

**DESCRIPTION AND QUALITY OF SOME MANGO
VARIETIES GROWN IN HAWAII
AND THEIR SUITABILITY FOR FREEZING**

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DESCRIPTION AND QUALITY OF SOME MANGO VARIETIES GROWN IN HAWAII AND THEIR SUITABILITY FOR FREEZING

INTRODUCTION

Quick-freezing of Hawaii fruits is a comparatively new process in the Islands, and much work is needed to determine the methods that will provide products of high quality. Mangos grow on all the Hawaiian Islands, but not all varieties are available on every island. Since 1949, this laboratory has frozen all of the superior named mango varieties obtainable (unknown seedlings were not included), varying the treatment and type of product, and testing the frozen samples after different periods of storage.

This paper presents the descriptions of 21 Hawaii varieties of mangos and the results of freezing tests (for 20 varieties) for two seasons.

DESCRIPTION OF FRUIT

Since descriptions of the mango varieties commonly found in Hawaii are not readily available (the excellent bulletin by W. T. Pope published in 1929 is now out of print), this bulletin includes not only data on freezing, but a description of fresh mangos such as might be useful for the housewife or the processor (table 1). The variety and source, size, form, color of skin and flesh, thickness of skin, texture of flesh, and the fruit flavor are described for all the fresh fruits investigated. Texture and flavor of flesh were rated by an organoleptic panel (see p. 15). A glossary of words used by horticulturists to describe mango "forms" in table 1 with definitions of terms is presented on page 10. These terms are also used to label the drawings showing the form characteristics of Hawaii mangos (figure 1).

Size

The size of mangos is influenced by climate and soil conditions. They have been classed by weight as small, medium, large, and very large in table 1. Fruit 4 to 8 ounces is considered small; from 8 to 12 ounces, medium; 12 to 16 ounces, large; and 16 ounces and over, very large.

Form

The description of mango forms is best explained by the drawings in figure 1.

Color of Skin and Flesh

Skin color is varied; it may run from greenish-yellow, through bright yellow to red in ripe fruit. The flesh colors ranged from a greenish-yellow to a deep orange.

Thickness of Skin

Skin may be thin, medium thick, or very thick. It may be removed easily, which is termed "glove peel," or it may adhere closely to the flesh and need to be removed with a knife.

Texture of Flesh

Texture of flesh is varied; the most desirable is smooth, fine-grained, and relatively free of fibers. Some fruits have a slippery texture which is not particularly desirable.

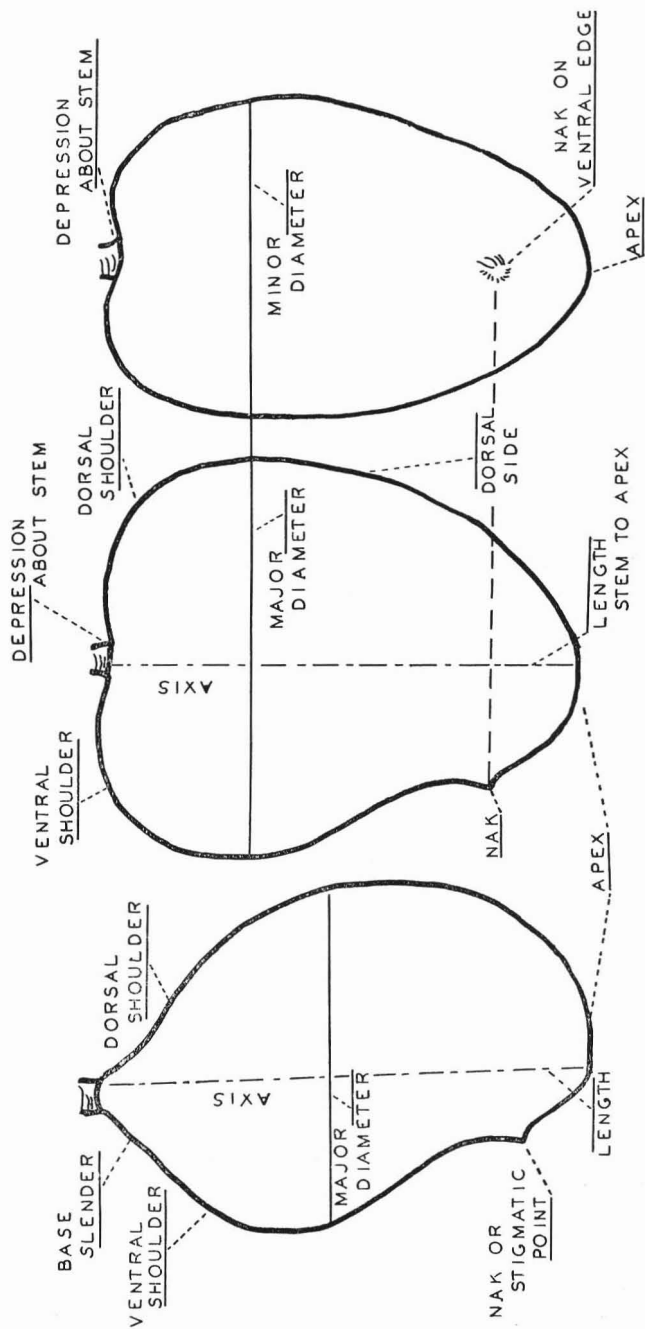


Fig. 1. Form characteristics of Hawaii mangoes (after Pope, 2).

TABLE 1. DESCRIPTION OF SOME MANGOS GROWN IN HAWAII.

VARIETY AND SOURCE	SIZE	FORM	COLOR		THICKNESS OF SKIN	TEXTURE OF FLESH	FLAVOR
			Skin	Flesh			
BICKNELL (Oahu)	Small— av. wt. 4 oz.	Roundish with beak or nak at apex	Greenish peel overlaid with orange cheek; small light pinpoint dots over all	Yellow with green cast; overlaid with green veins under peel	Thin; difficult to remove	Smooth, except for fibers under peel	Very tart and astringent; (acid affects jaw)
BISHOP (Kauai)	Medium— wt. 8-12 oz.	In general, oval; shoul- ders nearly equal; dorsal side symmetrically round- ed to apex; ventral side tapers slightly from mid- dle to prominent nak, slight depression about stem.	Greenish yellow with heavy red cheeks overlaid with small dark and light dots	Yellow with greenish cast	Very thin; difficult to remove	Very coarse; slippery	Strong turpentine aroma and flavor
BOSWELL (Oahu)	Small— av. wt. 4 oz.	Oblong; base slender around stem; pro- nounced nak with de- pression above	Bright yellow and very smooth	Yellow- orange	Medium thick; easily removed	Firm; relatively free of fibers	Excellent flavor; sweet and mild
BROOKS LATE (Kauai)	Medium— wt. 8-12 oz.	Oval with ventral and dorsal shoulders full; depression around stem, apex rounded with nak inconspicuous	Green with yellowish pink blush; small promi- nent light green dots overlay skin	Bright yellow- orange	Medium thick	Somewhat porous but very juicy; fibers deep into flesh under peel	Tart; on acid side

TABLE 1. (cont'd.)

