ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACEUTICAL SCIENCES

Published by JK Welfare & Pharmascope Foundation Journal Home Page: www.ijrps.com

A Comparative Study on the Carbohydrate profile and *In-vitro* Glycaemic Index of Processed Basil (*Ocimum basilicum)* Seeds Incorporated Idlis

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Article History:

Received on: 30 Oct 2020
Revised on: 26 Nov 2020
Accepted on: 30 Nov 2020

Keywords:

Carbohydrate Profile,
Glycaemic Index,
Idli,
Ocimum basilicum,
Value Addition

ABSTRACT

The tiny black *Ocimum basilicum* seeds, also called as basil or sabja seeds aid to keep blood sugar levels under control by decelerating the carbohydrate conversion into glucose, a simple sugar. Raw and Steamed *Ocimum basilicum* seeds in the proportions of 5% (RV1, SV1), 10% (RV2, SV2), 15% (RV3, SV3) and 20% (RV4, SV4) of the black gram have been incorporated in the idli formulation. The results depicted that as the proportion of *O. basilicum* seeds increased the total carbohydrate and sugar values showed a decline, whereas the cellulose, hemicellulose and resistant starch values increased. At 120 minutes, the mean *in vitro* glycaemic index of the control idli was estimated to be 66.45 $\pm$ 0.03, while the mean estimated glycaemic index value of raw *O. basilicum* seed incorporated variations of idli namely RV1, RV2, RV3 and RV4 were 55.09 $\pm$ 0.02, 53.19 $\pm$ 0.02, 51.44 $\pm$ 0.01 and 48.09 $\pm$ 0.01 respectively. The mean estimated glycaemic index value of steamed *O. basilicum* seed incorporated variations of idli SV1 was found to be 62.72 $\pm$ 0.01, SV2 was 60.43 $\pm$ 0.01, SV3 was 58.16 $\pm$ 0.02, and SV4 was 56.63 $\pm$ 0.02 at 120 minutes. Hence it is opined that the 20% raw *O. basilicum* seed incorporated idli is very much low in estimated G.I values can be used in idli preparation as a means to offer a lower glycaemic index to the obese, diabetic and cardiac disorder populations.

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ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v11i4.3956

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INTRODUCTION

Glycaemic Index indicates the rate at which the blood sugar levels raise after ingestion of a particular food in an observed period of time in comparison with the controls like glucose or white bread. The glycaemic index (GI) is considered as an important indicator of glycaemic response (Jenkins *et al.*, 1981). Diets with a low GI are associated with decreased glycaemic response and proves beneficial for lower and more consistent postprandial insulin release, reducing body weight, total body fat and visceral fat, levels of pro-inflammatory markers and the occurrence of dyslipidemia and hypertension (Feliciano *et al.*, 2014). Salari-Moghaddam *et al.* (2019), observed a significant positive association between dietary GI and abdominal obesity, especially in women. The study result of Zafar *et al.* (2019) has proved that the low-GI diets reduce glycated hemoglobin (HbA1c) levels, fasting blood glucose levels, BMI, total cholesterol, and LDL, but had no effect on fasting insulin, HOMA-IR, HDL, triglycerides, or insulin requirements. Even with these limitations, GI continues to capture the attention of physicians and nutritionists alike as it does offer a rational way of ranking carbohydrate-containing foods that has the potential to favorably affect the prevention and management of diabetes (Madhu, 2017). Idli, a South Indian staple diet which had been into controversies in recent times, has been acknowledged as a wholesome, nutritious food by many health professionals. As it is a steamed food product, the ease in digestion brands idli as a significant diet from infants to geriatrics. The issue of concern in idli is that it is categorized as a high glycaemic food with GI around 69, making it unfit for diabetics to consume. Hence, several food scientists have taken the initiative to modify the GI of idli by processing the rice used for idli preparation (Chelliah *et al.*, 2019), replacing the quantity of rice with millets lower the G.I. of idli (Nazni and Shalini, 2010).

Research study on the addition of jowar to idli has shown a low glycaemic response compared to rice Rawa idli (Jahan *et al.*, 2018). Researchers have substituted amaranth grain flour (Nazni *et al.*, 2014), oats and guar gum flour (Giri *et al.*, 2017) to lower GI of idli and enhance its nutritional value making idli an ideal diet even for people suffering from non-communicable diseases. Phytomedicine the field that utilizes plants and its parts for medicinal purposes in the treatment and prevention of non-communicable diseases especially diabetes has a long history compared to the conventional medicine (Choudhury *et al.*, 2018).

