A COMPARATIVE STUDY ON TWO FORMS OF *CANDIDA TROPICALIS* (CAST.) BERKHOUT

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Taxonomic studies on 32 strains of *Candida tropicalis* and its allies revealed that they could be divided into two forms. *C. tropicalis* form I (24 strains) had a GC content of 34.1–34.9%, assimilated soluble starch, had an antigenic structure of 1, 2, 3, 4, 5, 6, and formed wrinkled colonies with hair when they aged. *C. tropicalis* form II (8 strains) had a GC content of 36.3–36.8%, did not assimilate soluble starch, had an antigenic structure of 1, 2, 3, 4, (5), (6), and formed smooth colonies without hair when they aged. These two forms are also differentiated by the proton magnetic resonance spectra of alkali-extracted mannans. Since taxonomic characteristics of strains of form I are identical with those of the standard description of *C. tropicalis*, the strains of form II should be represented as a new species. The name *Candida subtropicalis* is proposed for the strain of form II and the description of this species is given.

It is well known that the yeast *Candida tropicalis* (CAST.) BERKHOUT rapidly assimilates soluble starch as a sole source of carbon, and strains which lack this ability have not been recorded in the literatures (1–3). In the past few years, however, several strains of yeast which resemble *C. tropicalis* but do not assimilate this carbon compound have often been isolated from natural sources. The present authors provisionally dealt with these strains as *C. tropicalis* form II and with those of typical *C. tropicalis*, which assimilate soluble starch, as *C. tropicalis* form I (4). After a precise comparative study on these two forms, it was clarified that they were closely related to each other but could be clearly differentiated on the basis of the GC content in DNA and serological characteristics, in addition to the taxonomic criteria commonly employed.

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MATERIALS AND METHODS

Microorganisms. Thirty-two strains of *Candida tropicalis* and its allies were employed. Source of strains is listed in Table 1. *Candida albicans* J-1501, *C. stellatoidea* J-1016, *C. guilliermondii* J-1023, *C. parapsilosis* (*C. parakrusei*) J-1015, *C. krusei* J-1005, and *Torulopsis glabrata* J-4002 were also used in the serological investigation.

Taxonomic characteristics. Taxonomic characteristics were investigated mainly by the methods of WICKERHAM (5), and of LODDER and KREGER-VAN RIJ (6). Macromorphology, vitamin requirement and maximum growth temperature were determined by the procedures previously reported (7, 8).

Determination of DNA base composition. DNAs were isolated and purified by the method previously reported (9). The DNA base composition was calculated from the thermal denaturation temperature (T_m) using the formula of MARMUR and DOTY (10). T_m was measured by the apparatus described by YAMADA and KOMAGATA (11).

Extraction and purification of polysaccharide. The yeast cells grown for 48 hr on Sabouraud's agar medium were harvested and washed 3 times with distilled water and heated at 100° for 2 hr. After centrifugation, the cells were suspended in 5 volumes of 2% aqueous potassium hydrochloride solution and extracted for 2 hr at 100°. The succeeding procedures for extraction and purification of polysaccharide followed the methods reported by GORIN and SPENCER (12).

Antigenic analysis. The methods for the preparation of antisera, the slide agglutination test, and the absorption test of agglutinins were similar to those described previously (13).

Gel diffusion precipitation method. Precipitation reactions were performed by the gel diffusion method using 0.85% of Noble agar (Difco) in borate buffer, pH 8.4 (14). A 0.1% solution of purified polysaccharide was used for antigen in the outer wells and undiluted antiserum was placed in the central well.

Determination of proton magnetic resonance spectrum of polysaccharide. The proton magnetic resonance (PMR) spectrum was determined with 20% solution of polysaccharide in D₂O at 70° using a Hitachi 60-MHz nuclear magnetic resonance spectrometer in which tetramethylsilane was used as external standard.

RESULTS

Taxonomic characteristics

As shown in Tables 2 and 3, two forms of *C. tropicalis* closely resembled each other in taxonomic criteria commonly employed. A few differences were found in the following characteristics: Strains assigned to *C. tropicalis* form I usually formed wrinkled colonies with characteristic hair when they aged,

Table 1. Strains employed.