CAMBODIANA (Oahu)	Medium— wt. 8-10 oz.	Oblong to oblong-ovate; depression about stem; apex pointed	Greenish- yellow to deep yellow; smoo.h	Deep yellow	Thin and tender	Very juicy; fiber-free	Sub-acid; slightly aromatic
FAIRCHILD (Kauai) (Oahu)	Medium— wt. 8-12 oz.	Oval with ventral shoul- der large; apex pointed and near center	Greenish with deep yellow- orange over- cast; scattered, white pinpoint dot overlay	Lemon- yellow	Thin; difficult to remove	Rather dry; fibers under peel but not deep into flesh	Tart; suggestive of turpentine, but not unpleasant
HADEN (Oahu and Kauai)	Very large— av. wt. 16 oz. or more	Round; oblique—very full ventral and dorsal shoulders with depres- sion around stem; apex rounded with nak very inconspicuous.	Mostly yellow with red cheeks when ripe; overlaid with many pinpoint yellowish dots	Yellow- orange to deep orange	Thick; easily removed from ripe fruit	Somewhat coarse and slightly stringy beneath peel; few fibers deep in flesh; slippery	Mild, aromatic; excellent
HANSEN (Oahu)	Small to medium— wt. 6-10 oz.	Form roundish, ovate- reniform or ovate-ob- lique with distinct beak at stigmatic point	Greenish-yellow to light yellow with dark red cheeks; stem area overlaid with small yellow dots	Yellow- orange	Medium thick	Very juicy	Quite tart, little starchy; resembles a Pirie
HOLT (Oahu and Kauai)	Small to medium— wt. 8-12 oz.	Full dorsal and ventral shoulders with depres- sion around stem; oval shaped with 2 flat sides; apex broad; rather point- ed toward the ventral; nak very prominent	Greenish yellow with white specks at stem; very smooth	Deep orange	Thick and tough; glove peels when ripe	Coarse and spongy; few fibers except around seed; some slipperiness	Very tart, with aroma of Pirie

TABLE 1. (cont'd.)

HOTOKE (Kauai)	Medium— av. wt. 8 oz.	Oblique — unsymmetri- cal; ventral shoulder large; apex pointed	Yellow with casts of red	Light yellow— almost lemon colored	Very thin; tears easily on peeling	Smooth and slightly slippery; very few fibers	Extremely mild or bland
JOE WELCH (Mapalehu 30) (Molokai)	Large to very large— wt. 14–20 oz.	High ventral shoulder —sloping dorsal—fruit oval to round, slightly oblique; full apex with pronounced depression above prominent nak; also depression around stem	Light to deep yellow with red bloom near stem end; over- lay of deeper red dots; very smooth.	Deep yellow orange	Thin; glove peels	Very smooth and fine- grained; almost fiber- free; slight slipperiness	Mild; excellent fruit
JULIE (Oahu)	Small to medium— wt. 4–8 oz.	Roundish with broad apex; very pronounced nak at center of apex	Greenish- yellow with pinpoint white dots overlaid; dark red dots around stem	Deep orange	Medium thick	Fibrous and extremely soft and juicy; stringy under peel	Somewhat tart; resembles Joe Welch
KALIHI (Oahu)	Medium— av. wt. 8 oz.	Roundish with blunt double apex; slight de- pression around stem	Golden apricot (yellow- orange) — sometimes splashed irreg- ularly with bright red about the shoulder; small pinpoint white dots	Yellow to orange	Medium in thickness, smooth; peels easily	Strings and bristling texture to flesh due to small fibers throughout; firm	Somewhat tart; pleasing aroma

TABLE 1. (cont'd.)

KRUSE (Kauai)	Medium to large— av. wt. 1.2 oz.	Roundish with pointed apex; length and breadth almost equal	Lemon-yellow; overlaid with green cast and light yellow pinpoint dots	Yellow- orange	Medium thick; peels easily	Firm with compara- tively few strings except directly under peel; extremely smooth	Slightly tart, but good
LEMON CHUTNEY (Kauai)	Small— av. wt. 5 oz.	Oblong; slightly oblique base full about stem; dorsal shoulder slight; ventral shoulder high; slight depression around nax	Rich, lemon yellow	Yellow	Thin and paper- like	Firm, but slightly fibrous; juicy	Sub- acid or mild
LOTT'S SPECIAL (Oahu)	Medium to large— wt. 8-20 oz.	Roundish; ovate - reni- form or ovate-oblique with distinct beak at stigmatic point	Yellow with green cast and slight rose blush on cheek with overcast of white dots	Yellow- orange to orange	Medium thick	Very juicy and very fibrous	Extremely sweet, also strong turpentine flavor
ONO (Oahu)	Small— av. wt. 4 oz.	Ovate-reniform or ovate- oblique with distinct beak at stigmatic point; rounded apex	Yellow with orange-blush cheek; over- laid with small light pinpoint dots	Yellow- orange	Extremely thin	Firm, and slightly juicy; large furry area around pit	Flavor somewhat bland, also slight turpentine taste

TABLE 1. (cont'd.)

