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Development and evaluation of the physical properties of polyherbal formulations for antiobesity

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Abstract
In the current investigation, seven polyherbal formulations were developed using fruits, vegetables, medicinal herbs and spices by considering their anti-obesity potential. Polyherbal formulations were carefully composed using nine medicinal herbal powders (*Garcinia cambogia*– malabar tamarind rind, *Commiphora wightii* –guggul gum resin, *Embelica officinalis*–aonla fruits, *Terminalia chebula* – haritaki fruits, *Terminalia bellirica*– bibhitaki fruits, *Curcuma longa* – turmeric rhizome, *Zingiber officinale*– turmeric rhizome, *Moringa oleifera* – drumstick leaves and *Piper longum* – long pepper fruits). Physico-chemical parameters such as bulk density, tapped density, Carr's index, Hausner's ratio and angle of repose were determined according to standard procedure. Bulk density and tapped density of all the seven polyherbal formulations were in the range of 0.50 - 0.56 g/cm^3 and 0.60 – 0.67 g/cm^3, respectively. Analysis of physical properties revealed better stability and flowability, relatively low level of contamination with good quality polyherbal formulations.

Keywords: polyherbal formulation, antiobesity, fruits, vegetables

1. Introduction

Obesity and overweight are defined as a condition of excessive or abnormal fat accumulation in adipose tissue, to the extent that health may be impaired. Energy imbalance causes excess fat formation, particularly in the abdominal area. Increased intake of energy-dense foods, decreased intake of food rich in micronutrients and bioactive substances, and decreased physical exercise all contribute to this energy imbalance (Greenberg and Martin, 2006) [11]. The prevalence of obesity is growing worldwide and one in five people are being affected (Lee, 2012) [14].

Obesity is a complex condition resulting from biological, behavioural and environmental factors, although it is mostly caused by a lack of physical exercise and a long-term consumption of energy-dense foods. Obesity has become one of the most serious issues in modern society, and extensive research is presently on-the-go to find a solution (Bray *et al*., 2016) [4]. The results of using pharmaceutical drugs for weight management are unclear, and long-term usage of these anti-obesity drugs could have serious side effects. Surgical manipulations are only effective in the most extreme of situations (Mechanick *et al*., 2013) [16]. In addition to individual-level interventions, population- or community-level obesity interventions have been sought by changing behavioural factors such as boosting physical activity, reducing sedentary living, eating a nutritious diet, and so on. Weight management is also aided by changes in policies and the environment (Kumanyika *et al*., 2008) [13].

The Food and Drug Administration (FDA) approved modern medications including Orlistat, Liraglutide, Naltrexone and Phentermine for obesity control, however long-term usage is not safe and produces mood enhancement and cardiovascular excitement (Aronne, 2002) [1]. As a result of the negative effects of modern pharmaceuticals, herbal treatments have become increasingly popular. Because of their natural occurrence, presumed safety, and nutritional and medicinal potential, they are preferred over synthetic ones.

Herbal medications are considered as one of the traditional forms of medicine. Herbal treatments often contain a number of phyto-constituents that often work together synergistically. Natural remedies have gained in popularity and acceptance in most developed and developing countries over the last decade (Ekoe *et al*., 2013) [7]. Although the majority of herbal remedies are regarded safe for human consumption, some of them may be dangerous and cause unpleasant side effects (Asif, 2012) [2].

Several anti-obesity, hypoglycaemic and hypolipidemic properties have been reported previously through studies in plants like *Garcinia cambogia*, *Emblica officinalis*, *Terminalia chebula*, *Terminalia bellerica*, *Moringa oleifera*, *Piper longum* and *Curcuma longum* etc. Hence, pharmacologically these plants have shown strong rationale in the prevention and management of obesity associated clinical conditions. By considering anti-obesity effect of various horticultural crops including medicinal plants, the research on development of polyherbal formulation of new anti-obesity drug from natural plants/herbs that are locally available appears to be attractive and pioneering. The polyherbal formulation emerging from the research work shall provide medicinal health benefit at reduced price and with no side effect than synthetic or conventional medicine. In this back drop, the present experiment was undertaken to focus mainly on developing and evaluating polyherbal formulation from locally available fruits, vegetables, spices and medicinal herbs.

