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Assessment of taste perception and candidal carriage rate in diabetics - a cross sectional study

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Abstract

Diabetes mellitus is a chronic metabolic disorder characterized by hyper glycemia due to impaired insulin secretion, and reduced peripheral action of insulin or both. It has innumerable complications in the oral cavity including opportunistic infections like oral candidiasis and alterations in the taste. Various studies have been carried out for prevalence of oral complications in diabetes but there is no evidence of studies related to the association between the taste alteration and oral candidiasis in type 2 diabetes mellitus. Our study is aimed to assess the taste perception along with candida carriage rate in the diabetic patients and find the association between these two in type 2 diabetes patients This study comprises of a total 40 patients divided into two groups- group A -20 healthy volunteers as a control group without diabetes mellitus type 2 and group B- 20 patients with diabetes mellitus type 2. To assess the taste perception, the tongue was divided into four quadrants and basic tastes were tested and the response was collected. The tongue swab was collected to assess the candida carriage rate. There was a significant difference in the taste in diabetic patients and the sweet taste was more altered. The candidal colony count in the diabetic group was increased when compared to the control group and a significant association exists between the taste perception and the candida carriage rate ($p<0.001$). This study has found a significant association between taste perception and candida growth in the diabetic patients with impairment in the taste perception in the diabetic group.

Keywords: Diabetes mellitus, taste perception, candida carriage rate, taste impairment.

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1. Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyper glycemia due to impaired insulin secretion, and reduced peripheral action of insulin or both [1]. It is caused by dysfunction of the β-cells of the pancreatic islets that induces elevated plasma glucose levels. The categorization of diabetes as type 1, type 2 and gestational diabetes mellitus (GDM) proposed by the American Diabetes Association (ADA) in 1997 is still the most widely used classification and was endorsed by ADA. The form and duration of diabetes affect the severity of symptoms [1]. The long-term impairment, dysfunction, and failure of several organs caused by this chronic hyper glycemia can lead to macrovascular and microvascular complications, one of which is diabetic autonomic neuropathy (DAN). According to a poll conducted by the International Diabetes Federation (IDF) in 2021, there were around 537 million adults (20–79 years) living with diabetes globally, which equates to a 9.3% prevalence. By the year 2045, this figure is projected to rise to 700 million. According to the IDF, 134 million people would likely have diabetes in India by the year 2045, up from the current 77 million patients [2]. To detect and ingest nutrients while avoiding toxins and indigestible elements, organisms are guided by their sense of taste. The "basic" tastes for humans are bitter, umami, sour, salty, and sweet. The fact that taste performs 'functions' in addition to influencing food choices is a significant, underappreciated feature of taste. The release of digestive enzymes, the start of peristalsis, and an increase in mesenteric flow are all physiological reactions that are triggered when the taste buds are stimulated. Other physiological reactions include the release of insulin, the sympathetic activation of brown adipose tissue, an increase in heart rate, and others that prepare the body for metabolic adjustments [2]. Diabetes patients may exhibit reduced taste perception. A slower rate of receptor turnover may be connected to the pathophysiology of taste changes in DM. Furthermore, although it is still debatable, there is a link between taste impairment and diabetes neuropathies [3]. When it comes to fungi, diabetics have a higher prevalence of oral lesions brought on by Candida infection, including

denture stomatitis, pseudomembranous candidiasis, median rhomboid glossitis, and angular cheilitis. Moreover, diabetics frequently take systemic drugs that leads to decrease in salivary flow, which encourages the growth of microorganisms in dental biofilms. Candida albicans, a polymorphic fungus with the capacity to proliferate in the form of hyphae that colonise and infiltrate the tissues, is the major pathogen responsible for oral candidiasis [3]. Candida albicans are the normal commensals of the oral cavity present in the yeast form, in case of alteration in the host immune system, they transform to pathogenic form (hyphae) and cause infections [4].

This study was aimed to assess the taste perception and candida carriage rate in diabetic patients and the association between these two in diabetic patients.

2. Materials and methods

Ethical Clearance: Proper ethical consent was obtained from the institutional review board (SRMU/M&HS/SRMDC/2022/PG/019) was conducted in the department of oral medicine and radiology in SRM dental college Chennai from October 2022 to November 2022 and was conducted under standardized ethical principles following "Helsinki Declaration."