PARIS (Oahu)	Small— av. wt. 4 oz.	Oblong with rather extended apex; large ventral shoulder; nak not very prominent	Yellow with red cheek; heavy bloom; skin smooth with small white dots	Deep, bright yellow	Medium thick; difficult to remove	Comparatively dry; heavy fibres around pit	Tart with slight turpentine flavor
PIRIE (Oahu)	Medium— av. wt. 12 oz.	Roundish, ovate-reniform or ovate-oblique with distinct beak at stigmatic point	Greenish yellow with crimson cheeks and pale yellow dots	Bright yellow-orange	Moderately thin; some strings beneath	Fine-textured and juicy; fibers deep into flesh under peel	Sweet, spicy; may have slight turpentine flavor, not objectionable
WHITNEY (Oahu)	Medium— wt. 8-12 oz.	Oblong; with flattened side; rather extended apex; large ventral shoulder	Greenish yellow overlaid with light pinpoint dots	Lemon-yellow with green cast	Medium thick and leathery	Starchy; many strings under peel and fibrous around seed	Very aromatic; some flavor of turpentine
WOOTTEN (Oahu)	Medium— wt. 8-12 oz.	Roundish with broad apex; stem in shallow cavity	Yellow-orange with deeper orange bloom; overlaid with dark pinpoint dots; peel rough to touch	Yellow-orange, apricot color	Thin; hard to peel	Smooth-textured; dry, but very slippery	Mild

Flavor

Flavor depends considerably on personal likes and dislikes. Some fruits are tart and slightly astringent; others are bland and subacid. Sweetness is desirable. Turpentine flavor and starchiness are not considered good qualities; however, some mangos exhibit these characteristics when not completely ripe and lose them as the fruit matures. Prime ripeness and top quality fruit are essential for superior flavor.

GLOSSARY

- apex—blossom tip of mango; opposite to stem end of fruit
 axis—central vertical line of fruit from stem to apex, or maximum length of fruit
 dorsal—surface of mango turned *away* from the axis
 nak (or stigmatic point)—promontory of flesh near or at apex of fruit
 oblique—neither perpendicular nor horizontal, but slanting, inclined
 oblong—broadly elliptical; longer in one direction than another
 oval—egg-shaped
 ovate-oblique—egg-shaped and also slanting or inclined
 ovate-reniform—egg-shaped and also curved or bent like a half-moon
 stigmatic point—see *nak*
 ventral—opposed to dorsal, surface turned *toward* the axis

PHYSICAL AND CHEMICAL VALUES

Some physical and chemical characteristics of Hawaii varieties of mature mangos are presented in table 2.

Considerable variation in physical and chemical values was noted in table 2 not only between varieties but also within one variety from year-to-year, and from island-to-island in the same year. The physiological and climatic conditions of rainfall, sunshine, temperature, soil conditions, etc., probably contribute considerably to these differences within one variety.

Percent Flesh and Waste

The amount of mango flesh available for freezing (edible portion) ranged from 45.5 to 82.9 percent; the pit waste from 9.1 to 26.8 percent; skin or peel waste from 7.1 to 39.2 per cent; and the total waste from 17.1 to 55.0 percent. All of these figures exhibit wide disparity, making some varieties more desirable than others for freezer use.

Percent Moisture

These values ranged from 76.4 to 85.4 percent, a difference of 9.0 percent. Moisture values are somewhat more consistent than edible portion or waste values.

Ascorbic Acid

The ascorbic acid values for the 18 varieties checked showed wide divergence. Mangos as a group are considered only a fair source of vitamin C. However, the Holt (1951), Julie, Kalihi, and Wootten varieties proved to be good sources of ascorbic acid in 1951 and 1952. Great differences were again noted within one variety from year-to-year and island-to-island. For example, the Fairchild 1951

(Kauai) tested 26.0 milligrams ascorbic acid per 100 grams flesh, while the Fairchild 1952 (Kauai and Oahu) exhibited only 9.9 and 8.4 milligrams ascorbic acid per 100 grams edible portion.

pH

The pH range for the mangos listed in table 2 is wide. The mango varieties with the lowest pH did not exhibit the highest values of ascorbic acid, but the Haden and Holt varieties with pH values of 3.90 and 3.70 were scored "tart" in flavor by the taste panel. The Ono variety with a pH of 3.90 was considered somewhat "bland" in flavor and did not follow the Haden-Holt pattern.

COLOR CHART AND CODE*

Color has three dimensions, *hue*, *value*, and *chroma*, which fully and accurately describe any color as well as the three dimensions of a box describes its length, width, and breadth. Each of these dimensions can easily be measured and stated simply in writing.

Hue

Hue denotes the name of any color. When a prism breaks a ray of sunlight into a band (the spectrum) of its component colors, red, yellow, green, blue, etc., each is termed the *hue*, or common name of that color. Any red is red in *hue*. *Hue* is the first characteristic of a color that the eye detects. It is how we know, for instance, that a red is red and not green or any other color. In notating a color, its *hue* is indicated by the initial letter or letters of the color referred to—R for red, YR for yellow-red, Y for yellow, etc.

Value

Value is called the variable light strength of color. Pure white is so light that no color can be seen in it. Pure black is so black that no color can be seen in it. But between the two can be distinguished various degrees of light strength ranging from darkest gray, just above black, to lightest gray, just below white, and colors can be seen at these various intermediate levels of light strength. For instance, yellow is usually a light color and nearer to white than black. Purple-blue is usually a dark color, nearer to black than white.

The eye can readily distinguish and memorize ten different steps of *value*, graduated from black at the bottom up to white at the top. *Value* can be estimated with the unaided eye and accurately measured by comparing the color with the *value* scale. Pure black is indicated by numeral 0 at the bottom of the scale and pure white by 10 at the top of the scale. The pure gray is known as neutral and is indicated by the initial N with its level indicated by a numeral set above a line at the right as N2/, N3/, N7/, etc. N0/ is black and N10/ is white.

By comparing any color with the different grays of the scale, it is easy to distinguish the *value* of that color, which simply indicates how light or dark that color is. *Value* is notated by a numeral (corresponding to the numbered levels in the *value* scale) placed above a line to the right of the *hue* designation. For instance, a red of a lightness about halfway between black and white would be the fifth level of *value*, indicated as R5/.

*Excerpts from Munsell (1).

TABLE 2. SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF HAWAII VARIETIES OF MATURE MANGOS.