2. Materials and methods

2.1 Preparation of fruits, vegetables, spices and medicinal plants powder

Aonla fruits and ginger rhizomes harvested at optimum maturity were brought to the laboratory and thoroughly washed with tap water. After washing, aonla fruits were cut into pieces. Aonla fruits and peeled ginger rhizomes were sliced by using a sharp stainless-steel knife. Freshly harvested drumstick leaves were washed with tap water. Later these leaves were dried under the ceiling fan to remove the surface moisture. After preparation, aonla slices, ginger slices and drumstick leaves were dried in an electrical drier at 40-50°C till reaching a safe final moisture level of 7-8 per cent. These dehydrated products and purchased malabar tamarind, turmeric rhizomes, long pepper, guggul, haritaki and bibhitaki were crushed in a mixer to obtain a fine powder. Later these powders were passed through a 0.5 mm mesh size sieve and packed in aluminium pouches for further preparation of polyherbal formulations and physical property estimations.

2.2 Preparation of polyherbal formulations (PHF)

Different proportions of herbal powders of aonla fruit, Malabar tamarind rind, haritaki and bibhitaki fruit, ginger rhizome, drumstick leaf, turmeric rhizome, guggul gum resin, long pepper fruit were mixed for preparation of polyherbal formulations as per treatment details.

2.2.1 List of ingredients used in polyherbal formulations (PHF)

Botanical name	Common name	Family	Parts used
Garcinia cambogia	Malabar Tamarind	Myrtacease	Rind
Commiphora wightii	Guggul	Burseraceae	Gum-resin
Terminalia chebula	Haritaki	Combretaceae	Fruit
Termenelia bellerica	Bibhitaki	Combretaceae	Fruits
Curcuma longa	Turmeric	Zingiberaceae	Rhizome
Emblica officinalis	Amla	Euphorbiaceae	Fruits
Zingiber officinale	Ginger	Zingiberaceae	Rhizome
Moringa oleifera	Drumstick	Moringaceae	Leaves
Piper longum	Longpepper	Piperaceae	Fruits

The efficacy of individual herb or combination of two or three herbs have been reported both *in vitro* and *in vivo* for its several properties such as anti-obesity, lipid lowering, as appetite suppressants and as weight loss promoting agents. Based on previous research report we formulated a new polyherbal formulation by combining all the above nine individual herbs indifferent proportions.

2.3 Bulk density

The bulk density was expressed in kilogram or gram per cubic meter in an international unit because it was measured in cylinders (Movahhed and Mohebbi, 2016) [17]. The calculation of bulk was done using the formula is given below.

Bulk density (gcm⁄3) =Mass of powder /Initial volume of the powder

2.4 Tapped density

The tapped density is described as an increased bulk density gained later on mechanically tapping a container comprising powdered product (Movahhed and Mohebbi, 2016) [17]. The calculation of tapped density was done using the formula is given below.

Tapped density (gcm⁄3) = Mass of powder/Final volume of powder

2.5 Carr's index

Carr's index of powders was calculated by using the following formula.

Carr′s index=Tapped density−Bulk density/Tapped density × 100

2.6Hausner's ratio

The cohesiveness property of powder was assessed by Hausner's ratio (HR) which was calculated by the following formula (Hausner, 1967). It helps to notice the cohesiveness of the powder. The flowability in terms of Haunser' ratio index is classified as:

Hausner′s ratio=Tapped density/ Bulk density

2.7 Angle of repose

For determination of angle of repose (θ), the samples were poured through the walls of a funnel which was fixed at a position such that its lower tip was at a height of exactly 2.0 cm above a hard surface. The samples were poured till the time when the upper tip of the pile surface touched the lower tip of the funnel. The angle of repose was calculated using the following equation.

Tan θ = h/r,

θ = tan-1 (h/r)

Where, θ - angle of repose, h- height in cm and r- radius in cm.

Based on the angle of repose, Carr's index and Hausner's ratio, the flow property of the granules can be characterized.