One such noteworthy plant species, *basil* comes from the Greek *basileus* or "king. The benefits of *O. basilicum* include improving glucose homeostasis and lipid profiles for patients with diabetes, strengthening of the immune system, alleviating stress and anxiety, enhancing memory, Oral and skin health and healing (Singletary, 2018). The presence of polyphenols and flavonoids showcases *O. basilicum* seeds as a vital part of the daily food regime (Sestili *et al.*, 2018). With these glimpses of review of literature, it was decided in our study to incorporate the seeds of *Ocimum basilicum* in the idli formulation and read its impact on the carbohydrate profile and estimated glycaemic index of value-added idlis.

MATERIALS AND METHODS

Procurement and Processing of Raw Material

The raw materials required for the study such as parboiled rice, dehulled black gram and basil or sabja seeds (*Ocimum basilicum L.*) were purchased from the local market of Salem district, Tamilnadu. The ingredients rice and black gram were hand sorted, to make sure that only quality grains are used and the impurities were removed by washing with water. The basil seeds were hand-sorted and sieved to ensure quality. The seeds required for preparing idlis by incorporating steamed *O. basilicum* seeds were steamed for 8-10 minutes.

Formulation of Raw and Steamed *Ocimum basilicum L.* Seeds Incorporated Idlis

The cleaned, parboiled rice and dehulled black gram were soaked for 5 hrs in the water at room temperature separately in the ratio of 4:1 (Ghosh and Chattopadhyay, 2011), for control and in different proportions for respective variations of idli as shown in Table 1 and ground to batter. The batter was allowed to ferment for 7 hours (Nagaraju and Manohar, 2000). The batter was beaten well, raw and steamed *Ocimum basilicum* seeds in the proportions of 5% (RV1, SV1), 10% (RV2, SV2), 15% (RV3, SV3) and 20% (RV4, SV4) were incorporated into the respective proportions of batter and was allowed to stand for 15 minutes (Samateh *et al.*, 2018) for the seeds to gel. The batter was poured in an idli steamer and steamed till doneness which approximated to 5 to 8 minutes. Simultaneously the control idli was prepared by following the same procedure without the addition of basil seeds.

Determination of Carbohydrate profile

The control idli and developed variations of raw and steamed *O. basilicum* seeds incorporated idli were subjected to estimate the carbohydrate profile indices namely total carbohydrate, sugars, cellulose, hemicellulose and resistant starch. Carbohydrate and sugar content was assessed by IS 1656 and IS 6287 procedures respectively, while cellulose, hemicellulose and resistant starch in the idli samples were analyzed using the standard procedure by Mathews *et al.* (1993); AOAC (2002).

Estimation of *In Vitro* Glycaemic Index

Starch Hydrolysis percentage, ($C\infty$ %) corresponds to the concentration at equilibrium (t_{120}), and k is the kinetic constant. Hydrolysis index (HI) is calculated as a percentage of the total content of glucose released is compared to the standard glucose that is released between 0 and 180 minutes (Barine and Yorte, 2016). The estimated glycaemic index (EGI) was calculated using the equation,

$$\mathrm{EGI} = 39.71 + (0.549\mathrm{HI})$$

Statistical analysis

All experiments in the present analysis were conducted in triplicate, and mean values were reported. The descriptive statistical analyses were performed using IBM SPSS Statistics 16 Software package. The data were subjected to analysis of variance (One-way ANOVA) with Duncan's Post Hoc test ($P<0.05$) to determine the significant difference between the means.

Table 1: Ingredients in the preparation of control, raw and steamed *Ocimum basilicum.L.* seeds incorporated idlis.

Variations	Rice	Black gram dhal	Raw *O. basilicum* seeds	Steamed *O. basilicum* seeds
Control	100	25	-	-
RV1	100	23.75	1.25	-
RV2	100	22.5	2.5	-
RV3	100	21.25	3.75	-
RV4	100	20	5	-
SV1	100	23.75	-	1.25
SV2	100	22.5	-	2.5
SV3	100	21.25	-	3.75
SV4	100	20	-	5

Table 2: Carbohydrate profile of raw and steamed *Ocimum basilicum.L.* seeds incorporated idlis.

