Journal of Mycology Research. Vol 2, No 2, September 2015, Page 63-75

Saccharomyces cerevisiae var. boulardii as a eukaryotic probiotic and its therapeutic functions

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(Received: 4 August 2015, Accepted: 10 September 2015)

Abstract:

Fuller, in 1989, described probiotic microorganisms as "a live microbial feed supplement, which beneficially affects the host animal, by improving its intestinal microbial balance". *Saccharomyces cerevisiae* var. *boulardii* (*S.boulardii*) is an accurate probiotic yeast idol. The detection and budding of *S.boulardii*is firmly related to the impression of healthiness to promote microorganisms from foodstuff. *S.boulardii*is similar to *S.cerevisiae* in that it equally does not have the capability to penetrate into tissues like the Candida species is able to, hence they are not invasive. Some printed medicinal researches have shown the effectiveness and safety of *S.boulardii* for different illness indications in both adults and children. On the subject of the therapy employed, diverse indications of *S.boulardii* are as follows: Anticipation of antibiotic related diarrhea, recurring *Clostridium difficile* related diarrhea and colitis, severe viral and bacterial diarrhea, travelers' diarrhea, anti-inflammatory bowel syndromes as well as Crohn's disease and so on. These days, *S.boulardii* is regularly marketed as a probiotic in a lyophilized shape and is often referred to as *S.boulardii lyo*.

Keywords: Eukaryote, probiotic, therapeutic, yeast.

Introduction

The idea of probiotic microorganisms was offered and revealed through Élie Metchnikoff for its important value in the twentieth century. Originally, Metchnikov's hypothesis that lactic acid bacteria is able to extend life was arguable and some investigators doubted it (Floch, 2014; Guandalini, 2011; Lukaszewicz, 2012; Mirzaei *et al.*, 2012). Cheplin and Rettger in 1920 confirmed that Metchnikov's strain, at present is termed *Lactobacillus delbrueckii* subsp. *bulgaricus* could not survive within the human intestinal tract (Lukaszewicz, 2012). A logical debate is required to help forge and define the quarreled suggestions. This innovative phrase was probiotically employed by Werner Kollath in 1953 to show the distinguishing effect to damaging antibiotics, as well as the entire superior organic and inorganic compounds present (Lukaszewicz, 2012). Fuller in 1989, described probiotic microorganisms as, "a live microbial feed supplement, which beneficially affects the host animal by improving its intestinal microbial balance" (Fuller, 1989; Lukaszewicz, 2012). Sandersin 1996, plainlydefined probiotics as, microbes used for healthiness effects (Lukaszewicz, 2012).

Amongst the effects of probiotics, are the following: increased foodstuff digestion and absorption (Gareau *et al*., 2010; Pourjafar *et al*., 2011; Soccol *et al*., 2010; Vohra and Satyanarayana, 2012; Zaouche *et al*., 2000), diminishing blood cholesterol (Krasowska *et al*., 2007; Mirzae *et al*., 2011; Soccol *et al*., 2010), having anti- inflammatory property (Cain and Karpa, 2011; Choi *et al*., 2011; Dalmasso *et al*., 2006; Generoso *et al*., 2011; Lee *et al*., 2009; Ng *et al*., 2010; Pathoulakis, 2009; Sougioultzis *et al*., 2006; Thomas *et al*., 2011;), amplification of the immune system (Baumgart, 2007; Buts *et al*., 1990; Canonici *et al*., 2011; Czerucka and Rampal, 1999; Dalmasso *et al*., 2006; De Lianos *et al*., 2010; Fidan *et al*., 2009; Martins *et al*., 2010; Thomas *et al*., 2011) and antitumor results (Pourjafar and Ghasemnezhad, 2013), in addition toraising the body resistance in opposition to diseases (Floch, 2014; Gareau *et al*., 2010). Alternatively, they are manufactured today as a proper substitute for antibiotics in opposition to pathogenic substances in human beings and animals (Barc *et al*., 2008; Pourjafar and Ghasemnezhad, 2010; Soccol *et al*., 2010; Surawicz, 2010; Tiago *et al*., 2012; Zanello *et al*., 2009).

Nevertheless, for probiotic microorganisms to therapeutically exist effectively, it has been recommended that manufactured foods should contain a minimum of 10^7cfu/g probiotics and consumed no more than 100 g/day to contain useful consequences on the health state of the organism (Floch, 2014; Fuller, 1989; Gareau *et al*., 2010; Pourjafar *et al*., 2011; Soccol *et al*., 2010).