VARIETY	YEAR	SOURCE	NO. FRUIT	TOTAL WEIGHT	FLESH	PIT	PEEL	TOTAL WASTE	MOIS- TURE	ASCOR- BIC ACID	pH	COLOR CHART CODE (FLESH) *
BICKNELL	1952	Oahu	54	16.0	%	%	lbs.	%	%	mg./100 g.	4.20	10.0 YR 7/10
BISHOP	1952	Kauai	30	27.5	56.2	25.0	18.8	43.8	79.0	39.9	4.20	10.0 YR 7/10
BOSWELL	1951	Oahu	8	3.0	64.5	24.6	10.9	35.5	85.4	19.4	4.22	10.0 YR 7/10
BROOKS LATE	1952	Kauai	36	31.7	-----	-----	16.6	-----	-----	30.0	-----	-----
					64.6	18.1	17.3	35.4	76.4	30.6	4.30	7.5 YR 7/10 10.0 YR 7/10 2.5 Y 8/10
FAIRCHILD	1951	Kauai	51	27.5	45.5	25.0	30.0	55.0	-----	26.0	-----	-----
FAIRCHILD	1952	Kauai	74	32.0	70.8	25.0	24.2	49.2	79.0	9.9	4.00	10.0 YR 7/10
FAIRCHILD	1952	Oahu	34	14.0	60.8	21.4	17.8	39.2	80.3	8.4	4.20	10.0 YR 7/10
HADEN	1951	Kauai	24	25.5	49.0	11.8	39.2	51.0	-----	14.0	-----	-----
HADEN	1952	Molokai	53	30.7	63.4	20.3	16.3	36.6	82.3	10.5	3.90	10.0 YR 7/10
HADEN	1951	Oahu	30	33.7	69.7	10.4	19.9	30.3	-----	-----	-----	-----
HADEN	1952	Oahu	76	51.5	63.4	18.7	17.9	36.6	83.5	11.4	-----	10.0 YR 7/10 7.5 YR 7/10
HADEN (Loo)	1952	Oahu	3	2.7	70.9	9.1	20.0	29.1	-----	5.1	-----	-----
HANSEN	1952	Oahu	16	8.7	82.9	10.0	7.1	17.1	80.3	5.1	-----	7.5 YR 7/10
HOLT	1952	Kauai	57	38.2	60.8	26.8	12.4	39.2	84.8	17.8	3.70	7.5 YR 7/10 (gr) 7.5 YR 7/8
HOLT	1951	Oahu	9	5.2	61.8	19.1	19.1	38.2	-----	58.0	-----	-----

TABLE 2. (cont'd.)

HOLT	1952	Oahu	37	17.7	64.8	21.1	14.1	35.2	81.4	36.8	4.15	7.5 YR 7/10 (gr.) 2.5 Y 8/12
HOTOKE	1951	Kauai	38	20.5	58.5	19.5	22.0	41.5	.....	.....	.....	.....
JOE WELCH	1951	Molokai	156	140.0	65.4	22.0	12.6	34.6	.....	.....	.....	.....
JOE WELCH	1952	Molokai	39	25.7	64.0	21.4	14.6	36.0	84.9	21.9	4.55	7.5 YR 7/10 (darker) 7.5 YR 6/10
JULIE	1952	Oahu	25	12.2	57.2	20.4	22.4	42.8	76.4	53.1	4.30	7.5 YR 7/10
KALIHI	1952	Oahu	14	7.5	60.0	20.0	20.0	40.0	82.6	53.9	4.00	10.0 YR 7/10
KRUSE	1951	Kauai	62	39.7	62.1	13.2	24.5	37.7	.....	.....	.....	.....
KRUSE	1952	Kauai	30	21.5	65.2	11.6	23.2	34.8	84.3	1.4	4.30	10.0 YR 7/10
LOTT'S SPECIAL	1952	Oahu	11	9.2	67.6	18.9	13.5	32.4	79.9	13.5	4.45	7.5 YR 7/10 10.0 YR 7/10
ONO	1952	Oahu	23	10.0	62.5	20.0	17.5	37.5	80.8	32.9	3.90	10.0 YR 7/10
PARIS	1952	Oahu	60	23.0	46.8	23.9	29.3	53.2	80.7	20.0	4.65	7.5 YR 7/10
PIRIE	1951	Oahu	4	2.8	70.4	14.8	14.8	29.6	.....	.....	.....	.....
PIRIE	1952	Oahu	51	27.7	60.9	17.1	22.0	39.1	80.3	10.6	4.13	10.0 YR 7/10
WHITNEY	1952	Oahu	20	10.5	62.0	16.6	21.4	38.0	82.6	12.6	4.20	2.5 Y 10/10 2.5 Y 8/12
WOOTTEN	1952	Oahu	39	19.2	70.6	11.6	18.8	30.4	78.0	51.0	.....	10.0 YR 7/10

* From Munsell Color Chart. See p. 11 for explanation.

Two colors may be in the same *bue* (for instance, both red) and the same in *value* (that is, neither is lighter nor darker than the other), and yet be different in color strength. One may be a strong red and the other a weak, grayish red. This difference is the dimension of *chroma* by which the degree of color strength (intensity) is measured.

Hue is the name of a color. *Value* is the amount of light in a color. *Chroma* is the degree of strength in a color.

Chroma

A step in *chroma* is the unit of measure of change in a *bue* (color) between neutral gray and the maximum *chroma* of that *bue*. These steps graduate from neutral gray out to the strongest. *Chroma* is obtainable in any *bue* at any given *value*. The steps are numbered outward from N toward maximum *chroma*, and in notating the color the numeral is placed below the line, under the numeral for *value*. For instance, a red midway between white and black and five steps out in *chroma*, would be written R5/5. Red at a sixth level of *value* and three steps out in *chroma* would be written R6/3. Thus, the arrangement in notation of *bue*, *value*, and *chroma* is HV/C.

The *chromas* close to neutral are known as "weak"; those at or near maximum are called "strong." The mid-*chromas* are "moderate" *chromas*.

The color codes for the Haden (Oahu) mango taken from table 2 are 10.0 YR 7/10 and 7.5 YR 7/10. These codes would be interpreted in the following manner from the Munsell Color Charts:

10.0 YR is the *bue* symbol and is defined as "yellow-red yellow"; 7/10 is the *value/chroma*. The 7 is a light *value* only three steps removed from white, or one may say a very small amount of gray is present in the "yellow-red yellow"; 10 is the *chroma* of "yellow-red yellow" and is the strength of the color present; for this particular color, it is the most intense or strongest *chroma* on the chart and indicates a maximum of "yellow-red yellow."

7.5 YR indicates a *bue* of "yellowish-yellow-red" from the chart; a color with more red present than found in 10.0 YR. The *value/chroma* is again 7/10 and interpreted as in the preceding paragraph.