Variation	Carbohydrate (%)	Sugar (%)	Cellulose (%)	Hemicellulose (%)	Resistant Starch (%)
Control	21.49 ± 0.37^{b}	0.22 ± 0.02^{a}	1.02 ± 0.47^{e}	1.04 ± 0.05^{d}	0.67 ± 0.64^{e}
RV1	22.24 ± 0.27^{a}	0.16 ± 0.03^{c}	0.64 ± 0.04^{f}	0.83 ± 0.06^{e}	0.90 ± 0.02^{d}
RV2	20.78 ± 0.22^{c}	0.15 ± 0.03^{d}	1.87 ± 0.10^{c}	2.16 ± 0.09^{a}	0.94 ± 0.03^{c}
RV3	20.67 ± 0.18^{C}	0.14 ± 0.04^{e}	2.02 ± 0.09^{b}	2.46 ± 0.18^{a}	0.96 ± 0.02^{c}
RV4	17.78 ± 0.12^{d}	0.14 ± 0.02^{e}	2.29 ± 0.48^{a}	2.57 ± 0.03^{a}	1.13 ± 0.05^{a}
SV1	17.41 ± 0.19^{d}	0.16 ± 0.01^{b}	1.03 ± 0.04^{e}	1.05 ± 0.07^{d}	0.96 ± 0.03^{c}
SV2	15.64 ± 0.54^{e}	0.14 ± 0.04^{e}	0.83 ± 0.04^{f}	1.24 ± 0.09^{c}	0.96 ± 0.02^{c}
SV3	15.42 ± 0.25^{e}	0.13 ± 0.03^{f}	1.59 ± 0.04^{d}	1.60 ± 0.02^{c}	0.98 ± 0.01^{b}
SV4	12.98 ± 0.11^{f}	0.09 ± 0.02^{g}	1.67 ± 0.05^{d}	2.08 ± 0.04^{b}	1.01 ± 0.04^{b}

Each value in the table are represented as Mean ± SD. Means with the same superscript are not significantly different using Duncan's Multiple Range Test (P < 0.05).

RESULTS AND DISCUSSION

Determination of Carbohydrate profile

Carbohydrate profile is an important parameter to determine the quality of food. Based on the quantity and quality of carbohydrates in the foods consumed, certain foods prompt a marked increase trailed by a more or less fast fall in blood glucose, while others produce a smaller peak along with a steadier decline in plasma glucose (Kumar *et al.*, 2018).

Table 2 portrays the carbohydrate profile indices of the control and developed variations of raw and steamed *O. basilicum* seeds incorporated idlis. The mean carbohydrate value of the control idli was 21.49, while *O. basilicum* seeds incorporated variations of idli showed a significant difference in the carbohydrate values based on the quantity of seed incorporation and processing whether the raw or steamed variety of seed. Next to control the amount of carbohydrate was more in 5 % raw seed incorporated variation of idli (RV1) and the least amount of carbohydrate was present in the 20% steamed seed incorporated variation of idli (SV4). In terms of the sugar content, as the proportion of the seed incorporation increased, the sugar content of the idlis decreased. This decrease in the carbohydrate and sugar content in steamed variation may be due to the fact that during wet heat treatment processes, there is a considerable loss of low molecular weight carbohydrates (FAO, 1997).

This effect is also similar to the study on sweet potatoes, where the starch content decreased on steaming (Wei *et al.*, 2017). The non-starch polysaccharides cellulose and hemicellulose values and the resistant starch values were directly proportional to the seed incorporation levels. On comparing the variations of idlis based on the processing, more cellulose, hemicellulose and resistant starch content were observed in 20% raw *O. basilicum* seed incorporated variation of idli (RV4) than the 20% steamed *O. basilicum* seed incorporated a variation of idli (SV4). The study by (Cui *et al.*, 2012) has also reported that on exposure to steam, the cellulose and hemicellulose content decreased sharply.

Table 3: Concentration at equilibrium (t_{120}), kinetic constant (k), area under curve, calculated Hydrolysis Index (HI) and Estimated Glycaemic Index of raw and steamed *Ocimum basilicum.L.* seeds incorporated idlis.