Saccharomyces cerevisiae var. *boulardii* (*S.boulardii*) is accurate probiotic yeast. The detection and budding of *S.boulardii* is firmly related to the impression of healthiness to promote microorganisms from foodstuffs. The most renowned and popularized foodstuff all over Europe for the hypothesis of healthiness to promote microorganisms is yogurt (Czerucka, *et al*., 2007; Heitman, 2006; Im and Pothoulakis, 2010; Lukaszewicz, 2012; McFarland and Bernasconi, 1993).

Henri Boulard who was in Indochina in 1920 throughout the cholera epidemic, detected that some inhabitants chewing the crust of lychee, and mangosteen or who prepare a particular tea did not experience the signs of the cholera disease. This inspection directed Boulard to the separation of a tropical strain of yeast named *S.boulardii* from lychee and mangosteen fruit,whichis currently the only marketed probiotic yeast (Czerucka *et al*., 2007; Heitman, 2006; Lukaszewicz, 2012; McFarland and Bernasconi, 1993).

In the previous century, over half of the proposed probiotic prescription show that *S.boulardii* may be advantageous to the health of man. Boulard went back to France, where he separated and patented the strain and in 1947 sold it to Biocodex Company produced for its manufacture. *S.boulardii* was recorded as a medicine for the primary point in 1953 and until now it is the merely recorded eukaryotic probiotic microorganism (Czerucka, *et al*., 2007;Lukaszewicz, 2012).

This probiotic yeast was employed to be recognized as a split species as that of *Saccharomyces cerevisiae*, nevertheless, investigators have currently declared that *S. boulardii* is extremely like *cerevisiae*, consequently, it is a strain of *cerevisiae*. Conversely, the scientific name for it is *Saccharomyces cerevisiae* strain (or "variant" as it is sometimes identified) *boulardii*. However, *S.boulardii* is seen on the tags of manufactured goods (Büchl *et al*., 2010; Czerucka *et al*., 2007; Edwards-Ingram *et al*.,

2004; Edwards-Ingram *et al*., 2007; Ferreira *et al*., 2010; Hennequin *et al*., 2001; Klis *et al*., 2006; Lukaszewicz, 2012; MacKenzie *et al*., 2008; Malgoire *et al*., 2005; McCusker *et al*., 1994; Mitterdorfer *et al*., 2002; Rajkowska *et al*., 2009).

S.boulardii is similar to *S.cerevisiae* in quality but lacks the capability to penetrate into tissues like Candida species,subsequently, they are not invasive (Buts and De Keyser, 2006; Buts and De Keyser, 2010; Calderone and Fonzi, 2001; Lukaszewicz, 2012; McFarland and Bernasconi, 1993; Whiteway and Oberholzer, 2004). *S.boulardii* is incapable of forming spores; hence the opportunities of its translocation to other parts of the body diminishes (Lukaszewicz, 2012; Zaouche *et al*., 2000). The most noticeable differentiation between these yeasts is the extraordinarily high growth of *S.boulardii* at a temperature of 37ºC which fits excellently with the temperature of the human body. Also, the next significant aspect is its improved existence at acidic situation (Edwards-Ingram *et al*., 2007; Ferreira *et al*., 2010; Lukaszewicz, 2012). Several consequences of the survey on the differences and similarities between *S.boulardii* and *S.cerevisiae* are reviewed in Table 1.

Table 1. Outline of several dissimilarities and similarities between *S.cerevisiae* and *S.boulardii* (Lukaszewicz, 2012)

Saccharomycescerevisiae	***Saccharomyces boulardii***
Lower growth temperature (-30°C)	Higher growth temperature (-37°C)
Lower resistance to low pH	Higher resistance to low pH
utilize galactose	Do not utilize galactose
Sporogenous	Asporogenous on the contrary to *S.cerevisiae* but may produce fertile hybrids with of *S.cerevisiae* strains
There are steady strains with various ploidy	Trisomic for chromosome IX
Typing RFLPs or PCR failed to discriminate *S.boulardii* from *S. cerevisiae*	The Karyoype of *S.boulardii* are very like to those of *S. cerevisiae*
-	Microsatellite typing demonstrates genotypic variations