The majority of the Hawaii mango varieties in this study checked for color (table 2) fell into the categories interpreted for the Oahu Haden. A few samples which were of the yellow-green type (Whitney and Brooks Late) had *bues* of 2.5 Y (reddish yellow) with *value* and *chroma* readings of 8/10 and 8/12.

METHODS OF FREEZING

From the 19 varieties of Hawaii mangos available for freezer studies, about 900 samples were packed as follows:

Halves or cheeks. The peeled mangos were cut into cheeks or halves from the flat side of the fruit. These halves were packed in sugar sirups of 20, 25, and 35 percent concentration, both plain and with added ascorbic acid powder (1/4 teaspoon per pint of sirup). Some cheeks were also packed in dry sugar in proportions of 1 part of sugar to 32, 10, and 8 parts of fruit by weight. Sugar packs of the same proportions were also frozen with added ascorbic acid (1/4 teaspoon or 8 grams per pint). These dry packs are especially recommended for reprocessing into pies and cobblers and also may be used as dessert packs on short-time storage.

Finger slices. Several varieties of mangos available in ample supply were packed as finger slices. The halves or cheeks were cut into finger-length pieces and packed in sirups of the same concentrations, with and without added ascorbic acid, as used for cheeks or halves.

Purees. The flesh left clinging to the pits after the cheeks had been sliced off was scraped from the seed and put through a pureer (aluminum cone with wooden pestle) to remove any strings found near the seeds or other extraneous matter. This puree was packed with dry sugar in variations of 1 part of sugar to 10, 8, and 4 parts of puree by volume, plain and with added ascorbic acid ($\frac{1}{4}$ teaspoon per pint of puree). Purees may be reprocessed into ices, sherbets, ice creams, and beverages.

Fruit cocktails. Fruit cocktails were packed using mango chunks in several combinations with other fruits, such as

- 1) 1-part mango, 1-part lychee halves, one Surinam cherry for color
- 2) 1-part mango, 1-part pineapple chunks, one Surinam cherry for color
- 3) 1-part mango, 1-part mountain apple, one Surinam cherry for color

These fruit cocktails were packed in 20, 25, and 35 percent sugar sirups, plain and with added ascorbic acid ($\frac{1}{4}$ teaspoon per pint of sirup).

Whole mango. Whole fruit of a few varieties of mangos were frozen untreated except for aluminum foil wrap.

All the above samples were frozen at -14°F. (-24.5°C.) for 24 hours and then stored at 0°F. (-18°C.).

Not all fruits were packed by all methods, owing to scarcity of fruit for some varieties.

RESULTS OF FREEZING TRIALS: ORGANOLEPTIC TESTS

Taste tests were conducted on each of the 21 varieties of fresh fruit in order to acquaint the taste panel with the individual characteristics of each variety. Mangos tend to differ widely in their inherent qualities of color, flavor, texture, and sweetness, and within the same variety when grown under different physiological conditions, as from one island to another, and season and time of year.

A total of 897 frozen mango packs and variations representing 20 varieties were tested by a trained taste panel of 4 to 6 persons. Samples were scored for color, texture of fruit, flavor, degree of sweetness, and general opinion (see score sheet sample on next page).

A high score of 4 and a low of 1 covered the test range. The various mango packs were checked after 4 to 6 months freezer storage at 0°F. , and again after 9 to 12 months storage. A discussion of the scores appears in this section.

Table 3 shows the mango variety preference rating for each organoleptic factor (color, texture, flavor, sweetness, and general opinion) by types of packs (halves, fruit cocktails, finger slices, purees, and whole) for the 1951 and 1952 seasons. It is concluded with a list of the best all-around freezing varieties for each year.

Halves, Cheeks, and Fruit Cocktails

Color of cheeks in sirups. The color of mango cheeks, fresh and frozen, in various concentrations of sugar sirup remained uniform. With a few exceptions, the color of all the 21 varieties checked by the organoleptic panel fell into the "desirable" to "natural and characteristic color" categories (3.0 to 4.0). A few fruit colors were judged "undesirable but acceptable" (2.0 to 3.0) after freezer

storage, but not necessarily on long storage. The fruit varieties whose natural color was light yellow, lemon yellow, or yellow with green cast, seemed less attractive both fresh and after freezer storage than the orange-colored fruit. Into this category fell such varieties as the Bicknell, Bishop, and Whitney. The 1951 pack of Joe Welch did not have as good a color rating as the 1952 pack. This variety of fruit, along with the Holt, evidenced bruising very easily, and this showed up in the color as dark or translucent areas.

Very little graying or fading of color was apparent in mangos, and no browning of any type occurred. Subtropical yellow-orange fruits do not possess the browning factor found in temperate peaches and apricots, so they do not present color problems of this type.

GRADING SHEET FOR MANGOS

Product _____ Name _____
 Date _____

Numerical score value:	(4.0)	(3.0)	(2.0)	(1.0)
Color	Natural and characteristic color	Desirable	Undesirable but acceptable	Off-color
Texture	Firm but not hard	Slightly soft or hard	Soft or hard	Mushy
Flavor	Characteristic flavor	Desirable	Poor or bland	Off flavor
Degree of sweetness	Pleasingly sweet	Slightly too sweet or too tart	Very sweet or very tart	Tasteless
General opinion	Excellent	Good	Fair	Poor

Comments:

The concentration of sugar sirup which appeared to maintain the best consistent mango color was the 25 percent sirup. Adding ascorbic acid maintained a better-colored fruit in the sweeter sirups. The value of ascorbic acid added to sugar sirups was found to be most evident in the color of the samples held for 12 months freezer storage at 0°F.

Color of cheeks in sugar packs. The color of these mango samples fell predominantly in the "desirable" class (3.0 to 4.0). However, some deterioration appeared on freezer storage. The 1951 Joe Welch pack showed a marked drop in color quality in 12 months of freezer storage for all sugar packs. Neither the concentration of dry sugar nor the presence of added ascorbic acid seemed to have any specifically marked influence on the retention of color quality. The inherent color of the mango variety was of more importance in judging color.

Although no browning was evident, bruising of the fresh fruit and unevenness of color in the fruit was accentuated in freezer storage. It was manifest as translucent spots or unevenly colored areas.