Species	Strain	Source
<i>C. tropicalis</i> form I	AJ 4468	IFO 0006
"	AJ 4469	IFO 0589
"	AJ 4470	RIFY WF-191
"	AJ 4471	Spinach
"	AJ 4472	"Moyashi" (Soybean sprouts)
"	AJ 4473	"
"	AJ 4474	"
"	AJ 4475	"
"	AJ 4479	No. 131 (K. Yamada)
"	AJ 4486	<i>a</i>
"	AJ 4487	<i>a</i>
"	AJ 4488	<i>b</i>
"	AJ 4489	<i>b</i>
"	AJ 4490	<i>b</i>
"	AJ 4491	<i>b</i>
"	AJ 4492	<i>c</i>
"	AJ 4493	<i>b</i>
"	AJ 4494	<i>b</i>
"	AJ 4495	<i>b</i>
"	AJ 4496	<i>b</i>
"	AJ 4766	<i>C. benhamii</i> 61/477 IV (E. K. Novák)
"	AJ 4767	<i>C. benhamii</i> 61/477 IVa (")
"	AJ 4780	<i>b</i>
"	J-1017	IFO 1016
<i>C. tropicalis</i> form II	AJ 4476	Air, YO-146 (19)
"	AJ 4477	Air, YO-147 (19)
"	AJ 4478	Air, YO-148 (19)
"	AJ 4480	Soil, No. 315 (K. Yamada)
"	AJ 4497	Soil (R. Uchio)
"	AJ 5095	KY42-11 (K. Yamada)
"	AJ 4928	N7Y1 (")
"	AJ 5189	HY4217 (")

a: Isolated from adhesives in a seasoning manufacturing plant.

b: Isolated in a soybean protein factory.

c: Isolated in a monosodium glutamate manufacturing plant.

Table 2. Characteristics of two forms of *Candida tropicalis* (1).

Form of <i>C. tropicalis</i>	Appearance of aged colonies	Maximum growth temperature (°C)	Vitamin required	Fermentation						
				D-Glucose	D-Galactose	Saccharose	Maltose	Lactose	Raffinose	Melibiose
I	Wrinkled surface with hair	41–45	Biotin	+	+	+	+	–	–	–
II	Smooth or wrinkled surface without hair	40–41	Biotin	+	+	+	+	–	–	–

had a maximum growth temperature of 41–45°, usually 43–45°, and assimilated soluble starch. *C. tropicalis* form II usually formed smooth colonies when they aged, had a maximum growth temperature of 40–41°, and did not assimilate soluble starch.

DNA base composition

Base composition of DNA (GC content) of representative strains of *C. tropicalis* form I and form II is shown in Table 4. All the DNA preparations obtained gave monophasic melting curves in denaturation experiment of DNA, and were assumed to be free from satellite components of DNA. Form I and form II of *C. tropicalis* showed GC values of 34.1–34.9% (mean value, 34.5%) and 36.3–36.8% (mean value, 36.6%), respectively, and the difference between these two forms was 2.1%.

Serological analyses

Reciprocal agglutinin absorption experiments were carried out among antisera for and heated cells of several strains of two forms of *C. tropicalis* (Table 5). Agglutinin reacting only with *C. tropicalis* J-1017 (form I) remained in the antiserum for *C. tropicalis* J-1017 absorbed with cells of *C. tropicalis* AJ 4468 (form I), and also agglutinins reacting with both of *C. tropicalis* J-1017 and AJ 4468 were demonstrated in the antiserum for *C. tropicalis* J-1017 absorbed with *C. tropicalis* AJ 4476 (form II). Antiserum for *C. tropicalis* AJ 4476 absorbed with strains of *C. tropicalis* form I or II did not agglutinate the cells of any form of *C. tropicalis*. These results indicate that the antiserum for *C. tropicalis* form II did not contain additional antigen for *C. tropicalis* form I, and that a slight antigenic difference also existed within strains of *C. tropicalis* form I.

Further reciprocal agglutinin absorption experiments were performed

Table 3. Characteristics of two forms of *Candida tropicalis* (2).
Assimilation of carbon compounds.