Yeast taxonomy is derived customarily from their biochemical and physiological sketches. Nevertheless, it fails to discriminate between a number of yeast species or cultivars and it causes an argument whether *S.boulardii* is used as a species or subspecies of *S. cerevisiae*. Consequently, other molecular techniques have been expanded and employed to yeast strain typing and recognition. In addition, metabolic tracking through mass spectrometry is possibly helpful in this regard. By means of gas chromatography time of flight in mass spectrometry, there is a superior association with this genetic technique of strain taxonomy. Probiotic strains of *S.boulardii* show a tense grouping which is both metabolic and genetic. The most important biased metabolites are: lactic acid, Capric acid, fumaric acid, trehalose, glycerol 3-phosphate and myoinositol (Buts *et al*., 1994; Büchl *et al*., 2010; Czerucka *et al*., 2007; Edwards-Ingram *et al*., 2004;Edwards-Ingram *et al*., 2007; Ferreira *et al*., 2010; Hennequin *et al*., 2001; Klis *et al*., 2006; Lukaszewicz, 2012; MacKenzie *et al*., 2008; Malgoire *et*

al., 2005; McCusker *et al*., 1994; Mitterdorfer *et al*., 2002; Murzyn *et al*., 2010b; Rajkowska *et al*., 2009).

Therapeutic functions of *S.boulardii*

A probiotic in terms of its advantageous outcomes, *S.boulardii* has various characteristics from the mainly fundamental to highly progressed. One of the major advantages of employing *S.boulardii*, particularly at the time of taking antibiotics, is that it is not influenced antibiotics because it contains yeast (Barc *et al*., 2008; Beaugerie and Petit, 2004; Can *et al*., 2006; Guslandi, 2010; Kotowska *et al*., 2005; McFarland, 2006; McFarland *et al*., 1995, McFarland *et al*., 1994; Szajewska and Mrukowicz, 2005).Consequently, it also assists to keep pathogenic microscopic organisms and yeasts for instance Candida, from overpowering the human body at the time the antibiotics demolish the majority of the useful bacteria and mainly, but not the entire bad bacteria in the human gastrointestinal lumen (Krasowska *et al*., 2009; Lukaszewicz, 2012; Murzyn *et al*., 2010a; Murzyn *et al*., 2010b; Rajkowska *et al*., 2012; Shareck and Belhumeur, 2011; Whiteway and Oberholzer, 2004;). Some printed medicinal researches have shown the effectiveness and safety of *S.boulardii* for different illness indications in both adults and children (Guandalini, 2011; Im and Pothoulakis, 2010; Kurugöl and Koturoğlu, 2005; Villarruel *et al*., 2007). On the subject of the therapy employed diverse indications of *S.boulardii*are as follows:

Anticipation of antibiotic related diarrhea (Barc *et al*., 2008; Beaugerie and Petit, 2004; Can *et al*., 2006; Kotowska *et al*., 2005; McFarland, 2006; McFarland *et al*., 1995; Szajewska and Mrukowicz, 2005), recurring *Clostridium difficile* related diarrhea and colitis (Castagliuolo *et al*.,1999; Chen *et al*., 2006; McFarland, 2006; McFarland *et al*., 1994; Santino *et al*., 2014; Tasteyre *et al*., 2002), severe viral and bacterial diarrhea (Buts, 2009; Buts *et al*., 1986; Centina-Sauri and Sierra Basto, 1994; Dinleyici *et al*., 2011; Dinleyici *et al*., 2009; Guandalini, 2011; Guslandi *et al*., 2003; Martins *et al*., 2005; Szajewska and Skorka, 2009), travelers' diarrhea (Bisson *et al*., 2010; Kollaritsch et al., 1989; Lee *et al*., 2009), anti-inflammatory bowel syndromesas well as Crohn's disease (Cain and Karpa, 2011; Choi *et al*., 2011; Dalmasso *et al*., 2006; Guslandi *et al*., 2003; Lee *et al*., 2009; Maupas *et al*., 1983; Ng *et al*., 2010; Pothoulakis, 2009; Sougioultzis *et al*., 2006; Thomas *et al*., 2011; Zaouche *et al*., 2000), diarrhea in patients with enteral sensation (Centina-Sauri and Sierra Basto, 1994; Czerucka *et al*., 2007; Guandalini, 2011; Krasowska *et al*., 2010; Villarruel *et al*., 2007; Zanello *et al*., 2011), enhancement to hydration in adults and children (Kurugöl and Koturoğlu, 2005; Lukaszewicz, 2012; Szajewska and Skorka, 2009; Vandenplas *et al*., 2009),vaginal yeast infections (Heitman, 2006;Lukaszewicz, 2012; Skogaard, 2007), fever blisters (Lukaszewicz, 2012; Martins *et al*., 2011), canker sores and high cholesterol (Krasowska *et al*., 2007; Lukaszewicz, 2012; Czerucka *et al*., 2007). It has also been confirmed to be valuable in curing diarrhea related to the HIV virus (Lukaszewicz, 2012; Czerucka *et al*., 2007).

