recent years because of the inherent properties of encapsulating lipophilic drugs with higher payload [21]. After preparation SLNs are made mucoadhesive by surface modification i.e. coating the SLNs by mucoadhesive polymers such as sodium alginate and poloxamer, chitosan, and its various derivatives [21, 147–149]. In an in vivo study, Kharia et al. find that the nanoparticles containing poloxamer remain attached two folds longer time in stomach and small intestine in comparison to conventional dosage form [150]. In another in vivo study in rats, Carbopol 934-P-loaded nanoparticles stayed for 12 h as compared to control which last for 3 h [151].

7.4. Films

Because of easy application, versatility, and by the addition of permeation enhancer, films are potential pharmaceutical dosage forms for the delivery of biological drugs. Addition of mucoadhesive polymers increases their potential to apply on the mucus membranes as in the buccal cavity. They deliver APIs through mucosal membranes for their systemic effect and local effect. They also protect wounds or lesions formed on mucosal layer. Films are formed by solvent casting, hot melt extrusion, electro-spun nanofibers, and inkjet printing. These mucoadhesive films containing insulin are in clinical trials on their way to marketing and many proteins and peptides are also being explored for delivery through mucoadhesive films [152, 153]. In a human in vivo study, Fluconazole buccal mucoadhesive films with different combination of polymers showed a prolonged residence time of more than 300 min. The mucoadhesive polymers used in this study were arranged with respect to their residence time as follows: HPMC∼HEC > SALG > Eudragit > chitosan [154]. Kumria et al. developed the mucoadhesive films for buccal cavity with HPMC E90, HPMC K100, and Eudragit NE 30D in different combinations and achieved the residence time of 422 and 451 min in human volunteers [155].

7.5. Tablets

Tablets are the most commonly used oral dosage form in the current era. Mucoadhesive tablets can be designed for local, systemic, or sustained release of the drug by adhering to mucosa. Buccal, gastric, intestinal, and vaginal mucosa are the most commonly studied for mucoadhesive tablets. Depending upon the type of application, these can be matrix, biphasic, controlled released, floating, or pulsatile release tablets. The polymers used for the preparation of mucoadhesive tablets include sodium alginate, carbomers/carbopols, HPMC, chitosan, and poloxamer, etc. [156–160]. In a mucoadhesion comparative study in human volunteers, Nafee et al. found 12–13 h residence time on buccal mucosa for tablets prepared from Polycarbophil and Carbopol with HPMC on buccal mucosa [161]. Similarly Giunchedi et al. found that the use of chitosan and alginate in tablet increased the presence of drug in saliva up to 3.5 h as compared to 2 h with chitosan tablets and 30 min with a mouthwash [162]. El-Nabarawi et al. prepared tablets from guar gum with or without CMC or HPMC and achieved a residence time up to 8 h when the tablets were applied to gingival mucosa in human volunteers [163]. The tablets when prepared with a thickness in range of 1–2 mm are known as discs. Mucoadhesive discs are intended to be used for cheek, periodontal, or gingival application. These are advantageous over buccal tablets due to their ease of use and causing less disturbance in the buccal cavity owing to their thinner shape. Like other buccal drug delivery systems, it shows first-pass metabolism bypass, delivery of small- to macromolecular drugs and additionally it possess a simplicity of application and removal as compared to other noninvasive routes, i.e., pulmonary, nasal, and rectal [164]. Most reported mucoadhesive polymers used to prepare mucoadhesive discs by direct compression include xanthan gum, polyacrylic acid, sodium CMC, chitosan, sodium alginate, polycarbophil, and polyethylene oxide [164–167]. Ali et al. achieved residence time of 5.58 (±0.33) h for the discs prepared by using CMC, hydroxymethyl cellulose, and mannitol when applied to buccal mucosa in healthy human volunteers [168].

7.6. Beads

In recent years mucoadhesive beads as a gastro retentive drug delivery system have attained great attention due to their simplicity, biodegradability, compatibility, locality, and stability [169]. Beads are multiunit carrier system hence overcomes the problem of "all or none" delivery of API inherited with single unit carrier system through GIT [170].

The mucoadhesive polymers involved in the formulation of beads are either single or in combination to optimize the properties of mucoadhesion, buoyancy, swelling, and release. These polymers include pectins, chitosan, xanthan gum, polyelectrolyte complexes, gellan gum, sodium alginate and its derivatives, etc. [32, 169–172].