegetables, with special interest in anti-carcinogenic effects. In lettuce, there is a well recognized disparity in the contribution of head lettuce as compared to the other commonly used forms (Table 2) (Rubatzky and Yamaguchi 1997). This disparity actually applies only to vitamins A and C, and calcium. We have begun a new project in our breeding program to investigate these differences, as well as cultivar differences within types, and the possibility of making improvement in nutrient content. An interesting aspect of this goal is the unique heading trait of iceberg lettuce and the possible differences between the green outer leaves and the whitish interior

**Table 2.** Nutritional values for various types of lettuce. Values are for 100 g of edible product: Ca, calcium; P, phosphorus; Fe, iron; Na, sodium; P, potassium. Source: Rubatzky and Yamaguchi 1997.

Type	Minerals (g)					Vitamins		Water (%)	Fiber (g)
	Ca	P	Fe	Na	K	A (IU)	C (g)		
Crisp	22	26	1.5	7	166	470	7	95.5	0.5
Butter	36	26	1.8	7	260	1065	8	95.1	0.5
Romaine	44	35	1.3	9	277	1925	22	94.9	0.7
Leaf	68	25	1.4	9	264	1900	18	94.0	0.7

leaves. It appears possible that nutrient constituents may be affected differentially by this color difference.

The scope of our breeding program will be partly influenced by the fact that lettuce is consumed in great volume compared to many other vegetables with higher nutrient content. The actual contribution of lettuce to the human diet is considerably higher than the content per unit of weight would suggest (Stevens 1974).

In any case, leafy salad vegetables are important contributors of vitamins and minerals, such as vitamins A and C, calcium, and potassium. Anti-oxidant activity is obtained from vitamin C, vitamin A and other carotenoids, and vitamin E and other tocopherols. Phytochemicals without vitamin activity that are important anti-oxidants include a variety of flavonoids, which are associated with color, astringency, and bitterness. In leafy vegetables, red and purple colors in the leaves are caused by one group of flavonoids, the anthocyanins. These colors can be enhanced by breeding, both for their attractiveness and their anti-oxidant activity.

Significant and exciting changes have taken place in the world of fresh produce in the past thirty years. It is not unlikely that these changes will continue, extending the evolutionary story begun several thousand years ago.

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