S.boulardii can stops intestinal diseases via the devotion *in vitro* or the attack *in vivo* of *E. coli*, *C. difficile*and *Candida albicans* to the gastrointestinal region. *In vitro* researches, show that *S.boulardii* diminishes the expansion of *E. coli*, *Salmonella typhimurium*, *Shigella*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *C. albicans*, *Entamoeba histolytica* and *Blastocystis hominis*. Also, *in vitro* studies

illustrated that *S.boulardii* reduces cell invasion through *Yersinia enterocolitica* and *S. typhimurium* also showed *S.boulardii* damages, however it does not kill *H. pylori* (Castagliuolo *et al*., 1999; Chen *et al*., 2006; Cindoruk *et al*., 2007; Dahan *et al*., 2003; Dinleyici *et al*., 2011; Dinleyici *et al*., 2009; Fidan *et al*., 2009; Gedek, 1999; Krasowska *et al*., 2010; Lessard *et al*., 2009; Martins *et al*., 2010; Martins *et al*., 2011; McFarland, 2006; McFarland *et al*., 1994; Murzyn *et al*., 2010a; Murzyn *et al*., 2010b; Pontier-Bres *et al*., 2012; Rajkowska *et al*., 2012; Santino *et al*., 2014; Shareck and Belhumeur, 2011; Szajewska *et al*., 2010).

The prevalence of bacterial translocation in burn wound is increased through antibiotics, and this is decreased by *S.boulardii*, furthermore, it decreases the rate of antibiotic-stimulated bacterial translocation. *S.boulardii* contains an advantageous consequence in the cure of inflammatory bowel disease as restricted, *in vivo* (in mice), the number of immune cells that act in response to an inflamed colon. This restriction diminishes the strengthening of the inflammatory reaction, which results in less injury to the colon. It also helps to block the secretion of inflammation sourcing chemicals for the human body (Buts *et al*., 1990; Buts *et al*., 1986; Buts et al., 1994; Cain and Karpa, 2011; Chen et al., 2006; Dalmasso et al., 2006; Generoso *et al*., 2011; Lukaszewicz, 2012; Martins *et al*., 2005; Ng *et al*., 2011; Pothoulakis, 2009; Szajewaka and Mrukowicz, 2005; Zaouche *et al*., 2000).

S.boulardii stimulates the synthesis of various enzymes, for example the lactase enzyme employed to digest lactose, which enhances nutrient and electrolytic absorption. This yeastis able to stop feedbacks to foodstuff antigens in infants and young children that have "leaky gut" (Buts *et al*., 1994; Lukaszewicz, 2012; Murzyn *et al*., 2010b).

*S.boulardii*is generally taken in pill shape; however the dose differs depending on the required medication. In the cure of diarrhea with antibiotics, investigators generally prescribe daily doses in milligrams (mg) (Barc *et al*., 2008; Buts *et al*., 1986; Can *et al*., 2006; Krasowska *et al*., 2010; Lukaszewicz, 2012; McFarland, 2006; McFarland, 2010).Some recommendations for clinical application of *S.boulardii* in adults is summarized in Table 2.

Table 2. Outline of recommendations for clinical employ of *S.boulardii* in adults (Lukaszewicz, 2012; McFarland, 2010)

Employ pro disease	Employing dose (mg/ml)	Employing era
Cure of *Clostridium difficile* diseases	1000	28 days
Inflammatory bowel disease	750-1000	50 days to 180 days
Acute adult diarrhea	500-750	8-10 days
H. pylori symptoms	1000	14 days
Irritable bowel syndrome	500	28 days
Enteral nutrition-related diarrhea	2000	8- 28 days
Prevention of Travelers' diarrhea	250-1000	through trip is 21 days
Prevention of antibiotic related diarrhea	500-1000	Throughout antibiotics with further 3 days to 14 days after
Giardiasis	500	28 days
HIV-related diarrhea	3000	7 days

Whereas itdoes not have side effects, ensure early supply of your medications before you start taking *S.boulardii*, particularly if you are allergic to yeast, pregnant, or breast-feeding. *S.boulardii* appears in over the counter supplements, which can be taken orally. To add further probiotic foodstuffs into our diet, there are extra alternatives other than just yoghurt (Büchl*et al*., 2010; Czerucka and Rampal, 1999; Diezmann and Dietrich, 2009; Ferreira *et al*., 2010; Floch, 2014; Im and Pothoulakis, 2010). Cheese, butter milk, Kefir, kombucha, sauerkraut and miso, contain a wealth of digestive supporting probiotic microorganisms that are capable of normalizing the body (Floch, 2014; Fuller, 1989; Pourjafar *et al*., 2010; Vohra and Satyanarayana, 2012).