Variation	C∞ (%)	K	AUC	Calculated HI (%)	EGI (%)
Control	57.23±0.05	0.0184±0.00	12184.76±10.51	48.71±0.04	66.45±0.02
RV1	40.67±0.03	0.0301±0.00	7186.68±5.68	28.73±0.02	55.48±0.01
RV2	35.85±0.04	0.0332±0.00	6143.94±6.49	24.56±0.03	53.19±0.02
RV3	31.65±0.04	0.0349±0.00	5344.57±6.09	21.36±0.03	51.44±0.01
RV4	25.76±0.04	0.0598±0.00	3820.64±5.36	15.27±0.02	48.09±0.01
SV1	52.56±0.03	0.0215±0.00	10484.97±5.28	41.91±0.02	62.72±0.01
SV2	49.23±0.02	0.0238±0.00	9442.50±3.99	37.75±0.02	60.43±0.01
SV3	45.94±0.04	0.0271±0.00	8408.95±7.62	33.61±0.03	58.16±0.02
SV4	43.54±0.04	0.0299±0.00	7711.88±7.37	30.83±0.03	56.63±0.02

Estimation of *In Vitro* Glycaemic Index

The in-vitro measurements are simple, and economical when compared to *in vitro* tools and will be a reliable indicator of the required values, and may act as a pilot screening method to *in- vivo* measurements (Argyri *et al.*, 2016). Table 3 shows the equilibrium constant (C∞), the kinetic constant (K), calculated hydrolysis index (HI) and the estimated glycaemic index (EGI) values of control, raw and steamed *O. basilicum* seeds incorporated variations of idlis. The control idli had the highest calculated HI and EGI values, proving it to be medium glycaemic food. The raw *O. basilicum* seeds incorporation reduced the Estimated Glycaemic Index values of idlis from 55.48(RV1) to 48.09(RV4).

The decrease in EGI was found proportional to the level of incorporation of seeds. An analogous result was found for the steamed *O. basilicum* seeds incorporated variations of idlis too. The EGI values fell from 62.72% (SV1) to 56.63% (SV4). The calculated HI values for all the variations showed similar trends to EGI values. It should be noted that on comparing the raw and steamed variations of idlis, in spite of the same level of seeds incorporation the raw *O. basilicum* seeds incorporated variations of idlis had a low EGI value. The results of this study is similar to the study that confirms, that wet heat gelatinizes starch to a greater extent than dry heat and found to be associated with higher GI values (Widanagamage, 2013).

The processing methods, to a greater extent, impacts the EGI values. The EGI values of roasted *O. basilicum* seeds incorporated idli ranged from 56.73% to 56.22% (Arivuchudar and Nazni, 2020). The AUCs of digested starch over 2 hours were significantly lower for the raw *O.basilicum* seeds incorporated variations. The measure of Area Under the Curve (AUC) provides an integrated expression of insulin levels over time, so as to best assess the degree of increase in insulin levels (Allison *et al.*, 1995).

Also, the AUCs, calculated HI and Estimated GI values can be correlated with the resistant starch values too. The more the resistant starch in the variations, the lower is the EGI value of those variations of idli. The low GI, as well as high resistant starch, reduces the insulin resistance by lowering the blood glucose levels in diabetic patients as well improves the lipid metabolism and prevents cardiovascular diseases (Kannayiram *et al.*, 2020). To summarize, the incorporation of 20 % raw *O.basilicum* seeds has resulted in a low glycaemic idli compared to all the other developed products. It should also be pointed out that the methanolic extract of *O. basilicum* seed has proved effective for the treatment of diabetes and lipid-lowering activities in streptozotocin induced diabetes rat (Parikh and Kothari, 2020).

CONCLUSION

Though, *O. basilicum* seeds owing to their pharmaceutical properties, have formed a major fragment in the treatment of many ailments especially in Chinese medicine, the inclusion of *O. basilicum* seeds as a routine food is not in practice. Hence, in order to familiarise the *O.basilicum* seeds, they were incorporated into the much familiar and routine food, Idli. The presence of mucilage, a rich source of hydrocolloid with outstanding functional properties, has helped in developing idlis of desired texture. From the study conducted, in vitro starch hydrolysis of all the variations of the idlis were significantly affected ($p < 0.05$) by the process used (raw & steamed seeds) and the proportion of *O. basilicum* seeds added in the formulation. Resistant starch content increased significantly ($p < 0.05$)

in 20% variations of raw and steamed *O. basilicum* seeds incorporated variations, compared with the control. It was also found that resistant starch content is inversely related with a hydrolysis index value, which resulted in lower estimated glycaemic index values in idlis with higher incorporation level of *O. basilicum* seeds. On comparing the raw and steamed *O. basilicum* seeds incorporated variations of idli, it can be concluded that all the variations of raw *O.basilicum* seeds incorporated idlis had a lower G.I value, while 20% of incorporation exhibited the least Estimated Glycaemic Index value. Thus, the idli (control) with medium glycaemic index value has been transformed to low Glycaemic idli because of incorporation of 20% raw *O. basilicum* seed.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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