Color of cocktail in sirups. Both types of fruit cocktail presented a good color score ranging from 3.5 to 4.0. Cocktails containing mango chunks of the true orange color were somewhat more attractive than were mango chunks of the lemon-yellow color group, when mixed with pineapple or lychees because the orange-colored fruits presented a great color contrast to the white lychees and yellow pineapple chunks. Fruit cocktails were found to retain a bright color throughout all of the storage periods tested (4 to 12 months). The mango, mountain apple, Surinam cherry cocktail had nice color contrasts since the red skin of the apple remained bright. Samples with ascorbic acid showed the same color scores as the samples without added ascorbic acid, and the concentrations of sugar sirups showed no observable effect on color quality.

Texture of cheeks in sirups. Texture values for frozen mango cheeks packed in sugar sirups declined noticeably from the fresh mango score for most varieties (4.0 to 2.2 for Hotoke; 3.7 to 2.0 for Lott's Special, etc.) The Wootten variety maintained consistently good texture on freezer storage. In the fresh state, this is a very firm-fleshed mango. Mango varieties having a soft, tender texture in the fresh state showed some texture deterioration on freezer storage (Julie, Lott's Special, Bishop, and Hotoke).

Neither the concentration of the sugar sirups nor the addition of ascorbic acid showed any specific effects on the texture of frozen mango cheeks. Damage to the fruit is more attributable to freezing than to any of the substances added. Freezing removed some of the moisture from the fruit tissues, which caused them to collapse on thawing. The breakdown in texture was a physical phenomenon rather than a chemical one. Tissue breakdown was somewhat more evident as the storage time increased.

Sugar sirups exerted some protection over texture, since immersing the fruit in liquid caused most of the fruit moisture in the cheeks to stay inside the cell structure and kept the fruit full and plump.

Texture of cheeks in sugar packs. Mango cheeks packed for freezing in 32, 10, or 8 parts of fruit to 1 part of sugar showed texture scores lower in quality than those found in the fresh or in sirup-packed mango cheeks. Scores for most mango varieties fell in the "undesirable but acceptable" class (2.0 to 3.0) with a few exceptions. The Ono, Holt (Kauai), Wootten, and Pirie varieties had the highest texture scores for all the various sugar packs and storage periods.

The length of time in freezer storage and the concentration of sugar used in the packs had about equal effect on texture scores. One year (12 months) freezer storage caused a noticeable decline in texture quality for many mango varieties (Wootten, 3.7 to 1.8; Brooks Late, 2.8 to 1.8). These changes were noted most in the 1-part sugar to 32-parts fruit pack. Sugar packs of 1:10 parts of fruit showed much smaller texture changes on storage; while the 1:8 parts of fruit pack showed the least changes on storage. This would indicate a protective value of sugar on texture quality in freezer storage at 0°F.

Sugar-packed fruits are intended primarily for reprocessing the mango into other products. They do not have the nice appearance found in the sugar-sirup fruit packs because of the significant osmotic changes in the mango. Dry sugar has a tendency to pull moisture out of the fruit to bring the sugar into solution,

TABLE 3. MANGO VARIETIES RECOMMENDED FOR FREEZING, LISTED BY RATE OF PREFERENCE.*
(From 1951 and 1952 freezer studies.)

TYPE PACKS	COLOR		TEXTURE		FLAVOR		SWEETNESS		GENERAL OPINION	
	1951	1952	1951	1952	1951	1952	1951	1952	1951	1952
Cheeks in sirups	Haden Holt Joe Welch Kruise	Bishop Fairchild Haden Hansen Holt Joe Welch	Joe Welch Haden (K)† Fairchild (K)	Joe Welch Holt Ono Pirie Wootten	Fairchild (K) Haden Holt's Special Ono Pirie	Joe Welch Kruise Haden (K) Fairchild (K)	Fairchild (O)† Haden (O) Joe Welch Wootten Brooks Late Kruise	Fairchild (K) Joe Welch	Fairchild (K) Joe Welch	Ono Wootten Haden Hansen Fairchild Pirie
	Hotoke Joe Welch Kruise	Hansen Holt Kruise Ono Wootten Joe Welch	Joe Welch Hotoke Fairchild (K)	Wootten Hansen Holt (K) Ono	Wootton Pirie	Fairchild (K) Haden (K) Joe Welch Kruise	Fairchild Joe Welch Ono Kruise Whitney Brooks Late	Fairchild Joe Welch Kruise Haden	Joe Welch Kruise Haden	Pirie Wootten Ono

TABLE 3 (cont'd.)

Fruit cocktails in sirups	Kruse Hotoke Fairchild	Wootten Ono Joe Welch Kruse Hansen Bishop Brooks Late	Fairchild Kruse Joe Welch	Wootten Ono Fairchild Holt Joe Welch	Fairchild Haden Hotoke	Wootten Hansen Pirie Haden	Hotoke Kruse Fairchild Joe Welch	Wootten Whitney Hansen Joe Welch Kalihi Kruse Pirie Lott's Special	Fairchild Joe Welch Hotoke	Wootten Pirie Fairchild Hansen Lott's Special
Purees with sugar		Lott's Special Haden Julie Kruse Wootten Pirie		Kruse Julie Lott's Special Ono Bishop Haden		Julie Lott's Special Wootten Kruse		Lott's Special Haden Julie		Kruse Wootten Julie Ono
Slices in sirups		Fairchild Haden (O) Holt		Fairchild (K) Holt		Fairchild (K)		Haden Fairchild (K)		Fairchild (K)

* Best all-around freezing varieties: 1951—Joe Welch, Hotoke, Fairchild; 1952—Wootten, Fairchild, Pirie, Hansen, Ono, Joe Welch.
 † Kauai. ‡ Oahu.

creating a balance between the concentration of the liquid phase inside and outside the fruit. However, all the moisture drawn out of the fruit does not go back into the fruit once the sugar solution is formed. For this reason sugar packs may present a somewhat compact or shrivelled texture when the storage time is prolonged and the sugar concentration high.

Texture of cocktails in sirups. Both types of fruit cocktails scored within the 2.5 to 3.5 range ("slightly soft or hard" to "firm but not hard"). In many of the cocktail samples, the chunks of mango were slightly soft in texture. This was most obvious in the mango, pineapple, cherry combinations because of the contrasting firm texture of pineapple. The mango, mountain apple, Surinam cherry combination had desirable and pleasing texture contrast because the mountain apple maintained its crispness on freezing and thawing.