Generally, yeast as of Saccharomyces kind has been employed in humans and a better nourishment for all ages and innovative requests in industries are being expanded. These nourishments are of high quality and are utilized as food additive or to get several manufactured goods for instance the white or living cocktail (Buts *et al*., 1986; Büchlet *al*., 2010; Czerucka *et al*., 2007; Vohra and Satyanarayana, 2012). Yeast cells are in addition a famous source of proteins, nucleicacids, vitamins and minerals, it contains a purely vigorous form of chromium, and identified as glucose tolerance factor (Czerucka *et al*., 2007; De Lianos *et al*., 2010; Lukaszewicz, 2012). *S.boulardii* frees its passageway during gastrointestinal pathway at least with 1500diverse compounds (Lukaszewicz, 2012; Martins *et al*., 2011; Zanello *et al*., 2011). At the same time as vitamins are compulsory exogenous natural compound which are also consumed, enzymes facilitate the change of bigger compounds to smaller ones which might be taken in by the brush rim. The brush rim is the structured shaped through which the micro villi raises the cellular surface region for emission, absorption, adhesion and transduction of indicators. Inside the gastrointestinal area , the brush rim is vital for digestion and nutrient absorption (Buts and De Keyser, 2010; Canonici *et al*., 2011; De Lianos *et al*., 2010; Toma *et al*., 2005; Zaouche *et al*., 2000). It has been demonstrated that oral administration of *S.boulardii* improved the actions of the brush rim ectomembrane enzymes e.g. lactase, aminopeptidase and alkaline phosphatase. *S.boulardii* cells have considerable quantities of polyamines (spermidine and spermine) which influences cell maturation, enzyme expression and membrane transport, consequently, polyamines were recommended as mediators in the intestinal trophic reaction (Buts *et al*., 1986; Buts *et al*., 1994; Büchl *et al*., 2010; Lukaszewicz, 2012).

Generally, in consumption time of products containing *S.boulardii*; Side effects of dehydration and constipation are extraordinary and irrelevant in healthy individuals and takes just a few days. Diarrhea might take place when the flora of gastrointestinal lumen alters (Lukaszewicz, 2012).

Conclusions

S.boulardii is a factual probiotic yeast superstar. There are plenty randomized, double-blind placebo-controlled investigations demonstrating the efficacy of *S.boulardii* in the cure and prevention of gastrointestinal disorders (Choi *et al*., 2011; Kotowska *et al*., 2005; Maupas *et al*., 1983; McFarland *et al*., 1994; Szajewska and Skorka, 2009; Villarruel *et al*., 2007). For the past 30 years, doctors have suggested it to cure patients with diarrhea. It facilitates the adjustment of intestines and guards them from pathogens and other abnormalities in the intestinal

lining. Doctors have also related the defects in the intestinal wall with diverse gastrointestinal illnesses. In contradiction to the majority of the indexed medicines which are distinct, pure composites, *S.boulardii* has been proven to be valuable through different mechanisms. Consequently, because of the diverse interactions of the compound, more studies should be conducted. However, it is furthermore very arduous, expensive and time consuming. There are a number of organisms in the conventional fermented foodstuff that has been investigated to be potentially advantageous for human well- being. Nevertheless, probiotic microorganism properties are strain explicit and extremely often not fine described. Properties of strains from the similar species might be extremely dissimilar; consequently for the well-being of humans, in addition, the advantages of the probiotic strain ought to be well illustrated. It is obvious that the micro flora of the human body is too complex and it is significant to maintain proper homeostasis, which can be disturbed by the intake of antibiotics. This can be averted or recovered by means of suitable probiotic microorganisms. Nevertheless, by reason of the complication of the probable interactions and diverse mechanisms of these actions, it is extremely complicated to record and commercialize probiotics. It is a big challenge to resolve this blockage in the future. These days, *S.boulardii* is regularly marketed as a probiotic in a lyophilized shape and is so often referred to as *S.boulardii lyo* (Lukaszewicz, 2012).

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