Carbon compound	<i>C. tropicalis</i> form I	<i>C. tropicalis</i> form II
D-Glucose	+	+
D-Galactose	+	+
Saccharose	+	+
Maltose	+	+
Lactose	—	—
L-Sorbose	+ or L	+ or L
Cellobiose	+ or L	V
Trehalose	+	+
Melibiose	—	—
Raffinose	—	—
Melezitose	+	+
Inulin	—	—
Soluble starch	+	—
D-Xylose	+	+
L-Arabinose	V	—
D-Arabinose	—	—
D-Ribose	V	V
L-Rhamnose	—	—
Ethanol	+	+
Glycerol	V	+ or L
Erythritol	—	—
Adonitol	+	+
Dulcitol	—	—
D-Mannitol	+	+
D-Sorbitol	+	+
α -Methyl-D-glucoside	+	+
Salicin	+ or L	V
K gluconate	+	L
Ca 2-ketogluconate	+	+
DL-Lactic acid	+ or W	V
Succinic acid	+ or W	+
Citric acid	+ or W	+ or L
Inositol	—	—

V: Variable, L: Latent, W: Weak.

Table 4. DNA base composition of some strains of *Candida tropicalis* form I and II.

Species	Strain	T _m (°C)	GC content in DNA (mol.%)	Reference
<i>C. tropicalis</i> form I	AJ 4468	83.4	34.4	18
"	AJ 4469	83.5	34.6	18
"	AJ 4470	83.5	34.6	
"	AJ 4471	83.3	34.1	
"	AJ 4479	83.6	34.9	
"	AJ 4488	83.4	34.4	
"	AJ 4766	83.3	34.1	18
"	J-1017	83.3	34.1	
<i>C. tropicalis</i> form II	AJ 4476	84.3	36.6	
"	AJ 4478	84.4	36.8	
"	AJ 4480	84.3	36.6	
"	AJ 5189	84.2	36.3	

Table 5. Reciprocal absorption experiments among strains of two forms of *Candida tropicalis*.

Antisera for	Absorbed with	<i>C. tropicalis</i> I J-1017	<i>C. tropicalis</i> I AJ 4468	<i>C. tropicalis</i> II AJ 4476	<i>C. albicans</i>	<i>C. stellatoidea</i>	<i>C. guilliermondii</i>	<i>C. parapsilosis</i>	<i>C. krusei</i>	<i>T. glabrata</i>
<i>C. tropicalis</i> I J-1017	<i>C. tropicalis</i> I AJ 4468	+	—	—	—	—	—	—	—	—
<i>C. tropicalis</i> I AJ 4468	<i>C. tropicalis</i> I J-1017	—	—	—	—	—	—	—	—	—
<i>C. tropicalis</i> I J-1017	<i>C. tropicalis</i> II AJ 4476	+	+	—	—	—	—	—	—	—
<i>C. tropicalis</i> II AJ 4476	<i>C. tropicalis</i> I J-1017	—	—	—	—	—	—	—	—	—
<i>C. tropicalis</i> I AJ 4468	<i>C. tropicalis</i> II AJ 4476	—	—	—	—	—	—	—	—	—
<i>C. tropicalis</i> II AJ 4476	<i>C. tropicalis</i> I AJ 4468	—	—	—	—	—	—	—	—	—

among antisera for *C. albicans*, *C. tropicalis* form I and II, and the cells of various species of *Candida* and *Torulopsis* (Table 6). The antiserum for *C. albicans* J-1501 absorbed with *C. stellatoidea* agglutinated cells of *C. albicans*, *C. tropicalis* J-1017 (form I), *C. tropicalis* AJ 4468 (form I), and *T. glabrata*, but did not agglutinate the cells of *C. tropicalis* AJ 4476 (form II). The same results were obtained in each antiserum for *C. tropicalis* J-1017, and for *C.*

tropicalis AJ 4468 which was absorbed with *C. stellatoidea*. These results suggest that a strain of *C. tropicalis* AJ 4476 lacks the antigen factor 6.

When antiserum for *C. tropicalis* AJ 4476 was absorbed either with *C. stellatoidea* or with *C. guilliermondii*, it demonstrated only a weak antibody related to antibody factors for antigen 6 and 5, respectively. This result indicates that a strain of *C. tropicalis* AJ 4476 (form II) has a part of antigen 6 as well as antigen 5 which produced only weak antibodies.

A comparative study for antigenic properties of 11 strains of *C. tropicalis* form I and 8 strains of form II was carried out in the same manner as described above (Table 7). In these experiments, all the strains of *C. tropicalis* form I and II were clearly differentiated by the fact that strains of form II lacked antigen 6 and 5 in their agglutinability and in the complete antibody-producing ability for these two antigens, and antigenic structure of *C. tropicalis* form II can be expressed as 1, 2, 3, 4, (5), (6), while 1, 2, 3, 4, 5, 6 has been proposed for typical strains of *C. tropicalis*, i.e., *C. tropicalis* form I (15).