Neither the variation in sugar-sirup concentrations, nor added ascorbic acid, nor the duration of freezing storage, showed any appreciable effect on texture quality in mango fruit cocktails.

Flavor of cheeks in sirups. The scores for flavor of the fresh, untreated mango cheeks fell principally in the "desirable" to "characteristic flavor" groups, but on addition of sugar sirups in 20, 25, and 35 percent concentrations, plain or with added ascorbic acid, most flavor scores fell from 0.5 to 1.0 points below the fresh score. The addition of the sirup exerted more influence on lowering the flavor score than the time spent in freezer storage at 0°F.

The delicate mango flavor was "lost" in the sirup sweetness and resulted in a "bland" or "poor-flavored" product. The less sweet 20 percent or 25 percent sirups produced a better-tasting product than the heavier 35 percent sirup. Ascorbic acid was often recognized by increased tartness, which enhanced the natural mango flavor.

The two most prominent varieties desired as fresh fruit—Pirie and Haden—gave acceptable frozen products. The flavor scores for the Pirie fell into the "desirable" to "characteristic flavor" group (3.0 to 4.0), and the Haden into the "bland" to "desirable" group (2.0 to 3.0).

Varieties that held their flavor well in various concentrations of sirups and throughout the storage periods fell principally in the strong-flavored group (Ono, Hansen, Lott's Special, Fairchild).

Flavor of cheeks in sugar packs. Dry sugar packs of mango cheeks, with or without additional ascorbic acid, were given considerably lower flavor scores by the organoleptic panel than fresh, untreated mango cheeks (Brooks Late, from 4.0 to 2.5; Fairchild, from 4.0 to 2.3). The sugar, in most instances, masked the true mango flavor.

Length of storage time appeared to be an important factor in mango sugar packs. Noticeable deterioration in flavor occurred from 9 to 12 months freezer storage in several varieties (Brooks Late, Haden, and Holt).

This type of fruit—1 part of dry sugar to 32, 10, or 8 parts of fruit—is intended for reprocessing use in cobbles, pies, jams, etc., and not as a dessert pack. However, good flavor maintenance in freezer storage is highly desirable in all types of frozen fruit packs.

Flavor of cocktails in sirups. The flavor of both types of fruit cocktails (mango, lychee, Surinam cherry, and mango, pineapple, and Surinam cherry) fell in the score range of 2.0 to 3.5 with a few exceptions. The majority of the packs had

flavor scores ranging from 2.7 to 3.2 (which is "poor" or "bland" to "moderately desirable").

In varieties where both types of fruit cocktails were frozen, the mango, lychee, cherry combination showed a score value slightly higher than the mango, pineapple, cherry combination.

The three concentrations of sugar sirups used—20, 25, and 35 percent, with and without added ascorbic acid—ranked about the same for scores. All seemed to mask the true mango flavor to some degree.

Storage had some injurious effect on the flavor scores. The samples held in storage longest showed the lowest scores.

The Wootten fruit cocktail containing mango, mountain apple, and Surinam cherry presented a good product. Its flavor compared well with the lychee, or pineapple cocktail combinations.

Sweetness of cheeks in sirups. The sweetness scores of mango cheeks in sugar sirups did not show as great a change in value between fresh and frozen samples as noted between fresh and frozen *flavor* scores.

The cheeks packed in the 35 percent sirup seemed to be less desirable for sweetness than cheeks packed in 20 to 25 percent sirups.

No significant changes in sweetness of mangos seemed to occur in storage.

Sweetness is probably more closely related to flavor than to any of the other factors on which a product would be judged.

Scores for mango cheeks ranged mainly in the 2.3 to 3.5 bracket. The Haden, Brooks Late, Fairchild, and Joe Welch varieties showed consistently good sweetness scores.

Sweetness of cheeks in sugar packs. Mango cheeks packed in dry sugar in proportions of 1 part of sugar to 32, 10, and 8 parts of fruit, respectively, were preferred by the taste panel in the same order. The less sweet packs (1:32 and 1:10) had a more distinct flavor and also presented better texture, since less moisture was withdrawn from the fruit to put the dry sugar into solution.

Fruit varieties with the highest fresh scores maintained the highest sweetness scores on freezing (Brooks Late, Haden, Ono, Whitney, Pirie, Wootten, etc.).

A slight decrease in score value was noted for some varieties on storage at 0°F., but the decrease was not consistent in all packs.

Ascorbic acid crystals added to the dry sugar packs had no noticeable influence on the sweetness scores in any of the three types of sugar packs.

Where the same mango varieties were available for both the 1951 and 1952 packs, the 1952 pack showed a slight advantage in fruit quality over the 1951 pack for the "sweetness" factor.

Sweetness of cocktails in sirups. In the majority of the fruit cocktail packs of all fruit combinations, the less sweet sirups, 20 percent and 25 percent, plain or with added ascorbic acid, received higher taste scores than the 35 percent sirup packs. Too heavy a sugar sirup tended to mask or cover up the fruit cocktail flavors.

The majority of the fruit cocktails made from the 19 mango varieties, had sweetness scores ranging from 2.7 to 3.8. These scores were interpreted from the score sheet as "slightly too sweet or slightly too tart" to "pleasingly sweet." Personal preference and taste tolerance for sweetness contributed a great deal toward the individual's scoring record.

Length of time in storage at 0°F. appeared to exert no significant effect on the sweetness scores. For some varieties the scores were lower after storage, while for other varieties the scores were higher after storage. No consistent trend was indicated. The mango, pineapple, cherry cocktail, using the Holt (Kauai) fruit, had a more desirable sweetness score than the mango, lychee, and cherry fruit cocktail. For most mango varieties, both types of fruit cocktail combinations scored equally for sweetness.

General opinion of cheeks in sirups. The "general opinion" scores are a "ranking" score as to whether the product is "excellent," "good," "fair," or "poor." This score should fall somewhere within the range of the other scores for color, texture, flavor, and sweetness; however, it had a tendency to be less than the other scores for many packs. The taste panel seemed to score "general opinion" more nearly in the same range as the "flavor" scores.