Carr's index, Hausner's ratio and Angle of repose

Carr's index	Hausner's ratio	Angle of repose	Flow property
<10	1.00-1.11	25-30	Excellent
11-15	1.12-1.18	31-35	Good
16-20	1.19-1.25	36-40	Fair
21-25	1.26-1.34	41-45	Passable
26-31	1.35-1.46	46-55	Poor
32-37	1.46-1.59	56-65	Verypoor
>38	>1.60	>66	Veryverypoor

2.9 Experimental design and data analysis

The experiment was carried out with 7 treatments and the experiment was repeated 3 times and pooled data was subjected to statistical analysis. Treatments were arranged in Complete Randomised Design. The data on the physical parameters recorded were subjected to completely randomized block design analysis. All values were expressed as mean±SEM. Statistical analyses were performed using Web Agri Stat Package (WASP) Version 2. Significant differences among means at P = 0.05 were determined by post hoc tests using Duncan's multiple range test.

3. Results and discussion

3.3 Bulk and tapped density (g/cm3)

According to Aziz *et al*. (2019) [3], the bulk and tapped density studies are important in powder formulations because they govern their packaging aspects. Bulk density is described as the ratio of mass of an untapped powder sample to its volume, including the contribution of inter-particulate void volume. As a result, the bulk density is determined by the density of powder particles as well as their spatial arrangement in the powder. Tapped density provides information on the consolidation of powder. The more consolidated the powder, the more resistant will be its flow.

In the present study, the bulk density of all seven polyherbal formulations varied between 0.50 and 0.56 g/cm3 (Table 1). In case of tapped density, all seven polyherbal formulations had a range from 0.60 – 0.67g/cm^3 indicating that these formulations were less bulky (Table 1). The results are in harmony with the outcomes of Patel *et al*. (2020) [20] who reported the bulk density of 0.79 per cent (w/w) and tapped density of 0.66 per cent (w/w) in polyherbal powder of their experiment. Investigation of Dudhal *et al*. (2018) revealed that the bulk density of polyherbal formulations varied from 0.58±0.06 to 0.66±0.02 g/ml (*Syzygium aromaticum* - 0.58±0.06 g/ml, *Piper nigrum* - 0.60±0.07, *Acacia catechu*– 0.66±0.02 g/ml and *Terminalia bellerica*- 0.62±0.02 g/ml). However, tapped density of polyherbal formulations exhibited a range from 0.62±0.08 to 0.74±0.03 g/ml (*Syzygium aromaticum*i - 0.65±0.01 g/ml, *Piper nigrum* - 0.70±0.05, *Acacia catechu*-0.64±0.09 g/ml and *Terminalia bellerica*-0.74±0.03 g/ml. In yet another study, bulk density of 0.38±0.02 to 0.48±0.02 g/ml was reported by Chandel *et al.* (2011) in the in-house polyherbal formulations (madhumehari - 0.38±0.02 g/ml, madhuhari - 0.47±0.03 and madhushoonya 0.48±0.02 g/ml). In the same study, tapped density of the same polyherbal formulations showed a range from 0.50±0.02 to 0.63±0.02 g/ml (madhumehari - 0.55±0.02 g/ml, madhuhari - 0.50±0.02 and madhushoonya 0.63±0.02 g/ml).

Table 1: Effect of different polyherbal compositions on bulk density and tapped density

Treatments	Bulk density(g/cm^3)	Tapped density(g/cm^3)
PHF-1	0.50^{d}	0.60^{e}
PHF-2	0.56^{a}	0.67^{a}
PHF-3	0.53^{bc}	0.64^{bc}
PHF-4	0.52^{bcd}	0.62^{cd}
PHF-5	0.51^{cd}	0.61^{de}
PHF-6	0.54^{ab}	0.64^{b}
PHF-7	0.54^{ab}	0.65^{b}
Mean	0.53	0.63
S.Em±	0.01	0.01
CD@5%	0.03	0.02

Note: Different alphabets within the column represent significant differences at (p<0.05)

3.1.1 Carr's index, Hausner's ratio and angle of repose

The flow properties of pharmaceutical powders are of utmost importance in the pharmaceutical industry. The powder flow behaviour is a key factor in a series of unit processes such as blending, compression, filling, transportation and scale-up operations (Splendor *et al*., 2013; Goldfarb and Ramachandruni, 2003) [21, 10]. The angle of repose, Hausner's ratio and Carr's index indicate the property of powder with respect to free-flowing nature and compressibility (Aziz *et al*., 2019) [3].