Study design: It is as cross sectional, case control observational study.

Study sample: A simple random sampling technique was employed to select the patients. A power of 80% with 5% level of significance, the minimum sample size required was estimated to be 20 for each group. The total study sample included 40 patients divided into 2 groups- group A- 20 healthy individuals as control group and group B- 20 patients with diabetes mellitus type 2. The study group was recruited based up on the fasting blood sugar, post prandial blood sugar and HbA1c values and the duration of diabetes mellitus. The study protocols were explained in detail and consent form was obtained from the participants. The Inclusion criteria included: Participants who are willing for the study, individuals above 18 years of age and history of type 2 diabetes mellitus. The exclusion criteria included: Individuals under 18 years of age, Patients with other systemic diseases like type 1 diabetes, hypertension, cardiac problems, renal diseases, immunosuppressive diseases etc., Smoking, tobacco or betel nut chewing, alcohol consumption, other illness associated with impaired taste perception, Long term use of antibiotics, steroids, other immune suppressive medications, Diseases of the tongue etc.,

Methodology:

Assessment of candida carriage rate:

Collection of specimens: The participants from both groups were instructed to fast for 2 hours prior to the procedure. The samples were collected using a sterile cotton swab rubbing against the dorsum of the tongue. It is stored without contamination in a sterile test tube and was transported to the microbiological lab for the identification of the candida albicans.

Culture methodology: They were cultured on the sabouraud's dextrose agar plate (with 10% chloramphenicol). For 48 to 72 hours, plates were aerobically incubated at 37 degrees Celsius. The presence of creamy white, pasty, opaque and smooth colonies suggested the presence of Candida. SDA culture plates with colony forming units were counted manually to establish the Candida colonies count. Those plates that did not exhibit Candidal development were placed on the bench for an additional 72 hours, checked once again, and then discarded as negative.

Taste assessment: The dorsum of the tongue was divided into four quadrants, namely right anterior quadrant, left anterior quadrant, right posterior quadrant, left posterior quadrant. Four basic taste solutions are prepared in lower and higher concentrations. Sweet- sucrose (0.05g/ml, 0.4g/ml), sour- citric acid powder (0.05g/ml, 0.3g/ml), salt- sodium chloride (0.016g/ml, 0.25g/ml), bitter- quinine hydrochloride powder (0.004 g/ml, 0.06g/ml) were mixed with the distilled water freshly before starting the procedure [14] (figure 1). The subjects were instructed to refrain from eating or drinking for one hour prior to the procedure and to rinse their mouth with water before starting the procedure and in between presenting the taste samples. The four quadrants on the dorsum of the tongue, four distinct tastants were administered directly using filter paper immersed in the solution for around five seconds (figure 2). The intensity of the flavours was then documented. The intensity rating scale, which ranges from 0 (no intensity) to 5 (great intensity), was used to record the flavours that the individuals perceived.

Statistical analysis: Statistical analysis was done by using IBM SPSS statistics for windows, version 26.0, armonk, ny: ibm corp. Released 2019). Descriptive statistics was done to assess the frequency and percentage. Shapiro Wilk test done to check the normality of the data. Mann Whitney U test used to compare test perception between two groups. Also to find the association of taste perception and candidal carriage. P-value <0.05 was considered to be statistically significant.

3. Results and Discussions

The results were tabulated individually according to the categories. The aim of the present study was to find the taste perception, candida carriage rate and its association in diabetic patients. We had a study group comprised of 20 diabetic patients with 12 male and 8 female and a control group of 20 healthy individuals with 13 male and 7 female. Majority of the participants were in 60-70 years age group in the study population followed by 50-60 years, 40-50 years, 30- 40 years. The control population had a majority of participants from 30-40 years age group (Figure 3). The mean age group of study population was 53.7±10.07 and control group was 42.93±13.8. We have categorized the diabetic patients based on the fasting blood sugar with the mean value of 139.55±51.64, post prandial blood sugar with the mean value of 207.85±66.30, HbA1c with the mean value of 7.88±1.44, ranged from 6 - 10.5. There were 11uncontrolled and 9 controlled diabetes mellitus patients. (< 7- controlled diabetes mellitus, >7- un controlled diabetes mellitus) based on HbA1c value. The role of taste in the management of the digestive process, the regulation of food intake, and the production of the neuroendocrine hormones responsible for hunger and satiety has been largely established. The four basic taste qualities—sweet, salty, sour, and bitter are