Gel diffusion-precipitation test

Gel diffusion-precipitation reaction of antisera for two forms of *C. tropicalis* against extracted polysaccharide of these strains and several other *Candida* species is shown in Figs. 1–3. These polysaccharides contained only D-mannose when they were hydrolyzed. When antiserum for *C. tropicalis* AJ 4468 (form I) was placed in the central well, an intensive precipitin band was formed against each of extracted mannans of *C. tropicalis* form I and II, and *C. guilliermondii* placed in the peripheral wells (Fig. 1). In this case, the precipitin band for *C. tropicalis* form I exhibited a spur to the precipitin band for *C. tropicalis* form II. When antiserum for *C. tropicalis* J-1017 (form I) was placed in the central well, intensive precipitin bands were formed against extracted mannans of *C. tropicalis* form I and *C. guilliermondii*, while precipitin band against mannan of *C. tropicalis* form II was very weak (Fig. 2). When antiserum for *C. tropicalis* form II was used, precipitin bands formed against mannans from the species mentioned above fused with each other, and no spur was observed in this case (Fig. 3). Mannans extracted from *C. parapsilosis* and *C. krusei* did not react with the antisera for any form of *C. tropicalis*.

Proton magnetic resonance spectrum of mannans extracted from two forms of C. tropicalis

The PMR spectra of mannans from two forms of *C. tropicalis* closely resemble each other (Fig. 4). Both have 4 signals with the same chemical shift in C-1-H region. However, it is worthy of note that the relative strength of the fourth signal near τ 5.0 is extremely weak in mannan from *C. tropicalis* form II than in that from *C. tropicalis* form I. The PMR spectrum of

Table 6. Antigenic characteristics of

Antisera for	Absorbed with	<i>C. trop.</i> I J-1017	<i>C. trop.</i> I AJ 4468
<i>C. albicans</i> J-1501	<i>C. tropicalis</i> I J-1017	0	0
	<i>C. tropicalis</i> I AJ 4468	0	0
	<i>C. tropicalis</i> II AJ 4476	0	0
	<i>C. stellatoidea</i>	2	2
	<i>C. guilliermondii</i>	3	2
	<i>C. parapsilosis</i>	3	3
	<i>C. krusei</i>	3	3
<i>C. tropicalis</i> I J-1017	<i>C. stellatoidea</i>	2	2
	<i>C. guilliermondii</i>	2	2
	<i>C. parapsilosis</i>	2	3
	<i>C. krusei</i>	3	3
<i>C. tropicalis</i> I AJ 4468	<i>C. stellatoidea</i>	2	2
	<i>C. guilliermondii</i>	2	2
	<i>C. parapsilosis</i>	3	3
	<i>C. krusei</i>	3	3
<i>C. tropicalis</i> II AJ 4476	<i>C. stellatoidea</i>	0	(1)
	<i>C. guilliermondii</i>	(1)	1
	<i>C. parapsilosis</i>	3	3
	<i>C. krusei</i>	3	3

^a Numerals of 1-3 and those in parentheses indicate degree of positive agglutina-

mannan from *C. tropicalis* form II was found to be closely related to that of *C. guilliermondii*.

DISCUSSION

Two forms of *C. tropicalis* can be differentiated on the basis of assimilation of soluble starch. Morphologically, aged colonies of form I are wrinkled with hair, while those of form II are smooth without hair. This difference, however, is not so important in yeast taxonomy since smooth-rough mutation is commonly observed in many species. These two forms show a slight difference in the maximum growth temperature. Namely, most strains of form

two forms of *Candida tropicalis*.

<i>C. trop.</i> II AJ 4476	<i>C. albicans</i>	<i>C. stellatoidea</i>	<i>C. guilliermondii</i>	<i>C. parapsilosis</i>	<i>C. krusei</i>	<i>T. glabrata</i>	Antibody factors
0	1 ^a	0	0	0	0	0	7
0	(1)	0	0	0	0	0	(7)
0	2	0	0	2	0	0	7...
0	3	0	0	0	0	1	6...
2	3	1	0	0	0	1	5...
3	3	2	2	0	0	2	4...
3	3	2	3	3	0	2	3...
0	2	0	0	0	0	(1)	6
0	2	1	0	0	0	(1)	5...
2	3	1	1	0	0	1	4...
3	3	3	3	1	0	3	3...
1	2	0	0	0	0	1	6
0	2	(1)	0	0	0	1	5...
3	3	2	3	0	0	1	4...
3	3	2	3	2	0	3	3...
(1)	(1)	0	0	0	0	(1)	(6)
(1)	1	(1)	0	0	0	(1)	(5)
3	3	2	3	0	0	0	4...
3	3	3	3	1	0	3	3...

tion.