The Carr's index is frequently used in pharmaceuticals as an indication of the compressibility of a powder. In a free-flowing powder, the bulk and tapped density would be close in value; therefore, the Carr's index would be small. On the other hand, in a poor-flowing powder where there are greater interparticle interactions, the difference between the bulk and tapped density observed would be greater, therefore, the Carr's index would be larger. A Carr's index greater than 25 is considered to be an indication of poor flowability, and below 15, of good flowability (Etti *et al*., 2014) [8]. The Hausner's ratio is a number that is correlated to the flowability of a powder or granular material. A Hausner's ratio greater than 1.25 - 1.40 is considered to be an indication of poor flowability. The Hausner's ratio is related to the Carr's index which is another indication of flowability (Rough *et al*., 2005).If the angle of repose is lower than 40°, it indicates good flowability; conversely, if the angle of repose is greater than 40°, it is an indication of cohesiveness (Maghsoodi *et al*., 2007) [15].

In the current experiment, the Carr's index of seven polyherbal formulations had a range from 18.52 to 20.75 per cent. In case of Hausner's ratio, the ratio of seven polyherbal formulations was varied from 1.20 to 1.25 (Table 2). Angle of repose values in the polyherbal formulations of current study varied from 36.16 to 40.87°. All the seven polyherbal formulations developed in this investigation had Carr's index value of less than 25.00 per cent, Hausner's ratio of < 1.35 and angle of repose value of < 45.00º which indicates passable flow property. The outcomes of the present investigation are comparable with the findings of Nimmi and George, (2012) [18] who observed low Hausner's value of 1.15 for polyherbal formulation (F-2) indicating good flow property, while formulation one (F-1) recorded a high Carr's index (20.75) indicating poor compressibility. According to the study of Kaushal *et al.* (2019) [12], the polyherbal powder developed by them registered the angle of repose and Carr's index values of 27.00and 12.28 per cent respectively. However, the lower the angle of repose value (25-30) indicates excellent flowability, while the higher the value (>66) of the angle of repose indicates the extremely poor flowability of the powder. Similarly, Vijayalakshmi (2018) [22] also reported the angle of repose value of 33.03 in polyherbal formulation that represented fair flow property. Polyherbal churna that recorded the Carr's index of 15.15 per cent, Hausner's ratio of 1.18, angle of repose 29.80° represented good flowability (Francis and Sudha, 2016) [9].

Table 2: Effect of different polyherbal composition on Carr's index, Hausner's ratio and angle of repose

Treatments	Carr's index (%)	Hausner's ratio	Angle of repose (°)
PHF-1	20.00^{bc}	1.21^{bc}	36.16^{e}
PHF-2	19.64^{cd}	1.25^{a}	38.28^{c}
PHF-3	20.75^{a}	1.20^{c}	40.87^{a}
PHF-4	19.23^{d}	1.24^{ab}	39.12^{b}
PHF-5	19.61^{cd}	1.20^{c}	40.61^{a}
PHF-6	18.52^{e}	1.21^{bc}	38.52^{c}
PHF-7	20.37^{ab}	1.23^{ab}	37.70^{d}
Mean	19.73	1.22	38.75
S.Em±	0.22	0.01	0.12
CD@5%	0.66	0.03	0.34

Note: Different alphabets within the column represent significant differences at ($p<0.05$)

4. Conclusion

In this experiment, seven polyherbal formulations were developed considering their anti-obesity potential. Polyherbal formulations were composed using nine medicinal herbs belonging to fruits, vegetables, spices and medicinal plants. The bulk density, tapped density, Carr's index, Hausner's ratio and angle of repose of all seven polyherbal formulations are found to be in the safe range to protect the formulations from deteriorative, microbial and physico-chemical reactions. The properties studied also indicated the fair flow properties of powder and their suitability in packaging by being less bulky.

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