General opinion scores for mango cheeks and sirups ranged from 1.8 to 4.0, but clustered mainly between 2.7 and 3.2. Interpreted from the score card, this meant that the samples were "fair" to "good." The Hanson, Ono, Pirie, and Wootten varieties all had consistently good scores for all three sirup packs with or without added ascorbic acid. Length of freezer storage time showed more effect on some varieties than others. Holt (Kauai) and Joe Welch and Wootten varieties all showed lower general opinion scores after 9 to 12 months freezer storage. The protective effect of added ascorbic acid was indicated by the slightly higher general opinion scores for all three sirup concentrations. The 20 percent sirup samples were given slightly higher scores than the samples packed in 25 percent and 35 percent sirups.

General opinion of cheeks in sugar packs. The general opinion scores for mango cheeks plus 1 part of sugar to 32, 10, and 8 parts of fruit were considerably lower than the general opinion scores for each fresh fruit variety, except Joe Welch. Most of these scores fell in the "fair" range (2.0 to 3.0) except for a few in the "good" range (3.0 to 4.0) and one or two in the "poor" range (1.0 to 2.0).

The Pirie variety, the Ono, and the Wootten were good fruits for sugar packs.

General opinion of cocktails in sirups. The general opinion scores on fruit cocktails packed in sugar sirups rated slightly lower than the other score factors of color, texture, flavor, and sweetness. This same trend has been noted for all types of mango packs.

Cocktail scores ranged from 2.0 to 3.7 with the major portion clustered around 3.0. Interpreted from the score sheet, the "general opinion" score on fruit cocktails was "good." The less sweet packs in 20 percent and 25 percent sirups were preferred to the 35 percent sirup pack.

Storage of the frozen samples for 9 to 12 months indicated a slightly lower score for most mango cocktails. Good quality prevailed up to 9 months of storage at 0°F., then dropped off in value.

Finger Slice Packs

Finger slice packs for Haden (Oahu), Holt, and Fairchild (Kauai) varieties followed very closely the scores for the mango cheeks of the same varieties packed in sugar sirups. Some individuals might prefer to serve this daintier appearing product than the mango cheeks for desserts. Otherwise, there should be no great difference between the two packs.

Purees

Color. All the mango varieties for which color was scored rated from 3.0 to 4.0 except the Joe Welch and Bicknell varieties, which ranged from 2.3 to 3.0. One of the fruits, Fairchild, showed a slight grayish cast in the purees held under freezer storage. The fruits with deep orange color made excellent colored purees (Haden, Holt).

Texture. Texture qualities showed pronounced differences by fruit varieties. The Julie, Bishop, Ono, Lott's Special, Haden (Molokai), and Kruse made very smooth, fibre-free homogeneous purees with scores ranging from 3.0 to 3.8. The Oahu Haden had much lower texture scores (2.2 to 2.3) than the Molokai Haden (3.8 to 4.0). This showed in some degree the differences which may exist in the same variety grown under varying physiological conditions.

The Pirie, Wootten, Whitney, Joe Welch, Bicknell, and Fairchild had lower texture scores (1.8 to 2.7) because of fibres present and the formation of a non-homogeneous, watery type of puree.

Flavor. The tart-flavored fresh mangos made the best flavored purees, a quality which becomes more pronounced on long freezer storage (Lott's Special, Julie, Wootten, and Kruse). The most desired fresh mango varieties of better-known types (Pirie, Holt, and Haden) produced rather bland, mild-flavored purees by organoleptic panel scores. Added ascorbic acid helped to maintain flavor in all varieties when stored for 9 to 12 months.

Sweetness. The purees with less sugar added were preferred to the sweeter purees, which had lost some of their mango flavor. The 1-part sugar to 10-parts puree was the most popular pack. Added ascorbic acid counteracted the sweetness and resulted in a higher score for some packs (Lott's Special, Haden, Julie varieties).

General opinion. By panel scores the Kruse, Wootten, Julie, and Ono purees were preferred to the other varieties sampled.

Whole Fruit

Freezing mangos whole and untreated is not satisfactory. The resulting product becomes very spongy in texture and has an undesirable flavor on thawing.

SUMMARY AND CONCLUSIONS

From organoleptic tests run on fresh and frozen samples of 19 varieties of mangos found in Hawaii and packed in the 1951 and 1952 seasons, the following conclusions have been drawn.

The fresh fruit samples had generally higher scores than the frozen samples.

The differences in taste panel preference for mango cheeks and slices packed in sirups were small; they were of the following order: 20 percent, sirup first; 25 percent, sirup second; 35 percent, sirup third.

In the fruit cocktail packs in sugar sirups, the same general trend for the less sweet sirups occurred as found in mango cheeks and slices.

Mango cheeks and slices and fruit cocktails packed in sirups with added ascorbic acid did not result in appreciably higher total scores over the plain sirup packs for each type fruit.

The dry sugar packs of mango cheeks were rated lower than the sirup-pack samples for most varieties.

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The dry sugar packs of mango cheeks were rated lower than the sirup-pack samples for most varieties.

Mango purees packed with sugar were scored higher than mango cheeks packed in dry sugar. For best quality and flavored purees, only firm-opaque flesh clinging to seeds (p. 15) should be used; do not use translucent-appearing flesh because off-flavors will develop during freezer storage.

Varieties

The mango varieties for each organoleptic category (color, texture, flavor, sweetness, and general opinion) checked by the panel in the 1951 and 1952 frozen packs are rated in order of choice in table 3. The best all-around mango varieties recommended for freezing on the basis of the 1951 and 1952 tests were: Joe Welch, Hotoke, and Fairchild for 1951; and Wootten, Fairchild, Pirie, Hansen, Ono, and Joe Welch for 1952. Only the Joe Welch and Fairchild varieties appeared on the list for both seasons; however, they did not hold the same rating each year.

The ideal mango to cultivate, possessing traits considered highly desirable in this study, would be one with: the size and proportion of flesh found in the Hansen; the flesh color of the Brooks Late or Pirie; the ease in peeling of the Boswell or Holt; the fibre-free smooth texture of the Hotoke or Joe Welch; the tart flavor of the Boswell, Ono, or Pirie. Hybridization and selection might be employed to produce an ideal all-purpose mango for freezing.

At present and for some time to come, freezing of mangos is likely to be done only at home for the following reasons: limited supply of suitable mangos; the amount of labor involved in preparing the fruit; the large amount of waste which adds to the cost. There is no doubt, however, that as a luxury frozen food item for homes and for the better hotels, there would be a good demand for commercial products during the season when fresh mangos are not available.

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