I could grow above 43°, while all the strains of form II show their maximum growth temperature at 40–41°. Some strains of form I, however, show their maximum growth temperature at 41–42°.

In spite of a scanty difference in taxonomic criteria commonly employed, the two forms of *C. tropicalis* were clearly differentiated by the DNA base composition and serological characteristics. Eight strains of form I of *C. tropicalis* showed the GC content ranging from 34.1 to 34.9% with a mean value of 34.5%, while 4 strains of form II of *C. tropicalis* showed the GC content ranging from 36.3 to 36.8% with a mean value of 36.6%. Therefore, a calculated difference of GC content between the two forms was 2.1%, which is not considered to be due to technical error but must be a true difference.

Table 7. Slide agglutination experiments for antigenic patterns of

Antisera for	Absorbed with	C.				
		J-1017	AJ 4468	AJ 4469	AJ 4470	AJ 4471
<i>C. albicans</i> J-1501	<i>C. tropicalis</i> I J-1017	0	0	0	0	0
"	<i>C. tropicalis</i> I AJ 4468	0	0	0	0	0
"	<i>C. tropicalis</i> II AJ 4476	0	0	0	0	0
"	<i>C. stellatoidea</i>	3 ^a	2	3	2	2
<i>C. tropicalis</i> I J-1017	<i>C. stellatoidea</i>	2	2	2	2	2
"	<i>C. guilliermondii</i>	2	2	2	2	2
<i>C. tropicalis</i> I AJ 4468	<i>C. stellatoidea</i> + <i>C. guilliermondii</i>	3	3	3	3	3
"	<i>C. guilliermondii</i>	2	2	2	2	2
<i>C. tropicalis</i> II AJ 4476	<i>C. stellatoidea</i> + <i>C. guilliermondii</i>	(1)	0	0	(1)	0
"	<i>C. guilliermondii</i>	1	1	1	1	1

^a Numerals of 1-3 and those in parentheses indicate degree of positive agglutina-

Serological characteristics also indicated the difference in the two forms. Slide agglutination test (Table 6) and gel diffusion precipitation reaction (Figs. 1-3) suggested that the strains of form I had additional antigens which were not possessed by those of form II, and that some of antigens of form II which are common to form I lack antibody-inducing ability. Diversity in serological characteristics was also reported in *C. albicans* (16, 17). Differing from the case of *C. tropicalis*, however, all the serotypes found in *C. albicans* have the same GC content in DNA, and show almost the same carbon assimilation patterns (18).

A difference was also found in the PMR spectra of alkali-soluble mannans from the two forms. Although PMR spectra of both mannans have 4 signals having the same chemical shift in the C-1-H region, the fourth signal near τ 5.0 is very weak in mannan of form II (Fig. 4).

From these considerations, it is concluded that the two forms of *C. tropicalis* must be closely related to each other but are clearly discriminated. It is considered that these two forms should be dealt with as different species for the sake of convenience. Since the yeast species coinciding with form II of *C. tropicalis* has not yet been reported, this form should be dealt as a new species. The present authors propose to name this yeast *Candida subtropicalis* since this yeast is assumed to be closely related to *C. tropicalis*. It is interesting that all the strains of *C. subtropicalis* known to date were isolated as strong hydrocarbon-utilizers. The strain AJ 4476 was chosen as the type strain of this species. This strain was deposited in the Fermentation

isolated strains of two forms of *Candida tropicalis*.

<i>tropicalis</i> form I						<i>C. tropicalis</i> form II							
AJ 4472	AJ 4479	AJ 4486	AJ 4488	AJ 4492	AJ 4766	AJ 4476	AJ 4477	AJ 4478	AJ 4480	AJ 4497	AJ 4928	AJ 5095	AJ 5189
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	2	3	2	3	0	0	0	0	0	0	0	0
2	2	2	2	2	2	0	0	0	0	0	0	0	0
2	3	3	3	2	2	0	0	0	0	0	0	0	0
3	3	3	3	3	3	1	1	1	1	1	1	1	1
2	2	2	2	2	2	1	(1)	1	1	1	1	1	1
0	0	0	0	0	0	(1)	0	0	(1)	(1)	(1)	0	(1)
(1)	(1)	(1)	(1)	1	1	(1)	(1)	(1)	1	1	(1)	(1)	1

tion.