recognised by the human gustatory system as a wide variety of flavour stimuli. The taste buds in the mouth are primarily responsible for taste [5]. Taste is adversely affected in diabetic patients. The mechanism of taste issues among diabetes people is still unknown. Previous research has shown a connection between taste impairment and diabetes neuropathies. Additional studies examined the relationship between the satiation phenomenon, glucose receptor defects, and changes in taste in diabetic patients [6]. For taste assessment, we have performed localized taste assessment in four quadrants of the tongue of diabetic patients and compared it with healthy volunteers. The sweet taste with lower and higher concentrations in all the four quadrants and some areas of sour and bitter taste in showed highly significant results ($p<0.0001$). The salt, sour and bitter taste in lower and higher concentrations in all the four quadrants showed moderately significant results ($p<0.001$) (Figure 5).

A similar study was performed by Gondivkar et al, Khera. S et al in six quadrants of the tongue of diabetic patients. Khera. S et al said that significant changes in the different areas of the tongue (RAT, RPT, LAT, LPT) and soft palate (RSP, LSP) for sweet and sour taste. No significant changes were seen in the RPT an LPT areas for salty taste and LPT for bitter taste where as other regions showed significant alterations [7]. Some researchers have performed whole mouth threshold method [2], [8], [9], taste strips and electro-gustometry for taste perception. In the present study there was a significant reduction in the taste perception in all four tastes in the diabetic patients while sweet taste being more altered along with few areas of bitter and sour taste. Kumar Z N et al in his study evaluated the sweet taste sensitivity in diabetes mellitus type 2 patients and said that type-II Diabetes Mellitus patients had lesser sensitivity for the sweet taste. Loss of sensitivity leads to the increase in sugar consumption being the risk factor for worsening the disease [9]. Previous studies says that there was impairment in the sweet taste among diabetic patients [11], [12]. In the oral cavity of healthy people, Candida species are frequently found, however this may not indicate that the person has a Candida infection. Separating those with commensal Candida from those with infection-associated Candida requires a threshold Candida concentration. Candida colony counts in healthy people are modest, that is, less than 50 CFU/100 L. On the other hand, people who have circumstances that make them more susceptible to infection have larger levels of the candida in their saliva, up to 1000 CFU/ml [13], [14]. In the present study we have analysed candida counts in the oral cavity of the individuals of both the groups using swab method on the dorsum of the tongue. We had 16 out of 20 diabetic patients and 5 out 20 patients positive for candida colonies. Comparison of candidal colony forming unit between study and control group shows that the study group has a mean and SD of candida carriage rate of 30.8±18.251 which was significantly higher than the control group with mean and SD of 14.65±5.470 SD. The results were statistically significant ($p<0.01$) (Figure 4). The inter quartile range was 35 and the median 10.5 CFU per swab. A similar study was conducted by Toovama. H et al in which Candida species were detected in the oral cavity in 67 of 200 patients (33.5 %) by the swab method. The median -23 CFU (interquartile range, 3 to 96 CFU)/ swab [13]. The mean candida colony count in study group was 30.8±18.251, and in the control group was 14.65±5.470.

Fungal infections are more common in diabetes mellitus patients, perhaps as a result of immune system problems, hyposialia, wearing dentures, the level of glycemic control, and medication use. An oral environment rich in carbohydrates allows for high levels of salivary glucose and can help aciduric yeasts persist in the oral cavity in diabetics with poor metabolic regulation. Additionally, the presence of carbohydrates in the diet may play a role by encouraging yeast colonisation, biofilm development, and oral adhesion. Additionally, they take systemic drugs that encourage a decrease in salivary flow, which promotes the growth of microbes in dental biofilms [16]. During hyper glycemic episodes, salivary glucose binds chemically reversible glycosylation products with proteins in tissues. This results in a buildup of glycosylation products in oral epithelial cells, which may increase the number of Candida receptors available [17]. The data implies that oral opportunistic infections, such as oral candidiasis, are more likely to occur in people with inadequate treatment or uncontrolled diabetes. Candida albicans, a polymorphic fungus with the capacity to proliferate in the form of hyphae that colonise and infiltrate the tissues, is the major pathogen responsible for oral candidiasis. unlike C. albicans, C. tropicalis, C. glabrata, and C. krausei, C. famata, C. kefyr, C. colliculosa, C. parapsilosis, C. guillermondii, and C. rugose which are widespread species, are also isolated [18]. In the present study we have isolated only candida albicans since they are the most common candida species from the tongue swab of the individuals. There are researches who had isolated different species of candida form the saliva of the diabetic patients [16], [18], [19], [20], [22]. The association between the taste perception and candida was studied, which showed that there was a significant association between them ($p<0.01$) (Figure 6). The association between the taste perception and fasting blood sugar, with the mean and SD were 139.55±51.64, postprandial blood sugar, with the mean and SD were 207.85±66.30 and hbA1c value, with the mean and SD were 7.88±1.44 and p value for all three associations were significant ($p<0.01$).