Fig. 1. Serological relationship among mannans of *Candida tropicalis* and allied species by gel diffusion-precipitation (1).

Center well: Anti-*C. tropicalis* AJ 4468 serum

Peripheral wells: Mannan solution

C. tr. I: *C. tropicalis* form I

C. tr. II: *C. tropicalis* form II

C. glm: *C. guilliermondii*

C. pk: *C. parapsilosis* (= *C. parakrusei*)

Fig. 2. Serological relationship among mannans of *Candida tropicalis* and allied species by gel diffusion-precipitation (2).

Center well: Anti-*C. tropicalis* J-1017 serum

Peripheral wells: Mannan solution

Fig. 3. Serological relationship among mannans of *Candida tropicalis* and allied species by gel diffusion-precipitation (3).

Center well: Anti-*C. tropicalis* AJ 4476 serum

Peripheral wells: Mannan solution

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Fig. 4. Proton magnetic resonance spectra of C-1-H region of mannans from *Candida tropicalis* and *Candida guilliermondii*.

Numerals indicate τ values.

DESCRIPTION

Candida subtropicalis NAKASE, FUKAZAWA et TSUCHIYA sp. nov.

Strain: See Table 1.

In medio liquido cellulae rotundae, subovoideae, ovoideae aut longae, $(2.5-9) \times (3-11-30) \mu$, singulae, binae aut catenatae. Anulus formatur. Cultura in agar (post unum mensem, 17°) flavoalbida, glabra, mollis, margine piloso. Pseudomycelium et mycelium formantur. D-Glucosum, D-galactosum,

saccharosum et maltosum fermentantur at non lactosum, raffinsum, nec melibiosum. In medio minerali D-glucosum, D-galactosum, saccharosum, maltosum, L-sorbose (aut lente), cellobiosum (varium), trehalosum, melezitum, D-xylosum, ethanolum, glycerolum (aut lente), adonitolum, D-mannitolum, D-sorbitolum, α -methyl-D-glucosidum, salicinum (varium), potassium gluconatum (varium), calcium 2-ketogluconatum, acidum DL-lacticum (varium), acidum succinicum, et acidum citricum (aut lente) assimilantur at non lactosum, melibiosum, raffinsum, inulinum, amylum, L-arabiosum, D-arabiosum, D-ribosum, L-rhamnosum, erythritolum, dulcitolum, nec inositolum. Nitras kalicus non assimilatur. Arbutinum non finditur. Biotinae necessariae ad crescentiam. Maxima temperatura crescentiar: 40–41°.

Growth in YM broth: After 3 days at 25°, cells are round, short oval, oval, or elongate, $(2.5-9) \times (3-11-30) \mu$, and occur singly, in pairs, or in chains. A thin pellicle is formed.

Growth on YM agar: After one month at 17°, the colony is pale yellowish white, smooth, soft, and has a ciliate margin.

Slide culture on potato glucose agar: True and pseudomycelium develop abundantly. Blastospores are round to short oval or oval, and occur singly, in chains, or in clusters.

Formation of ascospores: Not observed.

Fermentation: D-Glucose, D-galactose, saccharose, and maltose (occasionally weak) are fermented. Lactose, raffinose, and melibiose are not fermented.

Assimilation of carbon compounds: D-Glucose, D-galactose, saccharose, maltose, L-sorbose (sometimes latent), cellobiose (variable), trehalose, melezitose, D-xylose, ethanol, glycerol (sometimes latent), adonitol, D-mannitol, D-sorbitol, α -methyl-D-glucoside, salicin (variable), potassium gluconate (variable), calcium 2-ketogluconate, DL-lactic acid (variable), succinic acid, and citric acid (occasionally latent) are assimilated. Lactose, melibiose, raffinose, inulin, soluble starch, L-arabiose, D-arabiose, D-ribose, L-rhamnose, erythritol, dulcitol, and inositol are not assimilated.

Utilization of potassium nitrate: Negative.

Splitting of arbutin: Negative.

Splitting of fat: Positive.

Urease: Negative (on Christensen's medium)

Liquefaction of gelatin: Negative.

Formation of starch: Negative.

Requirement of vitamins: Biotin is required at 25°.

Maximum growth temperature: 40–41°.

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