In the present study there was a significant association between the taste perception and candida carriage rate in the diabetes type 2 patients. All the four basic taste shows statistically significant results. It suggests that the diabetic patients with candida carriage rate have impaired taste perception when compared to the healthy individuals. There are studies which has found the association between the taste perception and candida albicans rate. Sayuri et al studied the taste disorders in patients with candidosis of the tongue and in healthy "carriers" and "non-carriers" of *C. albicans. He* says that Patients with candidosis of the tongue and "carriers" of *C. albicans* demonstrated significantly higher incidences ($p<0.001$) of taste disorders than did "non-carriers" [21].

Table 1. Association of taste perception with fasting blood sugar

STUDY GROUP	PARAMETER	Z-SCORE	P VALUE
SWEET	FASTING SUGAR LEVEL Mean- 139.55±51.64	-3.785	0.00062**
SALT			
SOUR			
BITTER			

Table 2. Association of taste perception with post prandial blood sugar

STUDY GROUP	PARAMETER	Z-SCORE	P VALUE
SWEET	POST-PRANDIAL SUGAR LEVEL Mean- 207.85±66.30	-5.429	0.00038**
SALT			
SOUR			
BITTER			

Table 3. Association of taste perception with HbA1c

STUDY GROUP	PARAMETER	Z-SCORE	P VALUE
SWEET	HbA1C LEVEL Mean- 7.88±1.44	-8.429	0.00008**
SALT			
SOUR			
BITTER			

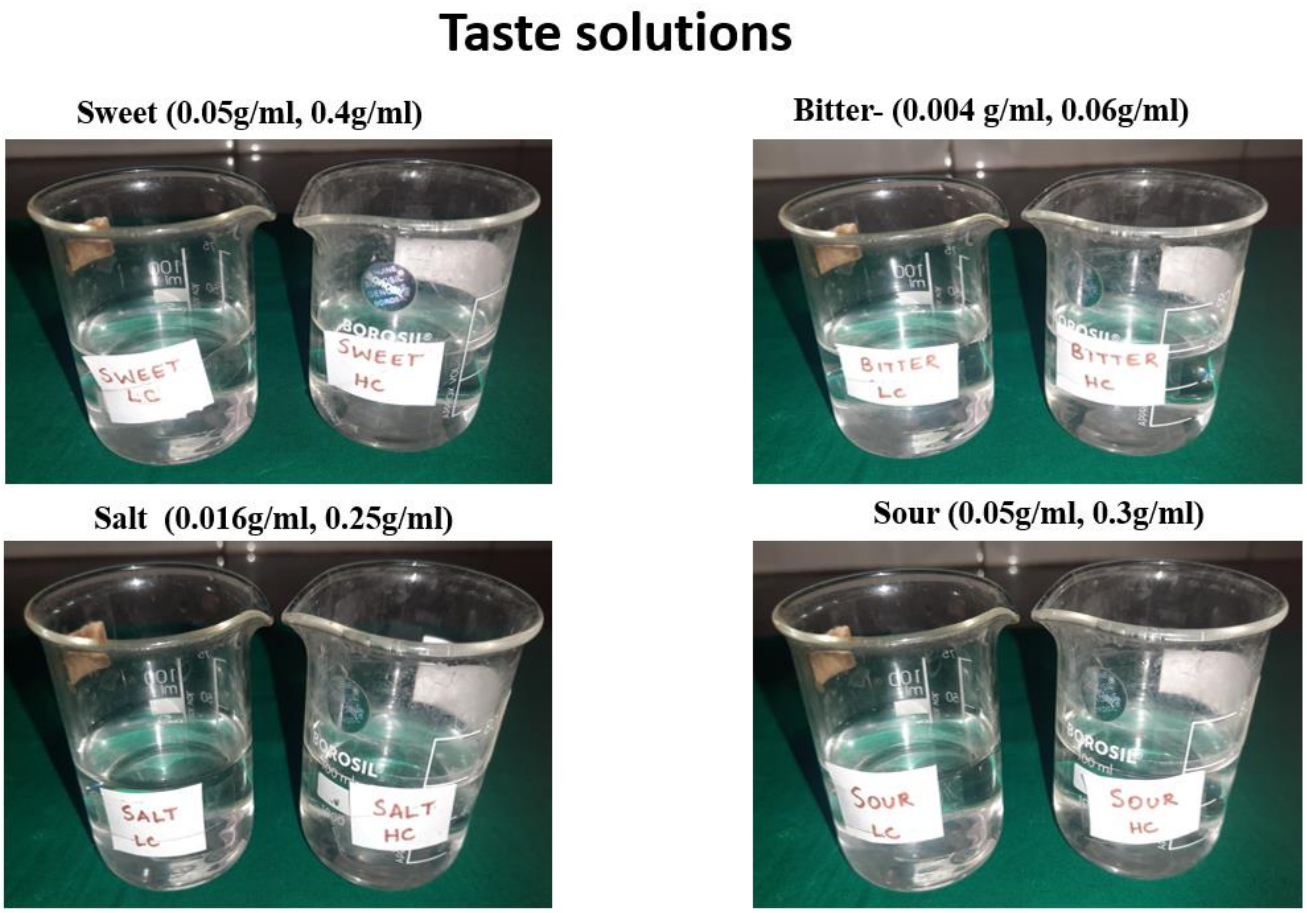

Figure 1: The preparation of various taste solutions

Figure 2. Taste assessment using filter paper method

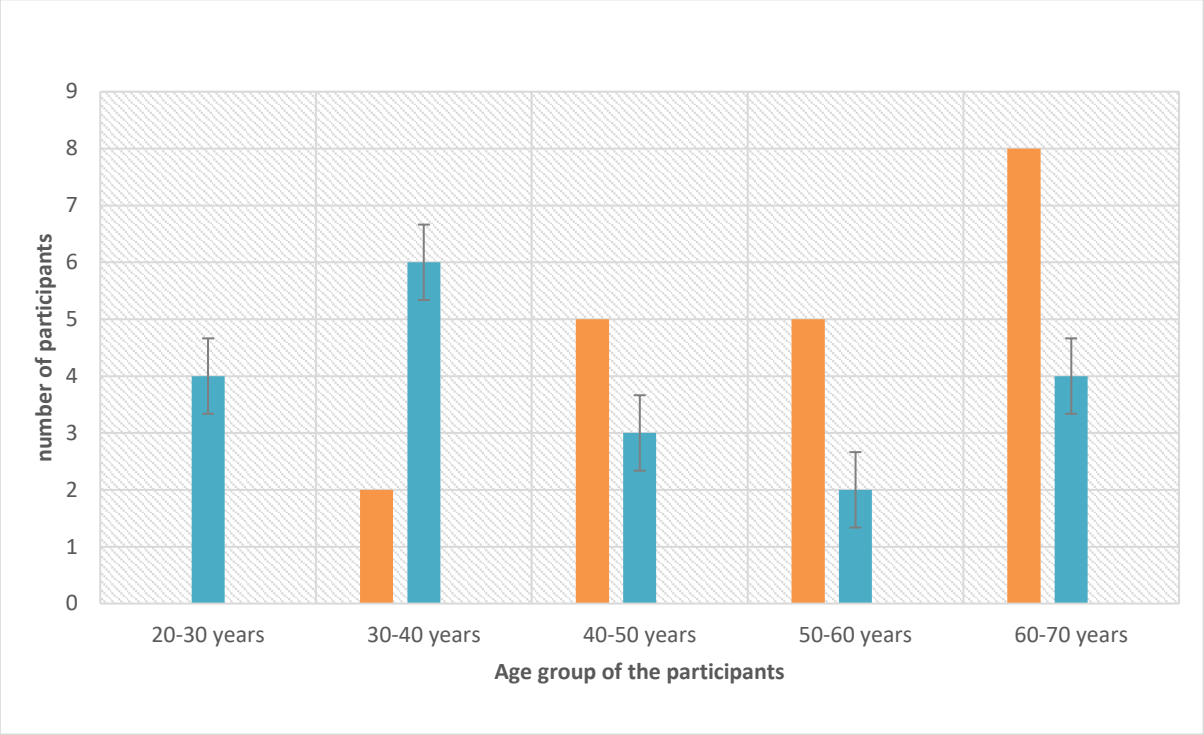

Figure 3. Age group of participants in study and control group

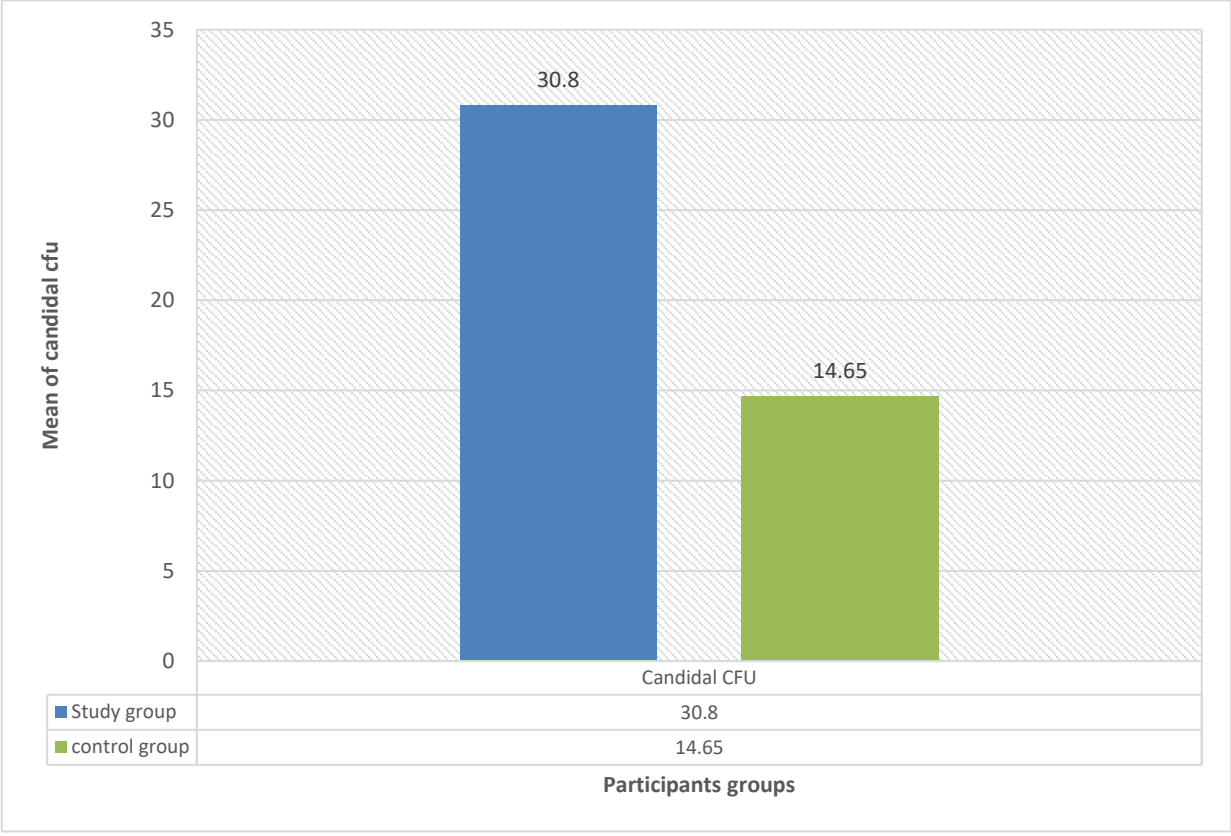

Figure 4. Comparison of candidal colony forming unit between study and control group

SWEET TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SWEET LC-RA	-4.4497	<0.00001***
SWEET LC-LA	-4.5849	<0.00001***
SWEET LC-RP	-4.5849	<0.00001***
SWEET LC-LP	-4.5849	<0.00001***
SWEET HC-RA	-4.3685	<0.00001***
SWEET HC-LA	-4.3144	<0.00001***
SWEET HC-RP	-4.3685	<0.00001***
SWEET HC-LP	-4.6255	<0.00001***

SALT TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SALT LC-RA	-3.5976	0.00016**
SALT LC-LA	-2.5697	0.00508**
SALT LC-RP	-1.798	0.0359**
SALT LC-LP	-2.6914	0.0357**
SALT HC-RA	-1.798	0.0359**
SALT HC-LA	-1.798	0.0035**
SALT HC-RP	-2.312	0.0104**
SALT HC-LP	-2.055	0.0197**

SOUR TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SOUR LC-RA	-2.826	0.00233**
SOUR LC-LA	-1.501	0.06681
SOUR LC-RP	-1.663	0.0359**
SOUR LC-LP	-2.164	0.01537**
SOUR HC-RA	-5.1259	<0.00001***
SOUR HC-LA	-2.5697	0.0050**
SOUR HC-RP	-2.55623	0.00523**
SOUR HC-LP	-1.5418	0.0617

BITTER TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
BITTER LC-RA	-3.3406	0.00233**
BITTER LC-LA	-4.02198	<0.00001***
BITTERLC-RP	-3.07019	0.00107**
BITTER LC-LP	-2.9349	0.00169**
BITTER HC-RA	-4.04399	<0.00001***
BITTER HC-LA	-4.04399	<0.00001***
BITTER HC-RP	-3.2865	0.005**
BITTER HC-LP	-3.4214	0.00031**

Figure 5. Difference in taste perception in study and control groups

SWEET TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SWEET LC-RA	-3.1378	0.00084**
SWEET LC-LA	-4.5849	0.00045**
SWEET LC-RP	-4.5849	0.00045**
SWEET LC-LP	-4.5849	0.00045**
SWEET HC-RA	-4.3685	0.00020**
SWEET HC-LA	-4.3144	0.00021**
SWEET HC-RP	-4.3685	0.00020**
SWEET HC-LP	-4.6255	0.00035*

SALT TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SALT LC-RA	-3.423	0.000632**
SALT LC-LA	-3.532	0.000565**
SALT LC-RP	-3.232	0.000126**
SALT LC-LP	-3.112	0.000152**
SALT HC-RA	-2.865	0.000134**
SALT HC-LA	-2.655	0.000129**
SALT HC-RP	-2.427	0.000122**
SALT HC-LP	-2.241	0.000101**

SOUR TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
SOUR LC-RA	-3.562	0.00056**
SOUR LC-LA	-3.235	0.000420**
SOUR LC-RP	-3.124	0.000412**
SOUR LC-LP	-4.532	0.000511**
SOUR HC-RA	-5.414	0.00032**
SOUR HC-LA	-2.863	0.000424**
SOUR HC-RP	-2.562	0.00034**
SOUR HC-LP	-2.458	0.00075**

BITTER TASTE

STUDY GROUP VS CONTROL GROUP	Z-SCORE	P VALUE
BITTER LC-RA	-4.562	0.00232**
BITTER LC-LA	-4.225	0.00185**
BITTERLC-RP	-3.263	0.0052**
BITTER LC-LP	-2.862	0.00438**
BITTER HC-RA	-3.528	0.00328**
BITTER HC-LA	-5.231	0.00268**
BITTER HC-RP	-5.255	0.00261**
BITTER HC-LP	-1.895	0.0045**

Figure 6. Association of taste perception with candida carriage rate

In a study by Fluitman KS et al performed taste and smell tests, collected anthropometric measurements and tongue swabs for analysis of microbial composition, along with candida albicans in older adults. According to him there was a negative correlation between the taste perception and the candida carriage rate [23].

4. Conclusions

In the literature search, there were no studies showing association between taste perception and candida growth in diabetic patients. Hence this study was aimed to find the association. The study concluded that there is a significant association between taste alteration and oral candidiasis in diabetic patients.

Future perspectives and limitations:

Candida carriage rate can be used in assessing the diabetic status of the individuals and can be considered as prognostic marker to test for taste perception in diabetic patients before and after treatment. The limitations are small sample size and further research is needed to find out prevalence of species of candida in diabetes mellitus and if any association with taste alteration.

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